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 ATLANTIC FLEET TRAINING AND TESTING STUDY AREA

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UPDATE ADDENDUM NOTES (December 2012)

This Update contains technical clarifications and corrections to the original Request for Regulations and Letters of Authorization of September 2012.

Changes in Section 1 include: 1) a correction to the example sources included in Table 1-2 for the MF1 and ASW2 (hours row only) bins and 2) a correction in Table 1-6 regarding the description of what was analyzed for both non-impulsive and impulsive Civilian Port Defense activities.

Changes in Section 5 include an update to the requested take numbers in Tables 5-1, 5-3, and 5-4, as well as the associated text in Sections 5.1 and 5.2.

Changes in Section 6 include: 1) a correction to the g(0) values in Table 6-6 that were used in the analysis, 2) a correction to the activities in Tables 6-12, 6-13, 6-23, 6-24, and 6-25 that were used in the analysis with respect to avoidance and mitigation, 3) updates to the take numbers in Tables 6-14, 6-15, 6-17, 6-26, and 6-28 as well as the associated text, and 4) corrections to a few of the in-text Table references in Section 6.

Changes in Section 11 include: 1) a correction regarding Lookouts in Section 11.1, 2) a correction to the Lookout requirement for missile exercises in Sections 11.1.2.2.8 and 11.1.2.2.9 to clarify that they are only required when aircraft are conducting the exercise, 3) a clarification to the Lookout requirement for ship shock trials in Section 11.1.2.2.14 to specify that there will be at least four Lookouts, 4) a clarification in Section 11.2.1.1.1 that pierside testing is included as part of Low-frequency and Hull-mounted Mid-frequency Active Sonar, and 5) a clarification to the mitigation for missile exercises in Section 11.2.1.2.9.

For clarity and understanding of the changes included in the Update, revisions are highlighted in green; deletions are denoted with ~~strikethrough~~.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFTT	Atlantic Fleet Training and Testing
ASW	Anti-Submarine Warfare
ASUW	Anti-Surface Warfare
CFR	Code of Federal Regulations
CV	Coefficient of Variation
dB	Decibel
DoD	Department of Defense
DS	Doppler Sonars
EIS	Environmental Impact Statement
ELCAS	Elevated Causeway System
ESA	Endangered Species Act
FA	Fathometers
FLS	Forward Looking Sonars
ft.	Feet
GI	Gastrointestinal
GOMEX	Gulf of Mexico
HF	High-Frequency
HBX	High Blast Explosive
HHS	Handheld Sonars
IEER	Improved Extended Echo Ranging
IMS	Imaging Sonars
in.	Inch
JAX	Jacksonville
kg	Kilogram
kHz	Kilohertz
lb.	Pound
LF	Low-Frequency
LOA	Letter of Authorization
m	Meters
M	Acoustic Modems
mi.	Miles
MF	Mid-Frequency
µPa	MicroPascal
MMPA	Marine Mammal Protection Act
NAEMO	Navy Acoustic Effects Model
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NEW	Net Explosive Weight

nm	Nautical Mile
NMFS	National Marine Fisheries Service
NRL	Naval Research Laboratory
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
OPAREA	Operating Area
P	Pingers
psi	Pounds per Square Inch
PTS	Permanent Threshold Shift
R	Acoustic Releases
rms	Root Mean Square
SAS	Synthetic Aperture Sonars
SDS	Swimmer Detection Sonars
SEL	Sound Exposure Level
SPL	Sound Pressure Level
SSS	Side Scan Sonars
SUS	Signal Underwater Sound
TNT	Trinitrotoluene
TORP	Torpedo
TTS	Temporary Threshold Shift
VACAPES	Virginia Capes
VHF	Very-High Frequency
USC	United States Code

1 INTRODUCTION AND DESCRIPTION OF ACTIVITIES

1.1 INTRODUCTION

The Department of the Navy (Navy) has prepared this consolidated request for regulations and two Letters of Authorization (LOAs) for the incidental taking (as defined in Chapter 5, Take Authorization Requested) of marine mammals during the conduct of training and testing activities within the Atlantic Fleet Training and Testing (AFTT) Study Area from 2014 through 2019. This application supports the request for a 5-year LOA for training activities and a 5-year LOA for testing activities. Training and testing activities evaluated in this document can span from brief, single unit events on the order of minutes to hours to weeks long multiple platform exercises.

The Marine Mammal Protection Act (MMPA) of 1972, as amended (16 United States Code [USC] Section [§] 1371(a)(5)), authorizes the issuance of regulations for the incidental taking of marine mammals by a specified activity for a period of not more than 5 years. The issuance occurs when the Secretary of Commerce, after notice has been published in the Federal Register and opportunity for comment has been provided, finds that such taking will have a negligible impact on the species and stocks of marine mammals and will not have an unmitigable adverse impact on their availability for subsistence uses. The National Marine Fisheries Service (NMFS) has promulgated implementing regulations under 50 Code of Federal Regulations (CFR) §§ 216.101-106 that provide a mechanism for allowing the incidental, but not intentional, taking of marine mammals while engaged in a specific activity.

The Navy is preparing an Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for the AFTT Study Area to evaluate all components of the proposed training and testing activities. A description of the AFTT Study Area (Figure 1-1) and various components is provided in Chapter 2, Duration and Location of Activities. A description of the training and testing activities for which the Navy is requesting incidental take authorizations is provided in the sections below. This request for LOAs is based on the proposed training and testing activities of the Navy's Preferred Alternative (Alternative 2 in the EIS/OEIS), referred to in this document as the Proposed Action.

This document has been prepared in accordance with the applicable regulations and the MMPA, as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law [PL] 108-136) and its implementing regulations. The basis of this request for Letters of Authorization is: (1) the analysis of spatial and temporal distributions of protected marine mammals in the AFTT Study Area (hereafter referred to as the Study Area), (2) the review of training and testing activities that have the potential to incidentally take marine mammals per the EIS/OEIS, and (3) a technical risk assessment to determine the likelihood of effects. This chapter describes those training and testing activities that are likely to result in Level B harassment, Level A harassment, or mortality under the MMPA. Of the activities analyzed in the AFTT EIS/OEIS, the Navy has determined that only the use of active sonar, in-water detonations, and temporary pile driving and removal have the potential to affect marine mammals that may be present within the Study Area. In addition to the potential impacts from specific activities, the Navy will also request takes from ship strikes that may occur during training or testing activities. These takes, however, are not specific to any particular training or testing activity.

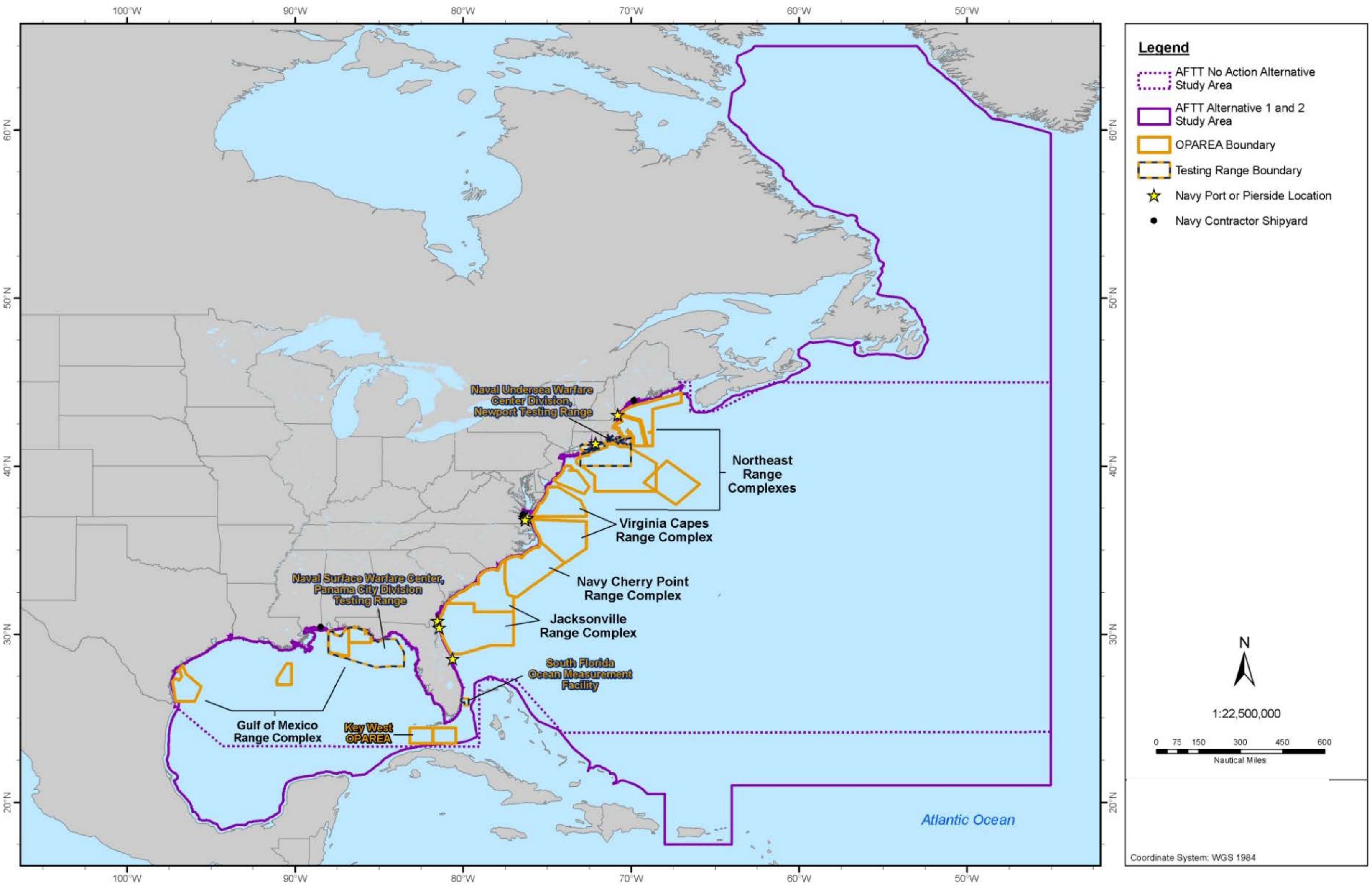

Figure 1-1. Atlantic Fleet Training and Testing Study Area

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 USC § 5062), which ensures 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 necessary 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 tests ships, aircraft, weapons, combat systems, sensors and related equipment, and conducts scientific research activities to achieve and maintain military readiness.

To meet all training and testing requirements, the Navy is preparing an EIS/OEIS to assess the potential environmental impacts associated with ongoing and proposed naval activities in the Study Area. The Navy is the lead agency for the AFTT EIS/OEIS, and NMFS is a cooperating agency pursuant to 40 CFR §§ 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.

1.3 OVERVIEW OF TRAINING ACTIVITIES

The Navy routinely trains in the AFTT Study Area in preparation for national defense missions. Training activities and exercises covered in this request for LOAs are briefly described below, and in more detail within Chapter 2 (Description of Proposed Action and Alternatives) and Appendix A (Navy Activities Descriptions) of the AFTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). Each military training activity described meets a requirement that can be traced ultimately to requirements set forth by the National Command Authority.[2]

1.3.1 DESCRIPTIONS OF CURRENT TRAINING ACTIVITIES WITHIN THE STUDY AREA

The Navy categorizes training activities into functional warfare areas called primary mission areas. Training activities fall into eight primary mission areas (Anti-Air Warfare; Amphibious Warfare; Strike Warfare; Anti-Surface Warfare; Anti-Submarine Warfare; Electronic Warfare; Mine Warfare; Naval Special Warfare). Most training activities are categorized under one of these primary mission areas; those activities that do not fall within one of these areas are in a separate "other" category. Each warfare community (surface, subsurface, aviation, and special warfare) may train within some or all of these primary mission areas.

The Navy describes and analyzes the impacts of its training activities within the AFTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). In its assessment, the Navy concluded that sonar use, underwater

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[1] Title 10, Section 5062 of the United States Code 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."

[2] National Command Authority (NCA) is a term used by the United States military and government to refer to the ultimate lawful source of military orders. The term refers collectively to the President of the United States (as commander-in-chief) and the United States Secretary of Defense.

detonations, and Elevated Causeway System (ELCAS) pile driving and removal 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 request for LOAs 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. In terms of Navy warfare areas, this includes:

- Amphibious Warfare (underwater detonations, ELCAS pile driving and removal)
- Anti-Surface Warfare (underwater detonations)
- Anti-Submarine Warfare (sonar, underwater detonations)
- Mine Warfare (sonar, underwater detonations)
- Naval Special Warfare (underwater detonations)

The Navy's activities in Anti-Air Warfare, Strike Warfare, and Electronic Warfare do not involve sonar use, underwater detonations, pile driving, 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 application. The analysis and rationale for excluding these warfare areas from this request for LOAs are contained in the Navy's AFTT EIS/OEIS.

1.3.1.1 Amphibious Warfare

The mission of amphibious warfare is to project military power from the sea to the shore through the use of naval firepower and Marine Corps landing forces. It is used to attack a threat located on land by a military force embarked on ships. Amphibious warfare operations include small unit reconnaissance or raid missions to large-scale amphibious operations involving multiple ships and aircraft combined into a strike group. Amphibious warfare training ranges from individual, crew, and small unit events to large task force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Such training includes shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, and air strike and close air support training. However, only those portions of amphibious warfare training that occur at sea were analyzed, in particular, underwater detonations associated with naval gunfire support training. The Navy conducts other amphibious warfare support activities in the near shore region from the beach to approximately 1,000 yards (914 m) from shore that could potentially impact marine mammals. This includes pile driving associated with temporary ELCAS installation and removal which is analyzed in this application.

1.3.1.2 Anti-Surface Warfare

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched cruise missiles or other precision-guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles. Anti-surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or exercise torpedo launch events.

1.3.1.3 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats. Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft. This training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes or simulated weapons.

1.3.1.4 Mine Warfare

The mission of mine warfare is to detect, and avoid or neutralize mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control or deny the enemy access to sea space. Naval mines can be laid by ships (including purpose-built minelayers), submarines or aircraft. Mine warfare training includes exercises in which ships, aircraft, submarines, underwater vehicles, or Marine Mammal Systems search for mines. Explosive Ordnance Disposal personnel train to destroy or disable mines by attaching and detonating underwater explosives to simulated mines. Other neutralization techniques involve impacting the mine with a bullet-like projectile or intentionally triggering the mine to detonate.

1.3.1.5 Naval Special Warfare

The mission of naval special warfare is to conduct unconventional warfare, direct action, combat terrorism, special reconnaissance, information warfare, security assistance, counter-drug operations, and recovery of personnel from hostile situations. Naval special warfare operations are highly specialized and require continual and intense training. Naval special warfare units are required to utilize a combination of specialized training, equipment, and tactics, including insertion and extraction operations using parachutes, submerged vehicles, rubber boats, and helicopters; boat-to-shore and boat-to-boat gunnery; underwater demolition training; reconnaissance; and small arms training.

1.4 Overview of Testing Activities

Testing activities covered in this request for LOAs are briefly described below, and in more detail within the AFTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). Each military testing activity described meets a requirement that can be traced ultimately to requirements set forth by the National Command Authority.

1.4.1 Descriptions of Current Testing Activities within the Study Area

The Navy researches, develops, tests, and evaluates new platforms, systems and technologies. Many tests are conducted in realistic conditions at sea, and can range in scale from testing new software to conducting ship shock trials and major weapons systems. Testing activities may occur independently of or in conjunction with training activities.

Many testing activities are conducted similarly to Navy training activities and are also categorized under one of the primary mission areas described above in Section 1.3.1 (Descriptions of Current Training Activities within the Study Area). Other testing activities are unique and are described within their specific testing categories. Because each test is conducted by a specific component of the Navy's research and acquisition community (which includes the Navy's System Commands and scientific research organizations), the testing activities described in this request for LOAs are organized by component as described below and in the order as presented.

The Navy describes and analyzes the effects of its testing activities within the AFTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). In its assessment, the Navy concluded that for the AFTT Draft EIS/OEIS, impulsive and non-impulsive underwater sounds resulting from active acoustics and underwater detonations were the stressors resulting in impacts on marine mammals that rose to the level of harassment as defined under the MMPA. Therefore, this request for LOAs provides the Navy's assessment of potential effects from these stressors in terms of the various activities in which they would be used.

In terms of these categories, Navy testing includes:

- Naval Air Systems Command (NAVAIR) Testing
    - Anti-Surface Warfare Testing (underwater detonations)
    - Anti-Submarine Warfare Testing (sonar, underwater detonations)
    - Mine Warfare Testing (sonar, underwater detonations)
- Naval Sea Systems Command (NAVSEA) Testing
    - New Ship Construction (sonar, other active acoustic sources, underwater detonations)
    - Shock Trials (underwater detonations)
    - Life Cycle Activities (sonar, other active acoustic sources, underwater detonations)
    - Range Activities (sonar, other active acoustic sources, underwater detonations)
    - Anti-Surface Warfare/ Anti-Submarine Warfare Testing (sonar, other active acoustic sources, underwater detonations)
    - Mine Warfare Testing (sonar, underwater detonations)
    - Shipboard Protection Systems and Swimmer Defense Testing (sonar, underwater detonations)
    - Unmanned Vehicle Testing (sonar)
    - Other Testing (sonar, other active acoustic sources, underwater detonations)
- Office of Naval Research (ONR) and Naval Research Laboratory (NRL) Testing
    - ONR/NRL Research, Development, Test & Evaluation (acoustic)

Other Navy testing activities (e.g., Anti-Air Warfare and Airguns) do not involve sonar use, 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 application.

1.4.1.1 Naval Air Systems Command Testing

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

Many platforms (e.g., the MH-60 helicopter) and systems (e.g., Airborne Towed Minehunting System) currently being tested by NAVAIR are already being used by the fleet or will ultimately be integrated into fleet training activities. Training with systems and platforms transferred to the fleet within the 2014-2019 timeframe are analyzed in the training sections of this application. This section only addresses NAVAIR's testing activities.

For the most part, NAVAIR conducts its testing activities in the same way the fleet conducts its training activities. However, there are some distinctions. Naval Air Systems Command's testing activities may occur in different locations than equivalent fleet training activities, and the manner in which a test of a particular system is conducted may differ slightly from the way the fleet trains with the same system. Because of these distinctions, the analysis of NAVAIR's testing activities and the fleet's training activities may differ.

1.4.1.1.1 Anti-Surface Warfare Testing

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched rockets and missiles or other precision-guided munitions. Anti-surface warfare testing includes air-to-surface gunnery and missile exercises.

Testing of anti-surface warfare systems is required to ensure the equipment used for defense from surface threats is fully functional under the conditions for which it will be used. Tests may be conducted on new guns or run rounds, missiles, and rockets. Testing of these systems may be conducted on new aircraft and on existing aircraft following maintenance, repair, or modification. For some systems, tests are conducted periodically to assess operability. Additionally, tests may be conducted in support of scientific research to assess new and emerging technologies. Testing events are often integrated into training activities and in most cases the systems are used in the same manner in which they are used for Fleet training activities.

1.4.1.1.2 Anti-Submarine Warfare Testing

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats. Anti-submarine warfare testing addresses basic skills such as detection and classification of submarines, distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare testing is conducted in coordinated, at-sea training events involving submarines, ships, and aircraft. This testing integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using various torpedoes and weapons.

1.4.1.1.3 Mine Warfare Testing

The mission of mine warfare is to detect, and avoid or neutralize mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying by aircraft to gain control or deny the enemy access to sea space. Mine warfare testing includes activities in which aircraft detection systems are used to search and record the location of mines for subsequent neutralization. Mine neutralization tests evaluate a system's effectiveness at intentionally detonating or otherwise disabling the mine. Different mine neutralization systems are designed to neutralize mines at the sea surface or within the water column. One system uses a bullet-like projectile to disable or destroy the mine. Another systems uses remotely operated vehicles to neutralized subsurface mines. All components of these systems are tested in the at-sea environment to ensure they meet mission requirements.

1.4.1.2 Naval Sea Systems Command Testing

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

1.4.1.2.1 New Ship Construction Activities

Ship construction activities include pierside testing of ship systems, tests to determine how the ship performs at sea (sea trials), and developmental and operational test and evaluation programs for new technologies and systems. Pierside and at-sea testing of systems aboard a ship may include sonar, acoustic countermeasures, radars, and radio equipment. In this request for LOAs, at piers and shipyards, only the use of sonar and other active acoustic sources was analyzed. During sea trials, each new ship propulsion engine is operated at full power and subjected to high-speed runs and steering tests. At-sea test firing of shipboard weapon systems, including guns, torpedoes, and missiles, are also conducted.

1.4.1.2.2 Shock Trials

One ship of each new class (or major upgrade) of combat surface ships constructed for the Navy must undergo an at-sea shock trial. A shock trial is a series of underwater detonations that send a shock wave through the ship’s hull to simulate near misses during combat. A shock trial allows the Navy to validate the shock hardness of the ship and assess the survivability of the hull and ship’s systems in a combat environment as well as the capability of the ship to protect the crew.

1.4.1.2.3 Life Cycle Activities

Testing activities are conducted throughout the life of a Navy ship to verify performance and mission capabilities. Sonar system testing occurs pierside during maintenance, repair, and overhaul availabilities, and at sea immediately following most major overhaul periods. A Combat System Ship Qualification Trial is conducted for new ships and for ships that have undergone modification or overhaul of their combat systems.

Radar cross signature testing of surface ships is conducted on new vessels and periodically throughout a ship’s life to measure how detectable the ship is to radar. Additionally, electromagnetic measurements of off-board electromagnetic signature are conducted for submarines, ships, and surface craft periodically.

1.4.1.2.4 Range Activities

NAVSEA’s testing ranges are used to conduct principal testing, analysis, and assessment activities for ship and submarine platforms, including ordnance, mines, and machinery technology for surface combat systems. Naval Surface Warfare Center, Panama City Division Testing Range focuses on surface warfare tests that often involve mine countermeasures. Naval Undersea Warfare Center Division, Newport Testing Range focuses on the undersea aspects of warfare and is, therefore, structured to test systems such as torpedoes and unmanned underwater vehicles. The South Florida Ocean Measurement Facility Testing Range retains a unique capability that focuses on signature analysis operations and mine warfare testing events.

1.4.1.2.5 Other Weapon Systems Development and Testing

Numerous test activities and technical evaluations, in support of NAVSEA's systems development mission, often occur in conjunction with fleet activities within the Study Area. Tests within this category include, but are not limited to, anti-surface warfare, anti-submarine warfare, and mine warfare tests using torpedoes, sonobuoys, and mine detection and neutralization systems.

1.4.1.3 Office of Naval Research and Naval Research Laboratory Testing

As the Navy's Science and Technology provider, ONR and NRL provide technology solutions for Navy and Marine Corps needs. The Office of Naval Research's mission, defined by law, is to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Further, ONR manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test and evaluation. The Ocean Battlespace Sensing Department explores science and technology in the areas of oceanographic and meteorological observations, modeling, and prediction in the battlespace environment; submarine detection and classification (anti-submarine warfare); and mine warfare applications for detecting and neutralizing mines in both the ocean and littoral environment. The ONR events include: research, development, test, and evaluation activities; surface processes acoustic communications experiments; shallow water acoustic communications experiments; sediment acoustics experiments; shallow water acoustic propagation experiments; and long range acoustic propagation experiments.

1.5 Description of Sonar, Ordnance, Targets, and Other Systems

The Navy uses a variety of sensors, platforms, weapons, and other devices, including ones used to ensure the safety of Sailors and Marines, to meet its mission. Training and testing with these systems may introduce acoustic (sound) energy into the environment. This section presents and organizes sonar systems, ordnance, munitions, targets, and other systems in a manner intended to facilitate understanding of the activities in which these systems are used. In this application underwater sound is described as one of two types; impulsive and non-impulsive. Underwater detonations of explosives and other percussive events are impulsive sounds. Sonar and similar sound producing systems are categorized as non-impulsive sound sources in this request for LOAs.

1.5.1 Sonar and Other Non-Impulsive Sources

Modern sonar technology includes a variety of sonar sensor and processing systems. In concept, the simplest active sonar emits sound waves, or "pings," sent out in multiple directions and the sound waves then reflect off of the target object in multiple directions. The sonar source calculates the time it takes for the reflected sound waves to return; this calculation determines the distance to the target object. More sophisticated active sonar systems emit a ping and then rapidly scan or listen to the sound waves in a specific area. This provides both distance to the target and directional information. Even more advanced sonar systems use multiple receivers to listen to echoes from several directions simultaneously and provide efficient detection of both direction and distance. It should be noted that active sonar is rarely used continuously throughout the listed activities. In addition, when sonar is in use, the sonar "pings" occur at intervals, referred to as a duty cycle, and the signals themselves are very short in duration. For example, sonar that emits a 1-second ping every 10 seconds has a 10 percent duty cycle. The Navy utilizes sonar systems and other acoustic sensors in support of a variety of mission requirements. Primary uses include the detection of and defense against submarines (anti-submarine warfare) and mines (mine warfare); safe navigation and effective communications; use of unmanned undersea vehicles; and oceanographic surveys.

1.5.2 Ordnance/Munitions

Most ordnance and munitions used during training and testing events fall into three basic categories: projectiles, missiles, and bombs. Ordnance can be further defined by their net explosive weight, which considers the type and quantity of the explosive substance without the packaging, casings, bullets, etc. Net explosive weight (NEW) is also the trinitrotoluene (TNT) equivalent of energetic material, which is the standard measure of strength of bombs and other explosives. For example, a 2,000-pound (lb.) (907 kilogram [kg]) bomb may have anywhere from 600 to 1,000 lb. (272 to 454 kg) of NEW. The Navy also uses non-explosive ordnance in place of high explosive ordnance in many training and testing events. Non-explosive ordnance munitions look and perform similarly to high explosive ordnance, but lack the main explosive charge.

1.5.3 Defensive Countermeasures

Naval forces depend on effective defensive countermeasures to protect themselves against missile and torpedo attack. Defensive countermeasures are devices designed to confuse, distract, and confound precision guided munitions. Defensive countermeasures analyzed in this request for LOAs include acoustic countermeasures, which are used by surface ships and submarines to defend against torpedo attack. Acoustic countermeasures are either released from ships and submarines, or towed at a distance behind the ship.

1.5.4 Mine Warfare Systems

Mine warfare systems fall into two broad categories, mine detection and mine neutralization.

1.5.4.1 Mine Detection Systems

Mine detection systems are used to locate, classify, and map suspected mines. Once located, the mines can either be neutralized or avoided. These systems are specialized to either locate mines on the surface, in the water column, or on the sea floor. The following mine detection systems were analyzed for this request for LOAs:

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

1.5.4.2 Mine Neutralization Systems

These systems disrupt, disable, or detonate mines to clear ports and shipping lanes, as well as littoral, surf, and beach areas in support of naval amphibious operations. Mine neutralization systems can clear individual mines or a large number of mines quickly. The following mine neutralization systems were analyzed for this request for LOAs:

- **Airborne Projectile-Based Mine Clearance System.** Laser-based detection systems search for mines and to fix mine locations, and neutralize mines by firing a small or medium-caliber inert, supercavitating projectile from a hovering helicopter.
- **Towed Influence Mine Sweep Systems.** These systems use towed equipment that mimic a particular ship's magnetic and acoustic signature triggering the mine and causing it to explode.
- **Unmanned/Remotely Operated Mine Neutralization Systems**. Surface ships and helicopters operate these systems, which place explosive charges near or directly against mines to destroy the mine.
- **Diver Emplaced Explosive Charges.** Operating from small craft, divers emplace explosive charges near or on mines to destroy the mine or disrupt its ability to function.

1.5.5 Classification of Non-Impulsive and Impulsive Sources

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater non-impulsive sound or impulsive energy, a series of source classifications, or source bins, were developed. 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;"
- simplifies the source utilization data collection and reporting requirements anticipated under the MMPA;
- ensures a conservative approach to all impacts estimates, as all sources within a given class are modeled as the loudest source (lowest frequency, highest source level, longest duty cycle, or largest net explosive weight within that bin; which
- allows analysis to be conducted in a more efficient manner, without any compromise of analytical results; and
- provides a framework to support the reallocation of source usage (hours/explosives) between different source bins, as long as the total numbers of takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training and testing requirements, which are linked to real world events.

As described previously in Chapter 1 (Introduction and Description of Activities), there are two primary types of source classes: non-impulsive and impulsive. A description of each source classification is provided in Tables 1-1 and 1-2. Non-impulsive sources are grouped into bins based on the frequency[3],

[3] Bins are based on the typical center frequency of the source. Although harmonics may be present, those harmonics would be several dB lower than the primary frequency.

source level[4], and, when warranted, and the application in which the source would be used. Impulsive bins are based on the net explosive weight of the munitions, ordnance, or explosive devices.

The following factors further describe the considerations associated with the development of non-impulsive source classifications:

- Frequency of the non-impulsive source:
    - Low-frequency (LF) sources operate below 1 kilohertz (kHz)
    - Mid-frequency (MF) sources operate at and above 1 kHz, up to and including 10 kHz
    - High-frequency (HF) sources operate above 10 kHz, up to and including 100 kHz
    - Very-high-frequency (VHF) sources operate above 100 kHz but below 200 kHz
- Source level of the non-impulsive source:
    - Greater than 160 decibels (dB) but less than 180 dB
    - Equal to 180 dB and up to 200 dB
    - Greater than 200 dB
- Application in which the source would be used:
    - How a sensor is employed supports how the sensor's acoustic emissions are analyzed.
    - Factors considered include pulse length (time source is "on"); beam pattern (whether sound is emitted as a narrow, focused beam, or, as with most explosives, in all directions); and duty cycle (how often or how many times a transmission occurs in a given period during an event)

1.5.6 Source Classes Analyzed for Training and Testing

Table 1-1 shows the explosive source classes and numbers used annually in Navy training and testing activities in the Study Area that were analyzed in this request for LOAs. Table 1-2 shows the non-impulsive active acoustic sources and numbers used annually in Navy training and testing activities that were analyzed. Table 1-3 shows the explosive source classes and numbers used non-annually in Navy training and testing activities. For example, some activities only occur once per 5-year period. Table 1-4 shows the non-impulsive active acoustic sources and numbers used non-annually in Navy training and testing activities that were analyzed.

[4] Source decibel levels are expressed in terms of sound pressure level and are values given in decibels (dB) referenced to one microPascal (μPa) at one meter.

Table 1-1. Explosive Source Classes Analyzed and Numbers Used during Annual Training and Testing Activities

Source Class	Representative Munitions	Net Explosive Weight[1] (lbs)	Number of Explosives (Annual) for Training Activities	Number of Explosives (Annual) for Testing Activities
E1	Medium-caliber projectiles	0.1-0.25	124,552	25,501
E2	Medium-caliber projectiles	0.26-0.5	856	0
E3	Large-caliber projectiles	0.6-2.5	3,132	2,912
E4	Improved Extended Echo Ranging Sonobuoy	2.6-5	2,190	1,432
E5	5 in. projectiles	6-10	14,370	495
E6	15 lb. shaped charge	11-20	500	54
E7	40 demo block/shaped charge	21-60	322	0
E8	250 lb. bomb	61-100	77	11
E9	500 lb. bomb	101-250	2	0
E10	1,000 lb. bomb	251-500	8	10
E11	650 lb. mine	501-650	1	27
E12	2,000 lb. bomb	651-1,000	133	0
E13	1,200 lb. HBX[2] charge	1,001-1,740	0	0
E14	2,500 lb. HBX charge	1,741-3,625	0	4
E15	5,000 lb. HBX charge	3,626-7,250	0	0

[1] Net Explosive Weight refers to the amount of explosives, the actual weight of a munition may be larger due to other components
[2] HBX; High Blast Explosive family of binary explosives that are composed of Royal Demolition Explosive (RDX) (explosive nitroamine), TNT, powdered aluminum, and D-2 wax with calcium chloride

Table 1-2. Active Acoustic Source Classes Analyzed and Hours Used during Annual Training and Testing Activities

Source Class Category	Source Class	Description	Units	Annual Training*	Annual Testing*
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals.	LF3	Low-frequency sources greater than 200 dB	Hours	0	0
	LF4	Low-frequency sources equal to 180 dB and up to 200 dB	Hours	0	254
	LF5	Low-frequency sources greater than 160 dB, but less than 180 dB	Hours	0	370
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals.	MF1	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)	Hours	9,844	220
	MF1K	Kingfisher mode associated with MF1 sonar	Hours	163	19
	MF2	Hull-mounted surface ship sonar (e.g., AN/SQS-56)	Hours	3,150	36
	MF2K	Kingfisher mode associated with MF2 sonar	Hours	61	0
	MF3	Hull-mounted submarine sonar (e.g., AN/BQQ-10)	Hours	2,058	434
	MF4	Helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)	Hours	927	776
	MF5	Active acoustic sonobuoys (e.g., DICASS)	Items	14,556	4,184
	MF6	Active sound underwater signal devices (e.g., MK-84)	Items	0	303
	MF8	Active sources (greater than 200 dB) not otherwise binned	Hours	0	90
	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	Hours	0	13,034
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	Hours	0	1,067
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80%	Hours	800	0
	MF12	Towed array surface ship sonar with an active duty cycle greater than 80%	Hours	687	144

* Sonobuoys, decoys, and torpedoes are presented as number of items instead of hours.

Table 1-2. Active Acoustic Source Classes Analyzed and Hours Used during Annual Training and Testing Activities (Continued)

Source Class Category	Source Class	Description	Units	Annual Training *	Annual Testing *
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 180 kHz) signals.	HF1	Hull-mounted submarine sonar (e.g., AN/BQQ-10)	Hours	1,676	1,243
	HF2	High-Frequency Marine Mammal Monitoring System	Hours	0	0
	HF3	Other hull-mounted submarine sonar (classified)	Hours	0	384
	HF4	Mine detection and classification sonar (e.g., Airborne Towed Minehunting Sonar System)	Hours	8,464	5,572
	HF5	Active sources (greater than 200 dB) not otherwise binned	Hours	0	1,206
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	Hours	0	1,974
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	Hours	0	366
	HF8	Hull-mounted surface ship sonar (e.g., AN/SQS-61)	Hours	0	0
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of anti-submarine warfare training and testing activities.	ASW1	Mid-frequency Deep Water Active Distributed System (DWADS)	Hours	128	96
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125) – Sources that are analyzed by item	Items	2,620	2,743
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., HDC ~~AN/SSQ-125~~) – Sources that are analyzed by hours	Hours	0	274
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)	Hours	13,586	948
	ASW4	Mid-frequency expendable active acoustic device countermeasures (e.g., MK-3)	Items	1,365	483
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)	Items	54	581
	TORP2	Heavyweight torpedo (e.g., MK-48)	Items	80	521

Table 1-2. Active Acoustic Source Classes Analyzed and Hours Used during Annual Training and Testing Activities (Continued)

Source Class Category	Source Class	Description	Units	Annual Training Hours*	Annual Testing Hours*
Doppler Sonars (DS): Sonars that use the Doppler effect to aid in navigation or collect oceanographic information.	DS1	Low-frequency Doppler sonar (e.g., Webb Tomography Source)	Hours	0	0
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars.	FLS2 – FLS3	High-frequency sources with short pulse lengths, narrow beam widths, and focused beam patterns used for navigation and safety of ships.	Hours	0	365
Acoustic Modems (M): Systems used to transmit data acoustically through the water.	M3	Mid-frequency acoustic modems (greater than 190 dB)	Hours	0	461
Swimmer Detection Sonars (SD): Systems used to detect divers and submerged swimmers.	SD1 – SD2	High-frequency sources with short pulse lengths, used for detection of swimmers and other objects for the purposes of port security	Hours	0	230
Synthetic Aperture Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor	SAS1	MF SAS systems	Hours	0	6
	SAS2	HF SAS systems	Hours	0	3,424
	SAS3	VHF SAS systems	Hours	0	0

* Sonobuoys, decoys, and torpedoes are presented as number of items instead of hours.

Table 1-3. Explosive Source Classes Analyzed and Numbers Used during Non-Annual Training and Testing Activities

Source Class	Representative Munitions	Net Explosive Weight[1] (lbs)	Number of Explosives (per activity) for Training Activities	Number of Explosives (per activity) for Testing Activities
E1	Medium-caliber projectiles	0.1-0.25	0	600
E2	Medium-caliber projectiles	0.26-0.5	2	0
E4	Improved Extended Echo Ranging Sonobuoy	2.6-5	2	0
E16	10,000 lb. HBX charge	7,251-14,500	0	12
E17	40,000 lb. HBX charge	14,501-58,000	0	4

Table 1-4. Active Acoustic Source Classes Analyzed and Hours Used during Non-Annual Training and Testing Activities

Source Class Category	Source Class	Description	Training Hours*	Testing Hours*
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kHz) signals.	LF5	Low-frequency sources greater than 160 dB, but less than 180 dB	0	240
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals.	MF9	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	0	480
High-Frequency (HF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 180 kHz) signals.	HF4	Mine detection and classification sonar (e.g., AN/AQS-20)	192	0
	HF5	Active sources (greater than 200 dB) not otherwise binned	0	240
	HF6	Active sources (equal to 180 dB and up to 200 dB) not otherwise binned	0	720
	HF7	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned	0	240
Forward Looking Sonar (FLS): Forward or upward looking object avoidance sonars.	FLS2 – FLS3	High-frequency sources with short pulse lengths, narrow beam widths, and focused beam patterns used for navigation and safety of ships.	0	240
Sonars (SAS): Sonars in which active acoustic signals are post-processed to form high-resolution images of the seafloor.	SAS2	HF SAS systems		720

* Sonobuoys, decoys, and torpedoes are presented as number of items instead of hours.

1.5.7 SOURCE CLASSES EXCLUDED FROM QUANTITATIVE ANALYSIS FOR TRAINING AND TESTING

An entire source class, or some sources from a class, are excluded from quantitative analysis within the scope of this request for LOAs if any of the following criteria are met:

- The source is expected to result in responses which are short term and inconsequential.
- The sources operate at frequencies greater than 200 kHz.
- The sources operate at source levels less than 160 dB.
- Classes contain sources needed for safe operation and navigation.

Table 1-5 presents a description of the sources and source bins that the Navy excluded from quantitative analysis.

Table 1-5. Source Classes Excluded from Quantitative Analysis

Source Class Category	Source Class	Justification
Fathometers (FA) High-frequency sources used to determine water depth	FA1 – FA4	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given their characteristics (e.g., narrow downward-directed beam). Such reactions are not considered to constitute ``taking'' and, therefore, no additional allowance is included for animals that might be affected by these sound sources. Fathometers generate a downward looking narrowly focused beam directly below the vessel (typically much less than 30 degrees), using a short pulse length (less than 10 msec). Use of fathometers is required for safe operation of Navy vessels.
Hand-held Sonar (HHS) High-frequency sonar devices used by Navy divers for object location	HHS1	Hand-held sonars generate very-high frequency sound at low power levels (150 – 178 dB re 1 µPascal), short pulse lengths, and narrow beam widths. Because output from these sound sources would attenuate to below any current threshold for protected species within approximately 10-15 m, and they are under positive control of the diver on which direction the sonar is pointed, noise impacts are not anticipated and are not addressed further in this analysis.
Doppler Sonar (DS)/Speed Logs Navigation equipment, downward focused, narrow beamwidth, HF/VHF spectrum utilizing very short pulse length pulses.	DS2, DS3, DS4	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given their characteristics (e.g., narrow downward-directed beam), which is focused directly beneath the platform. Such reactions are not considered to constitute ``taking'' and, therefore, no additional allowance is included for animals that might be affected by these sound sources.

Table 1-5. Source Classes Excluded from Quantitative Analysis (Continued)

Source Class Category	Source Class	Justification
Imaging Sonars (IMS) HF or VHF, very short pulse lengths, narrow bandwidths. IMS1 is a side scan sonar (HF/VHF, narrow beams, downward directed). IMS2 is a downward looking source, narrow beam, and operates above 180 kHz (basically a fathometer).	IMS1, IMS2	These side scan sonars operate in a very-high frequency range (over 120 kHz) relative to marine mammal hearing (Richardson et al. 1995; Southall et al. 2007). The frequency range from these side scan sonars is beyond the hearing range of mysticetes (baleen whales) and pinnipeds, and, therefore, not expected to affect these species in the Study Area. The frequency range from these side scan sonars falls within the upper end of odontocete (toothed whale) hearing spectrum (Richardson et al. 1995), which means that they are not perceived as loud acoustic signals with frequencies below 120 kHz by these animals. Therefore, these animals would not react to the sound in a biologically significant way. Further, in addition to spreading loss for acoustic propagation in the water column, high-frequency acoustic energies are more quickly absorbed through the water column than sounds with lower frequencies (Urick 1983). Additionally, these systems are generally operated in the vicinity of the sea floor, thus reducing the sound potential of exposure even more. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the IMS given their characteristics (e.g., narrow downward-directed beam and short pulse length [generally 20 msec]). Such reactions are not considered to constitute ``taking'' and, therefore, no additional allowance is included for animals that might be affected by these sound sources
High-Frequency Acoustic Modems (M) and Tracking Pingers (P)	M2, P1, P2, P3, P4	As determined for the Ocean Observatories Initiative for multi-beam echo sounder, SBP, altimeters, acoustic modems, and tracking pingers operating at frequencies between 2 and 170 kHz, fish and marine mammals would not be disturbed by any of these proposed acoustic sources given their low duty cycles, (single pings in some cases), short pulse lengths (typically 20 msec), the brief period when an individual animal would potentially be within the very narrow beam of the source, and the relatively low source levels of the pingers and acoustic modems. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics. Such reactions are not considered to constitute ``taking'' and, therefore, no additional allowance is included for animals that might be affected by these sound sources
Acoustic Releases (R) Systems that transmit active acoustic signals to release a bottom-mounted object from its housing in order to retrieve the device at the surface	R1, R2, R3	Mid-frequency acoustic release (up to 190 dB) and High-frequency acoustic release (up to 225 dB) Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these sound sources given that any sound emitted is extremely minimal. Since these are only used to retrieve bottom mounted devices they are typically only a single ping. Such reactions are not considered to constitute ``taking'' and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
Side Scan Sonar (SSS) Sonar that use active acoustic signals to produce high-resolution images of the seafloor	SSS1, SSS2, SSS3	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics such as a downward-directed beam and using short pulse lengths (less than 20 msec).. Such reactions are not considered to constitute ``taking'' and, therefore, no additional allowance is included for animals that might be affected by these sound sources.

1.6 PROPOSED ACTION

The Navy has been conducting military readiness training and testing activities in the AFTT Study Area for many decades, with some use of the range complexes and testing ranges dating back to the 1940s. Some of these activities were analyzed in the following publically available, related documents:

- Final Atlantic Fleet Active Sonar Training (AFAST) EIS/OEIS (January 2009)
- Virginia Capes Final EIS/OEIS (June 2009), Navy Cherry Point Final EIS/OEIS (June 2009), Jacksonville Range Complex Final EIS/OEIS (June 2009), Gulf of Mexico Range Complex Final EIS/OEIS (February 2011), and Final Environmental Assessment/Overseas Environmental Assessment on the Key West Range Complex (January 2010)
- Final EIS for Introduction of the P-8A Multi-Mission Maritime Aircraft into the U.S. Navy Fleet (March 2009)
- EIS for Introduction of F/A-18E/F Super Hornets to the East Coast of the U.S (July 2003)
- Shock Trials of the Mesa Verde (LPD-19) Final EIS/OEIS (May 2008)
- Environmental Impact Statement for the Shock Trial of the Winston S Churchill (DDG-81) (February 2001)
- Overseas Environmental Assessment for High Speed Sea Trials In the Gulf of Mexico (June 2009)
- Programmatic Overseas Environmental Assessment on Sinking Exercises (SINKEX) in the Western Atlantic Ocean (March 2006)
- Final EIS/OEIS for Undersea Warfare Training Range (July 2009)
- EIS/OEIS for Naval Surface Warfare Center, Panama City Division Mission Activities (January 2010)
- Environmental Assessment of Test Operations in Rhode Island Waters for the Naval Undersea Warfare Center Division, Newport Testing Range (May 2008)
- Environmental Assessment Transition of E-2C Hawkeye to E-2D Advanced Hawkeye at Naval Station Norfolk. Virginia and Naval Base Ventura County Point Mugu, California (January 2009)

The baseline of training and testing activities currently conducted in the Study Area are defined by existing Navy environmental planning documents, including the AFAST EIS/OEIS, Virginia Capes Final EIS/OEIS, Navy Cherry Point Final EIS/OEIS, Jacksonville Range Complex Final EIS/OEIS, Gulf of Mexico Range Complex Final EIS/OEIS, EIS/OEIS for Naval Surface Warfare Center, Panama City Division Mission Activities, Final Environmental Assessment/Overseas Environmental Assessment on the Key West Range Complex, and Environmental Assessment of Test Operations in Rhode Island Waters for the Naval Undersea Warfare Center Division, Newport Testing Range, and any associated MMMPA authorizations. The baseline testing activities also include those testing events that have historically occurred in the Study Area.

The tempo and types of training and testing activities have fluctuated within the Study Area due to changing requirements; the introduction of new technologies; the dynamic nature of international events; advances in warfighting doctrine and procedures; and changes in basing locations for ships, aircraft, and personnel (force structure changes). Such developments have influenced the frequency, duration, intensity, and location of required training and testing.

1.6.1 Study Area Additions

The Study Area has expanded beyond the areas included in previous Navy authorizations. This expansion of the Study Area is not an increase in areas where the Navy will train and test, but is merely an expansion of the area to be included in the incidental take authorization in support of the AFTT EIS/OEIS.

The AFTT Study Area now includes:

- Expanding north to the 65 degree north latitude line
- Expanding south to the 20 degree north latitude line
- Bays, harbors, and civilian ports: Narragansett Bay, the lower Chesapeake Bay and St. Andrew Bay for training and testing activities. Ports included for Civilian Port Defense training events include Earle, New Jersey; Groton, Connecticut; Norfolk, Virginia; Morehead City, North Carolina; Wilmington, North Carolina; Kings Bay, Georgia; Mayport, Florida; Beaumont, Texas; and Corpus Christi, Texas.
- Navy piers and Navy shipyards: Portsmouth Naval Shipyard, Kittery, Maine; Naval Submarine Base New London, Groton, Connecticut; Naval Station Norfolk, Norfolk, Virginia; Joint Expeditionary Base Little Creek – Fort Story, Virginia Beach, Virginia; Norfolk Naval Shipyard, Portsmouth, Virginia; Naval Submarine Base Kings Bay, Kings Bay, Georgia; Naval Station Mayport, Jacksonville, Florida; and Port Canaveral, Cape Canaveral, Florida.
- Navy-contractor shipyards: Bath, Maine; Groton, Connecticut; Newport News, Virginia; and Pascagoula, Mississippi.

1.6.2 Training

The training activities that the Navy proposes to conduct in the Study Area are described in Table 1-6. The table is organized according to primary mission areas and includes the activity name, associated stressor(s), description of the activity, the primary platform used (e.g., ship or aircraft type), duration of activity, amount of non-impulsive sound or explosives used in the activity, the areas where the activity is conducted, and the number of activities per year. More detailed activity descriptions can be found in the AFTT EIS/OEIS.

The Navy's Proposed Action is an adjustment to existing baseline training activities, as defined in the documents listed in Section 1.6 (Proposed Action) combined with changes in training needed due to force changes and slight modifications to previous study areas. The Navy's Proposed Action includes changes to training requirements necessary to accommodate:

- Force structure changes including the relocation of ships, aircraft, and personnel to meet Navy needs. As forces are moved within the existing Navy structure, training needs will necessarily change as the location of forces change.
- Development and introduction of ships, aircraft, and weapons systems.
- Current training activities that were not addressed in previous environmental documents.

Table 1-6. Training Activities within the Study Area

Stressor	Training Event	Description	Source Class	Number of Events per Year
Anti-Submarine Warfare (ASW)				
Non-Impulsive	Tracking Exercise/ Torpedo Exercise – Submarine (TRACKEX/TORPEX - Sub)	Submarine crews search, track, and detect submarines. Exercise torpedoes may be used during this event.	ASW4; MF3; HF1; TORP2	102
Non-Impulsive	Tracking Exercise/ Torpedo Exercise – Surface (TRACKEX/TORPEX - Surface)	Surface ship crews search, track and detect submarines. Exercise torpedoes may be used during this event.	ASW1,3,4; MF1,2,3,4,5,11,12; HF1; TORP1	764
Non-Impulsive	Tracking Exercise/ Torpedo Exercise - Helicopter (TRACKEX/TORPEX - Helo)	Helicopter crews search, detect and track submarines. Recoverable air launched torpedoes may be employed against submarine targets.	ASW4; MF4,5; TORP1	432
Non-Impulsive	Tracking Exercise/ Torpedo Exercise - Maritime Patrol Aircraft (TRACKEX/TORPEX - MPA)	Maritime patrol aircraft crews search, detect, and track submarines. Recoverable air launched torpedoes may be employed against submarine targets.	MF5; TORP1	752
Non-Impulsive	Tracking Exercise - Maritime Patrol Aircraft Extended Echo Ranging Sonobuoy (TRACKEX – MPA sonobuoy)	Maritime patrol aircraft crews search, detect, and track submarines with extended echo ranging sonobuoys. Recoverable air launched torpedoes may be employed against submarine targets.	ASW2	160
Non-Impulsive	Anti-Submarine Warfare Tactical Development Exercise	Multiple ships, aircraft and submarines coordinate their efforts to search, detect and track submarines with the use of all sensors. Anti-Submarine Warfare Tactical Development Exercise is a dedicated ASW event.	ASW3,4; HF1; MF1,2,3,4,5	4
Non-Impulsive	Integrated Anti-Submarine Warfare Course (IAC)	Multiple ships, aircraft, and submarines coordinate the use of their sensors, including sonobuoys, to search, detect and track threat submarines. IAC is an intermediate level training event and can occur in conjunction with other major exercises.	ASW 3,4; HF1; MF1,2,3,4,5	5

Table 1-6. Training Activities within the Study Area (Continued)

Stressor	Training Event	Description	Source Class	Number of Events per Year
Non-Impulsive	Group Sail	Multiple ships and helicopters integrate the use of sensors, including sonobuoys, to search, detect and track a threat submarine. Group sails are not dedicated ASW events and involve multiple warfare areas.	ASW 2,3; HF1; MF1,2,3,4,5	20
Non-Impulsive	ASW for Composite Training Unit Exercise (COMPTUEX)	Anti-Submarine Warfare activities conducted during a COMPTUEX.	ASW 2,3,4; HF1; MF1,2,3,4,5,12	5
Non-Impulsive	ASW for Joint Task Force Exercise (JTFEX)/Sustainment Exercise (SUSTAINEX)	Anti-Submarine Warfare activities conducted during a JTFEX/SUSTAINEX.	ASW2,3,4; HF1; MF1,2,3,4,5,12	4
Mine Warfare (MIW)				
Non-Impulsive	Mine Countermeasures Exercise (MCM) - Ship Sonar	Littoral combat ship crews detect and avoid mines while navigating restricted areas or channels using active sonar.	HF4	116
Non-Impulsive	Mine Countermeasures - Mine Detection	Ship crews and helicopter aircrews detect mines using towed and laser mine detection systems (e.g., AN/AQS-20, ALMDS).	HF4	2,538
Non-Impulsive	Coordinated Unit Level Helicopter Airborne Mine Countermeasure Exercises	Helicopters aircrew members train as a squadron in the use of airborne mine countermeasures, such as towed mine detection and neutralization systems.	HF4	8
Non-Impulsive	Civilian Port Defense	Maritime security operations for military and civilian ports and harbors. ~~Only the sonar portion of this activity is analyzed in this document.~~ Marine mammal systems may be used during the exercise.	HF4	1 event every other year
Other Training Activities				
Non-Impulsive	Submarine Navigational (SUB NAV)	Submarine crews locate underwater objects and ships while transiting in and out of port.	HF1; MF3	282

Table 1-6. Training Activities within the Study Area (Continued)

Stressor	Training Event	Description	Source Class	Number of Events per Year
Non-Impulsive	Submarine Navigation Under Ice Certification	Submarine crews train to operate under ice. During training and certification other submarines and ships simulate ice.	HF1	24
Non-Impulsive	Surface Ship Object Detection	Surface ship crews locate underwater objects that may impede transit in and out of port.	MF1K; MF2K	144
Non-Impulsive	Surface Ship Sonar Maintenance	Pierside and at-sea maintenance of sonar systems.	MF1,2	824
Non-Impulsive	Submarine Sonar Maintenance	Pierside and at-sea maintenance of sonar systems.	MF3	220
Amphibious Warfare (AMW)				
Impulsive	Naval Surface Fire Support Exercise - At Sea (FIREX [At Sea])	Surface ship crews use large-caliber guns to support forces ashore; however, the land target is simulated at sea. Rounds impact the water and are scored by passive acoustic hydrophones located at or near the target area.	E5	50
Anti-Surface Warfare (ASUW)				
Impulsive	Maritime Security Operations (MSO) - Anti-swimmer Grenades	Helicopter and surface ship crews conduct a suite of Maritime Security Operations (e.g., Visit, Board, Search, and Seizure; Maritime Interdiction Operations; Force Protection; and Anti-Piracy Operation).	E2	12
Impulsive	Gunnery Exercise (Surface-to-Surface) (Ship) – Medium-Caliber (GUNEX [S-S] – Ship)	Ship crews engage surface targets with ship's medium-caliber guns.	E1; E2	827
Impulsive	Gunnery Exercise (Surface-to-Surface) (Ship) – Large-Caliber (GUNEX [S-S] – Ship)	Ship crews engage surface targets with ship's large-caliber guns.	E3; E5	294
Impulsive	Gunnery Exercise (Surface-to-Surface) (Boat) (GUNEX [S-S] – Boat)	Small boat crews engage surface targets with small and medium-caliber guns.	E1; E2	434

Table 1-6. Training Activities within the Study Area (Continued)

Stressor	Training Event	Description	Source Class	Number of Events per Year
Impulsive	Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	Surface ship crews defend against threat missiles and other surface ships with missiles.	E10	20
Impulsive	Gunnery Exercise (Air-to-Surface) (GUNEX [A-S])	Fixed-wing and helicopter aircrews, including embarked personnel, use small and medium-caliber guns to engage surface targets.	E1; E2	715
Impulsive	Missile Exercise (Air-to-Surface) - Rocket (MISSILEX [A-S])	Fixed-wing and helicopter aircrews fire both precision-guided missiles and unguided rockets against surface targets.	E5	210
Impulsive	Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing and helicopter aircrews fire both precision-guided missiles and unguided rockets against surface targets.	E6; E8	248
Impulsive	Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircrews deliver bombs against surface targets.	E8; E9; E10; E12	930
Impulsive	Sinking Exercise (SINKEX)	Aircraft, ship, and submarine crews deliver ordnance on a seaborne target, usually a deactivated ship, which is deliberately sunk using multiple weapon systems.	E3; E5; E8; E9; E10;E11;E12	1
Anti-Submarine Warfare (ASW)				
Impulsive	Tracking Exercise - Maritime Patrol Aircraft Extended Echo Ranging Sonobuoy (TRACKEX – MPA sonobuoy)	Maritime patrol aircraft crews search, detect, and track submarines with extended echo ranging sonobuoys. Recoverable air launched torpedoes may be employed against submarine targets.	E4	160
Impulsive	Group Sail	Multiple ships and helicopters integrate the use of sensors, including sonobuoys, to search, detect and track a threat submarine. Group sails are not dedicated ASW events and involve multiple warfare areas.	E4	20

Table 1-6. Training Activities within the Study Area (Continued)

Stressor	Training Event	Description	Source Class	Number of Events per Year
Impulsive	ASW for Composite Training Unit Exercise (COMPTUEX)	Anti-Submarine Warfare activities conducted during a COMPTUEX.	E4	4
Impulsive	ASW for Joint Task Force Exercise (JTFEX)/Sustainment Exercise (SUSTAINEX)	Anti-Submarine Warfare activities conducted during a JTFEX/SUSTAINEX.	E4	4
Mine Warfare (MIW)				
Impulsive	Explosive Ordnance Disposal (EOD)/Mine Neutralization	Personnel disable threat mines. Explosive charges may be used.	E1; E4; E5; E6; E7; E8	618
Impulsive	Mine Countermeasures - Mine Neutralization – Remotely Operated Vehicles	Ship crews and helicopter aircrews disable mines using remotely operated underwater vehicles.	E4	508
Impulsive	Civilian Port Defense	Maritime security operations for military and civilian ports and harbors. ~~Only the sonar portion of this activity is analyzed in this document.~~ Marine mammal systems may be used during the exercise.	E2; E4	1 event every other year
Pile Driving and Pile Removal				
Impulsive	Elevated Causeway System (ELCAS)	A temporary pier is constructed off the beach. Supporting pilings are driven into the sand and then later removed. The Elevated Causeway System is a portion of a larger activity Joint Logistics Over the Shore (JLOTS) which is covered under separate documentation. Construction would involve intermittent impact pile driving of 24-inch, uncapped, steel pipe piles over approximately 2 weeks. Crews work 24 hours a day and can drive approximately 8 piles in that period. Each pile takes about 10 minutes to drive. When training events that use the elevated causeway system are complete, the piles would be removed using vibratory methods over approximately 6 days. Crews can remove about 14 piles per 24-hour period, each taking about 6 minutes to remove.		1

1.6.3 Testing

The testing activities that the Navy proposes to conduct in the Study Area are described in Table 1-7 and Table 1-8.

Table 1-7. Naval Air Systems Command Testing Activities within the Study Area

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Anti-Submarine Warfare (ASW)				
Non-Impulsive	Anti-Submarine Warfare Torpedo Test	This event is similar to the training event Torpedo Exercise. The test evaluates anti-submarine warfare systems onboard rotary wing and fixed wing aircraft and the ability to search for, detect, classify, localize, and track a submarine or similar target.	TORP1	242
Non-Impulsive	Kilo Dip	A kilo dip is the operational term used to describe a functional check of a helicopter deployed dipping sonar system. The sonar system is briefly activated to ensure all systems are functional. A kilo dip is simply a precursor to more comprehensive testing.	MF4	43
Non-Impulsive	Sonobuoy Lot Acceptance Test	Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a lot, or group, of sonobuoys in advance of delivery to the Fleet for operational use.	ASW2; MF5,6	39
Non-Impulsive	ASW Tracking Test—Helicopter	This event is similar to the training event anti-submarine warfare Tracking Exercise - Helicopter. The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking systems perform to specifications.	MF4,5	428

Table 1-7. Naval Air Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Non-Impulsive	ASW Tracking Test—Maritime Patrol Aircraft	This event is similar to the training event anti-submarine warfare Tracking Exercise - 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.	ASW2; MF5,6	75
Mine Warfare (MIW)				
Non-Impulsive	Airborne Towed Minehunting Sonar System Test	Tests of the Airborne Towed Minehunting Sonar System to evaluate the search capabilities of this towed, mine hunting, detection, and classification system. The sonar on the Airborne Towed Minehunting Sonar System identifies mine-like objects in the deeper parts of the water column.	HF4	155
Anti-Surface Warfare (ASUW)				
Impulsive	Air to Surface Missile Test	This event is similar to the training event Missile Exercise Air to Surface. Test may involve both fixed wing and rotary wing aircraft launching missiles at surface maritime targets to evaluate the weapons system or as part of another systems integration test.	E6; E10	239
Impulsive	Air to Surface Gunnery Test	This event is similar to the training event Gunnery Exercise Air to Surface. Strike fighter and helicopter aircrews evaluate new or enhanced aircraft guns against surface maritime targets to test that the gun, gun ammunition, or associated systems meet required specifications or to train aircrew in the operation of a new or enhanced weapons system.	E1	165

Table 1-7. Naval Air Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Impulsive	Rocket Test	Rocket testing evaluates the integration, accuracy, performance, and safe separation of laser-guided and unguided 2.75-in rockets fired from a hovering or forward flying helicopter or from a fixed wing strike aircraft.	E5	332
Anti-Submarine Warfare (ASW)				
Impulsive	Sonobuoy Lot Acceptance Test	Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a lot, or group, of sonobuoys in advance of delivery to the Fleet for operational use.	E3; E4	39
Impulsive	ASW Tracking Test—Helicopter	This event is similar to the training event anti-submarine warfare Tracking Exercise - Helicopter. The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking systems perform to specifications.	E3	428
Impulsive	ASW Tracking Test—Maritime Patrol Aircraft	This event is similar to the training event anti-submarine warfare Tracking Exercise - 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.	E3; E4	75
Mine Warfare (MIW)				
Impulsive	Airborne Mine Neutralization System Test	Airborne mine neutralization tests evaluate the system's ability to detect and destroy mines. The Airborne Mine Neutralization System Test uses up to four unmanned underwater vehicles equipped with HF sonar, video cameras, and explosive neutralizers.	E4; E11	165

Table 1-7. Naval Air Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Impulsive	Airborne Projectile-based Mine Clearance System	An MH-60S helicopter uses a laser-based detection system to search for mines and to fix mine locations for neutralization with an airborne projectile-based mine clearance system. The system neutralizes mines by firing a small or medium-caliber inert, supercavitating projectile from a hovering helicopter.	E11	237
Impulsive	Airborne Towed Minesweeping Test	Tests of the Airborne Towed Minesweeping System would be conducted by a MH-60S helicopter to evaluate the functionality of the system and the MH-60S at sea. The system is towed from a forward flying helicopter and works by emitting an electromagnetic field and mechanically generated underwater sound to simulate the presence of a ship. The sound and electromagnetic signature cause nearby mines to explode.	E11	72

Table 1-8. Naval Sea Systems Command Testing Activities within the Study Area

Stressor	Testing Event	Description	Source Class	Number of Events per Year
New Ship Construction				
Non-Impulsive	Surface Combatant Sea Trials - Pierside Sonar Testing	Tests ship's sonar systems pierside to ensure proper operation.	MF1,9,10; MF1K	12
Non-Impulsive	Surface Combatant Sea Trials - Anti-Submarine Warfare Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance and communications systems.	ASW3; MF 1,9,10; MF1K	10
Non-Impulsive	Submarine Sea Trials - Pierside Sonar Testing	Tests ship's sonar systems pierside to ensure proper operation.	M3; HF1; MF3,10	6

Table 1-8. Naval Sea Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Non-Impulsive	Submarine Sea Trials - Anti-Submarine Warfare Testing	Submarines demonstrate capability of underwater surveillance and communications systems.	M3; HF1; MF3,10	12
Non-Impulsive	Anti-submarine Warfare Mission Package Testing	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.	ASW1,3; MF4,5,12; TORP1	24
Non-Impulsive	Mine Countermeasure Mission Package Testing	Ships conduct mine countermeasure operations.	HF4	8
Life Cycle Activities				
Non-Impulsive	Surface Ship Sonar Testing/ Maintenance	Pierside and at-sea testing of ship systems occurs periodically following major maintenance periods and for routine maintenance.	ASW3; MF1, 9,10; MF1K	16
Non-Impulsive	Submarine Sonar Testing/ Maintenance	Pierside and at-sea testing of submarine systems occurs periodically following major maintenance periods and for routine maintenance.	HF1,3; M3; MF3	28
Non-Impulsive	Combat System Ship Qualification Trial (CSSQT) – In-port Maintenance Period	All combat systems are tested to ensure they are functioning in a technically acceptable manner and are operationally ready to support at-sea CSSQT events.	MF1	12
Non-Impulsive	Combat System Ship Qualification Trial (CSSQT) – Undersea Warfare (USW)	Tests ships ability to track and defend against undersea targets.	HF4; MF1,2,4,5; TORP1	9
NAVSEA Range Activities				
Naval Surface Warfare Center, Panama City Division (NSWC PCD)				
Non-Impulsive	Unmanned Underwater Vehicles Demonstration	Testing and demonstrations of multiple Unmanned Underwater Vehicles and associated acoustic, optical, and magnetic systems.	HF5,6,7; LF5; FLS2; MF9; SAS2	1 per 5 year period
Non-Impulsive	Mine Detection and Classification Testing	Air, surface, and subsurface vessels detect and classify mines and mine-like objects.	HF1,4; MF1K; SAS2	81

Table 1-8. Naval Sea Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Non-Impulsive	Stationary Source Testing	Stationary equipment (including swimmer defense systems) is deployed to determine functionality.	LF4; MF8; SD1,2	11
Non-Impulsive	Special Warfare Testing	Testing of submersibles capable of inserting and extracting personnel and/or payloads into denied areas from strategic distances.	MF9	110
Non-Impulsive	Unmanned Underwater Vehicle Testing	Unmanned Underwater Vehicles are deployed to evaluate hydrodynamic parameters, to full mission, multiple vehicle functionality assessments.	FLS2; HF 5,6,7; LF5; MF9; SAS2	88
Naval Undersea Warfare Center Division, Newport (NUWCDIVNPT)				
Non-Impulsive	Torpedo Testing	Non-explosive torpedoes are launched to record operational data. All torpedoes are recovered.	TORP1; TORP2	30
Non-Impulsive	Towed Equipment Testing	Surface vessel or Unmanned Underwater Vehicle deploys equipment to determine functionality of towed systems.	LF4; MF9; SAS1	33
Non-Impulsive	Unmanned Underwater Vehicle Testing	Unmanned Underwater Vehicles are deployed to evaluate hydrodynamic parameters, to full mission, multiple vehicle functionality assessments.	HF6,7; LF5; MF10; SAS2	123
Non-Impulsive	Semi-Stationary Equipment Testing	Semi-stationary equipment (e.g., hydrophones) is deployed to determine functionality.	ASW3,4; HF 5,6; LF 4,5; MF9,10	154
Non-Impulsive	Unmanned Underwater Vehicle Demonstrations	Testing and demonstrations of multiple Unmanned Underwater Vehicles and associated acoustic, optical, and magnetic systems.	FLS2; HF5,6,7; LF5; MF9; SAS2	1 per 5 year period

Table 1-8. Naval Sea Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Non-Impulsive	Pierside Integrated Swimmer Defense Testing	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and defend against swimmer/diver threats in harbor environments.	LF4; MF8; SD1	6
South Florida Ocean Measurement Facility (SFOMF)				
Non-Impulsive	Signature Analysis Activities	Testing of electromagnetic, acoustic, optical, and radar signature measurements of surface ship and submarine.	ASW2; HF1,6; LF4; M3; MF9	18
Non-Impulsive	Mine Testing	Air, surface, and sub-surface systems detect, counter, and neutralize ocean-deployed mines.	HF4	33
Non-Impulsive	Surface Testing	Various surface vessels, moored equipment and materials are testing to evaluate performance in the marine environment.	FLS2; HF5,6,7;LF5;MF9; SAS2	33
Non-Impulsive	Unmanned Underwater Vehicles Demonstrations	Testing and demonstrations of multiple Unmanned Underwater Vehicles and associated acoustic, optical, and magnetic systems.	FLS2; HF5,6,7; LF5; MF9; SAS2	1 per 5 year period
Additional Activities at Locations Outside of NAVSEA Ranges				
Anti-Surface Warfare (ASUW) / Anti-Submarine Warfare (ASW) Testing				
Non-Impulsive	Torpedo (Non-explosive) Testing	Air, surface, or submarine crews employ inert torpedoes against submarines or surface vessels. All torpedoes are recovered.	ASW3,4; HF1; M3; MF1,3,4,5; TORP1,2	26
Non-Impulsive	Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive torpedoes against artificial targets or deactivated ships.	TORP1; TORP2	2
Non-Impulsive	Countermeasure Testing	Towed sonar arrays and anti-torpedo torpedo systems are employed to detect and neutralize incoming weapons	ASW3; HF5; TORP 1,2	3

Table 1-8. Naval Sea Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Non-Impulsive	Pierside Sonar Testing	Pierside testing to ensure systems are fully functional in a controlled pierside environment prior to at-sea test activities.	ASW3; HF1,3; M3; MF1,3	23
Non-Impulsive	At-sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment.	ASW4; HF1; M3; MF3	15
Mine Warfare (MIW) Testing				
Non-Impulsive	Mine Detection and Classification Testing	Air, surface, and subsurface vessels detect and classify mines and mine-like objects.	HF4	66
Non-Impulsive	Mine Countermeasure / Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines that would otherwise restrict passage through an area.	HF4; M3	14
Shipboard Protection Systems and Swimmer Defense Testing				
Non-Impulsive	Pierside Integrated Swimmer Defense Testing	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and defend against swimmer/diver threats in harbor environments.	LF4; MF8; SD1	3
Unmanned Vehicle Testing				
Non-Impulsive	Unmanned Vehicle Development and Payload Testing	Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads used for different purposes.	MF9; SAS2	111
Other Testing Activities				
Non-Impulsive	Special Warfare Testing	Special warfare includes testing of submersibles capable of inserting and extracting personnel and/or payloads into denied areas from strategic distances.	HF1; M3; MF9	4

Table 1-8. Naval Sea Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Ship Construction and Maintenance				
New Ship Construction				
Impulsive	Aircraft Carrier Sea Trials - Gun Testing – Medium-Caliber	Medium-caliber gun systems are tested using non-explosive and explosive rounds.	E1	410
Impulsive	Surface Warfare Mission Package – Gun Testing- Medium Caliber	Ships defense against surface targets with medium-caliber guns	E1	5
Impulsive	Surface Warfare Mission Package – Gun Testing- Large Caliber	Ships defense against surface targets with large-caliber guns	E3	5
Impulsive	Surface Warfare Mission Package - Missile/Rocket Testing	Ships defense against surface targets with medium range missiles or rockets	E6	15
Impulsive	Mine Countermeasure Mission Package Testing	Ships conduct mine countermeasure operations.	E4	8
Ship Shock Trials				
Impulsive	Aircraft Carrier Full Ship Shock Trial	Explosives are detonated underwater against surface ships.	E17	1 per 5 year period
Impulsive	DDG 1000 Zumwalt Class Destroyer Full Ship Shock Trial	Explosives are detonated underwater against surface ships.	E16	1 per 5 year period
Impulsive	Littoral Combat Ship Full Ship Shock Trial	Explosives are detonated underwater against surface ships.	E16	2 per 5 year period
NAVSEA Range Activities				
Naval Surface Warfare Center, Panama City Division (NSWC PCD)				
Impulsive	Mine Countermeasure / Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines and mine-like objects.	E4	15
Impulsive	Ordnance Testing	Airborne and surface crews defend against surface targets with small-, medium-, and large-caliber guns, as well as line charge testing.	E5; E14	37

Table 1-8. Naval Sea Systems Command Testing Activities within the Study Area (Continued)

Stressor	Testing Event	Description	Source Class	Number of Events per Year
Additional Activities at Locations Outside of NAVSEA Ranges				
Anti-Surface Warfare (ASUW) / Anti-Submarine Warfare (ASW) Testing				
Impulsive	Torpedo (Explosive) Testing	Air, surface, or submarine crews employ explosive torpedoes against artificial targets or deactivated ships.	E8; E11	2
Mine Warfare (MIW) Testing				
Impulsive	Mine Countermeasure / Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines that would otherwise restrict passage through an area.	E4; E8	14
Other Testing Activities				
Impulsive	At-Sea Explosives Testing	Explosives are detonated at sea.	E5	4

1.6.4 Other Stressors – Vessel Strikes

Vessels strikes may occur from surface operations and sub-surface operations (excluding bottom crawling, unmanned underwater vehicles). Vessels used as part of the Proposed Action include ships, submarines and boats ranging in size from small, 22 ft. (7 m) rigid hull inflatable boats to aircraft carriers with lengths up to 1,092 ft. (333 m). Representative Navy vessel types, lengths, and speeds used in both training and testing activities are shown in Table 1-9.

Large Navy ships greater than 60 ft. (18 m) generally operate at speeds in the range of 10 to 15 knots for fuel conservation. Submarines generally operate at speeds in the range of 8 to 13 knots in transits and less than those speeds for certain tactical maneuvers. Small craft (for purposes of this discussion – less than 60 feet [18 meters] 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 vessel group 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. Additionally, there are specific events including high speed tests of newly constructed vessels including aircraft carriers, amphibious assault ships and the Joint High Speed Vessel (which will operate at an average speed of 35 knots). High speed ferries may also be used to support Navy testing in Narragansett Bay.

The number of Navy vessels used in the Study Area varies based on military training requirements, deployment schedules, annual budgets, and other unpredictable factors. Most training and testing activities involve the use of vessels. These activities could be widely dispersed throughout the Study

Area, but would be more concentrated 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 2 weeks.

Navy vessel traffic would especially be concentrated near Naval Station Norfolk in Norfolk, Virginia, and Naval Station Mayport in Jacksonville, Florida. There is no seasonal differentiation in Navy vessel use. Large vessel movement primarily occurs with the majority of the traffic flowing in a direct line between Naval Stations Norfolk and Mayport. The direct route the Navy predominantly uses between Norfolk and Jacksonville avoids a good portion of the coastal North Atlantic right whale migratory corridor and critical habitat, especially off the coasts of South Carolina and Georgia. There would be a higher likelihood of vessel strikes over the continental shelf portions than in the open ocean portions of the Study Area because of the concentration of vessel movements in those areas. Support craft would be more concentrated in the coastal areas in the areas of naval installations, ports and ranges.

The number of activities that include the use of vessels for testing events is comparatively lower (around 10 percent) than the number of training activities. In addition, testing often occurs jointly with a training event so it is likely that the testing activity would be conducted from a training vessel. Vessel movement in conjunction with testing activities could be widely dispersed throughout the Study Area, but would be concentrated near naval ports, piers, range complexes and especially the testing ranges in the Northeast Range Complexes, off south Florida and in the Gulf of Mexico. There would be a higher likelihood of vessel strikes over in these portions of the Study Area because of the concentration of vessel movement in those areas.

Propulsion testing events, also referred to as high-speed vessel trials, occur infrequently, but pose a higher strike risk because of the high-speeds at which the vessels need to transit to complete the testing activity. These activities would most often occur in the GOMEX Range Complex, but may also occur in the Northeast, VACAPES, and JAX Range Complexes.

Additionally, a variety of smaller craft will be operated within the Study Area. Small craft types, sizes and speeds vary. These events would be spread across the large marine ecosystems and open ocean areas designated within the Study Area. During training, 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.

Table 1-9. Typical Navy Boat and Vessel Types with Length Greater than 18 Meters Used within the Study Area

Vessel Type (>18 m)	**Example(s)** (specifications in meters (m) for length, metric tons (mt) for mass, and knots for speed)	**Typical Operating Speed** (knots)
Aircraft Carrier	**Aircraft Carrier (CVN)** length: 333 m beam: 41 m draft: 12 m displacement: 81,284 mt max. speed: 30+ knots	10 to 15
Surface Combatants	**Cruiser (CG)** length: 173 m beam: 17 m draft: 10 m displacement: 9,754 mt max. speed: 30+ knots **Destroyer (DDG)** length: 155 m beam: 18 m draft: 9 m displacement: 9,648 mt max. speed: 30+ knots **Frigate (FFG)** length: 136 m beam: 14 m draft: 7 m displacement: 4,166 mt max. speed: 30+ knots **Littoral Combat Ship (LCS)** length: 115 m beam: 18 m draft: 4 m displacement: 3,000 mt max. speed: 40+ knots	10 to 15
Amphibious Warfare Ships	**Amphibious Assault Ship (LHA, LHD)** length: 253 m beam: 32 m draft: 8 m displacement: 42,442 mt max. speed: 20+knots **Amphibious Transport Dock (LPD)** length: 208 m beam: 32 m draft: 7 m displacement: 25,997 mt max. speed: 20+knots **Dock Landing Ship (LSD)** length: 186 m beam: 26 m draft: 6 m displacement: 16,976 mt max. speed: 20+knots	10 to 15
Mine Warship Ship	**Mine Countermeasures Ship (MCM)** length: 68 m beam: 12 m draft: 4 m displacement: 1,333 max. speed: 14 knots	5 to 8
Submarines	**Attack Submarine (SSN)** length: 115 m beam: 12 m draft: 9 m displacement: 12,353 mt max. speed: 20+knots **Guided Missile Submarine (SSGN)** length: 171 m beam: 13 m draft: 12 m displacement: 19,000 mt max. speed: 20+knots	8 to 13
Combat Logistics Force Ships	**Fast Combat Support Ship (T-AOE)** length: 230 m beam: 33 m draft: 12 m displacement: 49,583 max. speed: 25 knots **Dry Cargo/Ammunition Ship (T-AKE)** length: 210 m beam: 32 m draft: 9 m displacement: 41,658 mt max speed: 20 knots **Fleet Replenishment Oilers (T-AO)** length: 206 m beam: 30 m draft: 11 displacement: 42,674 mt max. speed: 20 knots **Fleet Ocean Tugs (T-ATF)** length: 69 m beam: 13 m draft: 5 m displacement: 2,297 max. speed: 14 knots	8 to 12
Support Craft/Other	**Landing Craft, Utility (LCU)** length: 41m beam: 9 m draft: 2 m displacement: 381 mt max. speed: 11 knots **Landing Craft, Mechanized (LCM)** length: 23 m beam: 6 m draft: 1 m displacement: 107 mt max. speed: 11 knots	3 to 5
Support Craft/Other Specialized High Speed	**MK V Special Operations Craft** length: 25 m beam: 5 m displacement: 52 mt max. speed: 50 knots	Variable

2 DURATION AND LOCATION OF ACTIVITIES

Training and testing activities would be conducted in the Study Area throughout the year from 22 January 2014 through 21 January 2019. The Study Area is in the western Atlantic Ocean and encompasses the east coast of North America and the Gulf of Mexico. The Study Area starts seaward from the mean high water line east to the 45-degree west longitude line, north to the 65-degree north latitude line, and south to approximately the 20-degree north latitude line. The Study Area generally follows the United States Navy Commander Task Force 20 area of responsibility, covering approximately 2.6 million square nautical miles (nm^2) of ocean area, and includes designated Navy operating areas (OPAREAs) and special use airspace. Navy pierside locations and port transit channels where sonar maintenance and testing occur, and bays and civilian ports where training occurs are also included in the Study Area.

The Study Area also includes several Navy testing ranges and range complexes. A range complex is a designated set of specifically bounded geographic areas and encompasses a water component (above and below the surface), airspace and may encompass a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occur. Range complexes include established OPAREAS and special use airspace, which may be further divided to provide better control of the area and events being conducted for safety reasons.

- **OPAREA**. An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace. OPAREAs include the following:
    - **Danger Zones**. A danger zone is a defined water area used for target practice, bombing, rocket firing or other especially hazardous military activities. Danger zones are established pursuant to statutory authority of the Secretary of the Army and are administered by the U.S. Army Corps of Engineers. Danger zones may be closed to the public on a full-time or intermittent basis (33 Code of Federal Regulations [CFR] 334).
    - **Restricted Areas.** A restricted area is a defined water area for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for Government property and also provide protection to the public from the risks of damage or injury arising from the government's use of that area (33 Code of Federal Regulations (CFR) 334).

- **Special Use Airspace**. Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8). Types of special use airspace most commonly found in range complexes include the following:
    - **Restricted Areas.** Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense (DoD) and some are shared with non-military agencies.
    - **Military Operations Areas.** Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training and testing activities from instrument flight rules traffic and to identify visual flight rules traffic where these activities are conducted.

- **Warning Area.** Areas of defined dimensions, extending from 3 nm outward from the coast of the United States, which serve to warn non-participating aircraft of potential danger.
- **Air Traffic Control Assigned Airspace.** Airspace of defined vertical/lateral limits, assigned by Air Traffic Control, for the purpose of providing air traffic segregation between the specified activity being conducted within the assigned airspace and other instrument flight rules traffic.

The Study Area includes only the at-sea components of the range complexes and testing ranges. The Study Area also includes Narragansett Bay, lower Chesapeake Bay, St. Andrew Bay, and pierside locations. The remaining inland waters and land-based portions of the range complexes are not a part of the Study Area and will be or already have been addressed under separate National Environmental Policy Act (NEPA) documentation. Some training and testing occurs outside the OPAREAs (i.e., some activities are conducted seaward of the OPAREAs, and a limited amount of active sonar is used shoreward of the OPAREAs at and in transit to and from Navy piers). The Study Area is depicted in Figure 1-1. Regional maps (Figures 2-1, 2-2, and 2-2) are provided for additional detail of the range complexes and testing ranges.

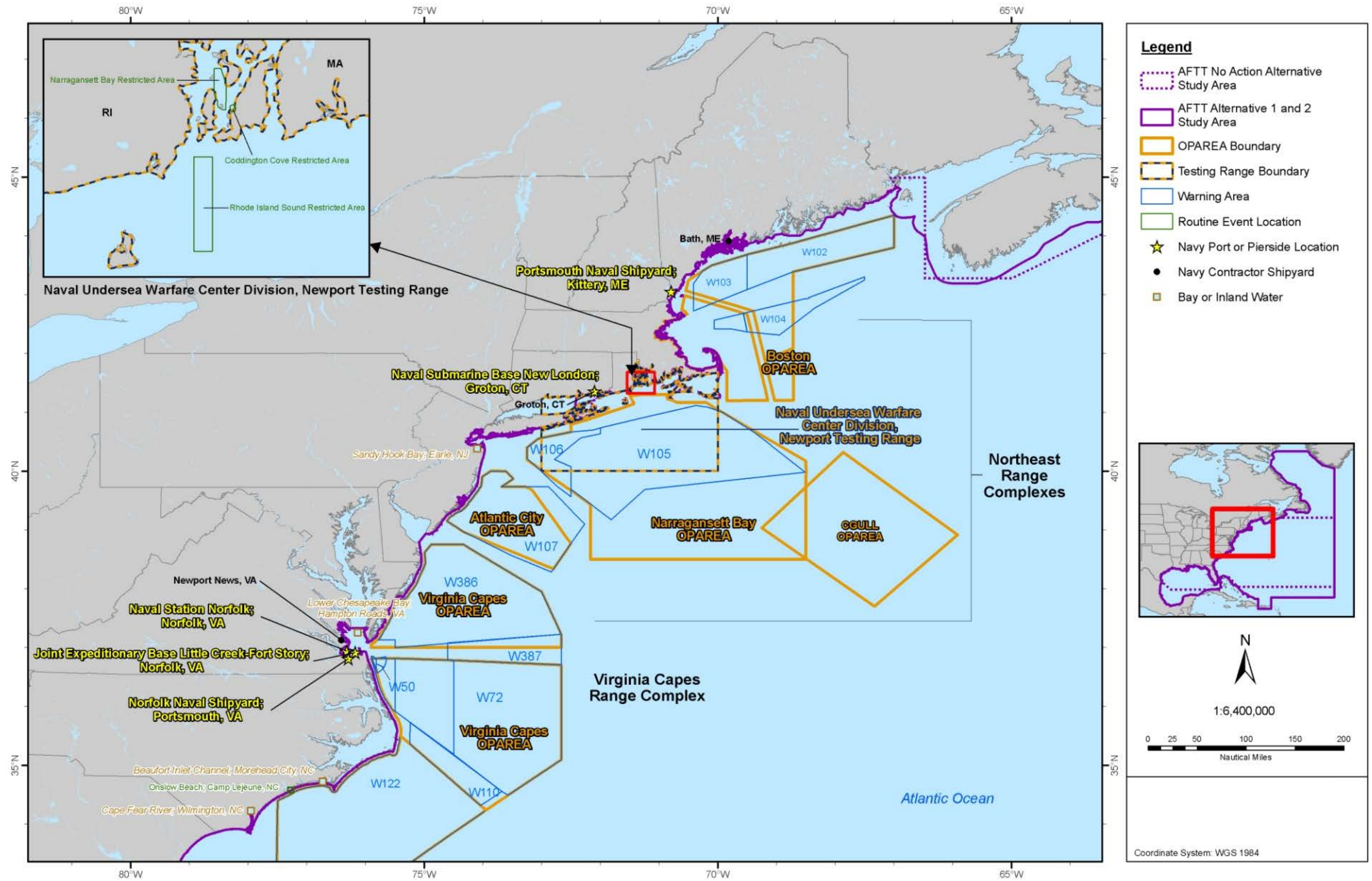


Figure 2-1. AFTT Study Area, Northeast Region

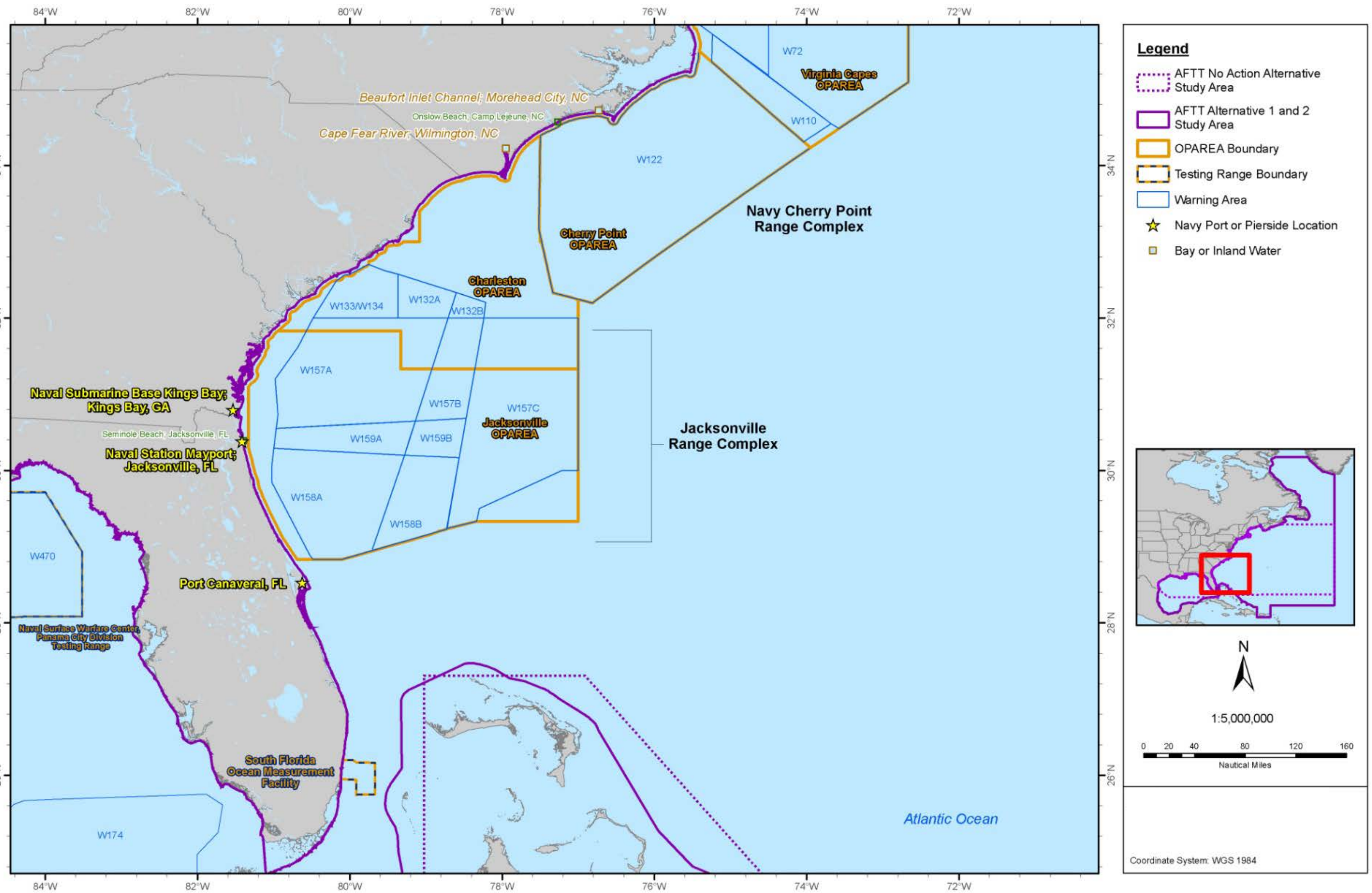


Figure 2-2. AFTT Study Area, Southeast Region

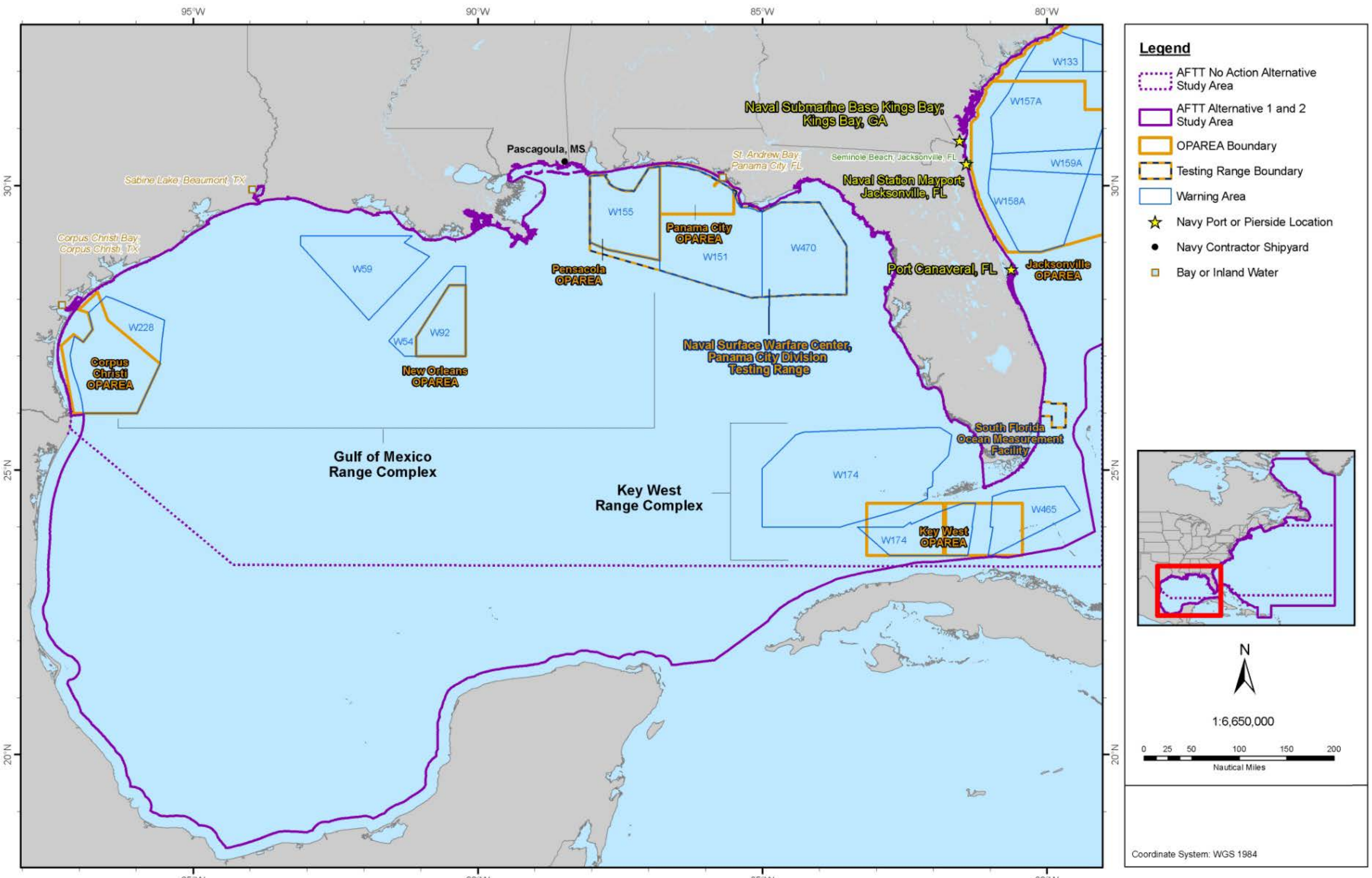


Figure 2-3. AFTT Study Area, Gulf of Mexico Region

2.1 NORTHEAST RANGE COMPLEXES

The three range complexes Boston Range Complex, Narragansett Bay Range Complex and Atlantic City Range Complex are collectively referred to as the Northeast Range Complexes (Figure 2-1). These range complexes span 761 miles (mi.) (1,225 km) along the coast from Maine to New Jersey. The Northeast Range Complexes include 30,930 nm^2 of special use airspace with associated warning areas and 45,619 nm^2 of surface and subsurface sea space of the Boston OPAREA, Narragansett Bay OPAREA, and Atlantic City OPAREA. The OPAREAs of the three complexes are outside 3 nm but within 200 nm from shore. For purposes of this document, the CGULL testing area is considered an OPAREA and part of the Northeast Range Complexes and includes 22,525 nm^2 of sea space.

2.2 NAVAL UNDERSEA WARFARE CENTER DIVISION, NEWPORT TESTING RANGE

The Naval Undersea Warfare Center Division, Newport (NUWCDIVNPT) Testing Range includes the waters of Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, and Long Island Sound (Figure 2-1). Three restricted areas are located within the area of the Naval Undersea Warfare Center Division, Newport Testing Range:

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

2.3 VIRGINIA CAPES RANGE COMPLEX

The Virginia Capes (VACAPES) Range Complex spans 270 miles (434.5 km) along the coast from Delaware to North Carolina from the shoreline to 155 nm seaward (Figure 2-1). The VACAPES Range Complex also includes established mine warfare training areas located within the lower Chesapeake Bay and off the coast of Virginia. The VACAPES Range Complex shore boundary roughly follows the shoreline from Delaware to North Carolina; the seaward boundary extends out 155 nm into the Atlantic Ocean proximate to Norfolk, Virginia. The VACAPES Range Complex includes 28,672 nm^2 of special use airspace overlying the VACAPES OPAREA. The VACAPES OPAREA encompasses 27,661 nm^2 of sea space and undersea space.

2.4 NAVY CHERRY POINT RANGE COMPLEX

The Navy Cherry Point Range Complex, off the coast of North Carolina, encompasses the sea space from the shoreline to 120 nm seaward (Figure 2-2). The Navy Cherry Point Range Complex is adjacent to the United States Marine Corps Cherry Point and Camp Lejeune Range Complexes associated with Marine Corps Air Station Cherry Point and Marine Corps Base Camp Lejeune. The Navy Cherry Point Range Complex is roughly aligned with the shoreline and extends out 120 nm into the Atlantic Ocean. The Navy Cherry Point Range Complex includes 18,966 nm^2 of special use airspace overlying the Cherry Point OPAREA. The Navy Cherry Point OPAREA encompasses 18,617 nm^2 of sea space and undersea space.

2.5 JACKSONVILLE RANGE COMPLEX

The Jacksonville (JAX) Range Complex spans 520 mi. along the coast from North Carolina to Florida from the shoreline to 250 nm seaward (Figure 2-2). The Undersea Warfare Training Range is located within the JAX Range Complex. The JAX Range Complex shore boundary roughly follows the shoreline and extends out 250 nm into the Atlantic Ocean proximate to Jacksonville, Florida. The JAX Range Complex includes approximately 50,068 nm^2 of special use airspace overlying the Charleston and Jacksonville OPAREAs. The JAX Range Complex includes two OPAREAs: Charleston and Jacksonville. Combined, these OPAREAs encompass 50,090 nm^2 of sea space and undersea space.

2.6 NAVAL SURFACE WARFARE CENTER CARDEROCK DIVISION, SOUTH FLORIDA OCEAN MEASUREMENT FACILITY TESTING RANGE

The Naval Surface Warfare Center Carderock Division operates the South Florida Ocean Measurement Facility, an offshore testing area in support of various Navy and non-Navy programs. The South Florida Ocean Measurement Facility Testing Range is located adjacent to the Port Everglades entrance channel in Fort Lauderdale, Florida (Figure 2-2). The test area at South Florida Ocean Measurement Facility includes an extensive cable field located within a restricted anchorage area, and two designated submarine operating areas. The South Florida Ocean Measurement Facility Testing Range does not include identified special use airspace. The airspace adjacent to South Florida Ocean Measurement Facility Testing Range is managed by the Fort Lauderdale International Airport. South Florida Ocean Measurement Facility Testing Range is divided into four subareas:

- The Port Everglades Shallow Submarine Operating Area is a 120-nm^2 area that encompasses nearshore waters from the shoreline to 900 ft. (274 m) deep and 8 nm offshore.
- The Notice of Intent Temporary Use Area is a 41-nm^2 area used for special purpose surface vessel and submarine operations where the test vessels are restricted from maneuvering and require additional protection. This Notice of Intent Temporary Use Area encompasses waters from 60 to 600 ft. (18 to 183 m) deep and from 1 to 3 mi. (1.6 to 4.8 km) offshore.
- The Port Everglades Deep Submarine Operating Area is a 335-nm^2 area that encompasses the offshore range from 900 to 2500 ft. (274 to 762 m) in depth and from 9 to 25 nm offshore.
- The Port Everglades Restricted Anchorage Area is an 11 nm^2 restricted anchorage area ranging in depths from 60 to 600 ft. (18 to 183m) where the majority of the South Florida Ocean Measurement Facility cables run from offshore sensors to the shore facility and where several permanent measurement arrays are used for vessel signature acquisition.

2.7 KEY WEST RANGE COMPLEX

The Key West Range Complex lies off the southwestern coast of mainland Florida and along the southern Florida Keys, extending seaward into the Gulf of Mexico 150 nm and south into the Straits of Florida 60 nm (Figure 2-3). The Key West Range Complex includes approximately 20,647 nm^2 of special use airspace overlying and north of the Key West OPAREA. The Key West OPAREA is 8,288 nm^2 of sea space and undersea space south of Key West, Florida.

2.8 GULF OF MEXICO RANGE COMPLEX

The Gulf of Mexico (GOMEX) Range Complex contains four separate OPAREAs: Panama City, Pensacola, New Orleans, and Corpus Christi (Figure 2-3). The OPAREAs within the GOMEX Range Complex are not contiguous but are scattered throughout the Gulf of Mexico unlike the previously described range complexes. The GOMEX Range Complex includes approximately 23,651 nm^2 of special use airspace overlying the Panama City, Pensacola, New Orleans, and Corpus Christi OPAREAs and airspace north of the New Orleans OPAREA. The GOMEX Range Complex encompasses 25,753 nm^2 of sea and undersea space, and includes 285 nm of coastline. The OPAREAs span from the eastern shores of Texas to the western panhandle of Florida. They are described as follows:

- Panama City OPAREA lies off the coast of the Florida panhandle and totals 3,084 nm^2.
- Pensacola OPAREA lies off the coast of Florida west of the Panama City OPAREA and totals 4,882 nm^2.
- New Orleans OPAREA lies off the coast of Louisiana and totals 2,607 nm^2.
- Corpus Christi OPAREA lies off the coast of Texas and totals 6,867 nm^2.

2.9 Naval Surface Warfare Center, Panama City Division Testing Range

The Naval Surface Warfare Center, Panama City Division Testing Range is located off the panhandle of Florida and Alabama, extending from the shoreline to 120 nm seaward, and includes St. Andrew Bay (Figure 2-3). Special use airspace associated with Naval Surface Warfare Center, Panama City Division includes warning areas overlying and east of the Pensacola and the Panama City OPAREAs. The Naval Surface Warfare Center, Panama City Division Testing Range includes the waters of St. Andrew Bay and the sea space within the Gulf of Mexico from the mean high tide line to 120 nm offshore. The Panama City OPAREA covers 3,084 nm^2 of sea space and lies off the coast of the Florida panhandle. The Pensacola OPAREA lies off the coast of Alabama and Florida west of the Panama City OPAREA and totals 4,882 nm^2.

2.10 Bays, Harbors and Civilian Ports

The Study Area includes Narragansett Bay, the lower Chesapeake Bay and St. Andrew Bay for training and testing activities. Ports included for Civilian Port Defense training events include Earle, New Jersey; Groton, Connecticut; Norfolk, Virginia; Morehead City, North Carolina; Wilmington, North Carolina; Kings Bay, Georgia; Mayport, Florida; Beaumont, Texas; and Corpus Christi, Texas.

2.11 Pierside Locations

The Study Area includes pierside locations where Navy surface ship and submarine sonar maintenance and testing occur. For purposes of this Request for LOAs, pierside locations include channels and transit routes in ports and facilities associated with ports and shipyards. These locations in the AFTT Study Area are located at the following Navy ports and naval shipyards:

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

Navy-contractor shipyards in the following cities are also in the Study Area:

- Bath, Maine;
- Groton, Connecticut;
- Newport News, Virginia; and
- Pascagoula, Mississippi.

3 MARINE MAMMAL SPECIES AND NUMBERS

Forty-eight marine mammal species are known to occur in the Study Area, 45 of which are managed by NMFS (Table 3-1). Relevant information on their status, distribution, abundance, and ecology is presented in Chapter 4, Affected Species Status and Distribution.

Table 3-1. Marine Mammal Occurrence within the Atlantic Fleet Training and Testing Study Area

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Order Cetacea							
Suborder Mysticeti (baleen whales)							
Family Balaenidae (right whales)							
North Atlantic right whale	*Eubalaena glacialis*	Endangered, Strategic, Depleted	Western North Atlantic	361 (0) / 361	Gulf Stream, Labrador Current	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Bowhead whale	*Balaena mysticetus*	Endangered, Strategic, Depleted	West Greenland	1,230[5] / 490-2,940	Labrador Current	Newfoundland-Labrador Shelf, West Greenland Shelf	–
Family Balaenopteridae (rorquals)							
Humpback whale	*Megaptera novaeangliae*	Endangered, Strategic, Depleted	Gulf of Maine	847 (0.55) / 549	Gulf Stream, North Atlantic Gyre, Labrador Current	Gulf of Mexico, Caribbean Sea, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Minke whale	*Balaenoptera acutorostrata*		Canadian east coast	8,987 (0.32) / 6,909	Gulf Stream, North Atlantic Gyre, Labrador Current	Caribbean Sea, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Bryde's whale	*Balaenoptera brydei/edeni*		Gulf of Mexico Oceanic	15 (1.98) / 5	Gulf Stream, North Atlantic Gyre	Gulf of Mexico, Caribbean Sea, Southeast U.S. Continental Shelf	–

[1] Taxonomy follows Perrin 2009.

[2] ESA listing status. All marine mammals are protected under MMPA. Populations or stocks for which the level of direct human-caused mortality exceeds the potential biological removal level, which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the ESA within the foreseeable future, or is listed as a threatened or endangered species under the ESA, or is designated as depleted under the MMPA are considered "strategic" under MMPA.

[3] Best CV / Min is a statistic measurement used as an indicator of the accuracy of the estimate. Stock designations for the U.S. Exclusive Economic Zone and abundance estimates from 2010 Stock Assessment Report (Waring et al. 2010).

[4] Occurrence in the Study Area includes open ocean areas—Labrador Current, North Atlantic Gyre, and Gulf Stream, and coastal/shelf waters of seven Large Marine Ecosystems—Gulf of Mexico, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Caribbean Sea, Scotian Shelf, Newfoundland-Labrador Shelf, West Greenland Shelf, and inland waters of — Kennebec River, Piscataqua River, Thames River, Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, Long Island Sound, Sandy Hook Bay, Lower Chesapeake Bay, James River, Elizabeth River, Beaufort Inlet, Cape Fear River, Kings Bay, St. Johns River, Port Canaveral, St. Andrew Bay, Pascagoula River, Sabine Lake, Corpus Christi Bay, and Galveston Bay.

[5] This species occurs in the Atlantic outside of the U.S. Exclusive Economic Zone; and therefore has no associated Stock Assessment Report. See the appropriate subsections below for details of populations that may be found within the Study Area. Abundance and 95 percent confidence interval are provided by the International Whaling Commission.

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Sei whale	*Balaenoptera borealis*	Endangered, Strategic, Depleted	Nova Scotia	386 (0.85) / 208	Gulf Stream, North Atlantic Gyre, Labrador Current	Gulf of Mexico, Caribbean Sea, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Fin whale	*Balaenoptera physalus*	Endangered, Strategic, Depleted	Western North Atlantic	3,985 (0.24) / 3,269	Gulf Stream, North Atlantic Gyre, Labrador Current	Caribbean Sea, Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Blue whale	*Balaenoptera musculus*	Endangered, Strategic, Depleted	Western North Atlantic	NA / 440[6]	Gulf Stream, North Atlantic Gyre, Labrador Current	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Suborder Odontoceti (toothed whales)							
Family Physeteridae (sperm whale)							
Sperm whale	*Physeter macrocephalus*	Endangered, Strategic, Depleted	North Atlantic	4,804 (0.38) / 3,539	Gulf Stream, North Atlantic Gyre, Labrador Current	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
		Endangered, Strategic, Depleted	Gulf of Mexico Oceanic	1,665 (0.2) / 1,409	–	Gulf of Mexico	–
		Endangered, Strategic, Depleted	Puerto Rico and U.S. Virgin Islands	unknown	North Atlantic Gyre	Caribbean Sea	–

[6] Photo identification catalogue count of 440 recognizable blue whale individuals from the Gulf of St. Lawrence is considered to be a minimum population estimate for the western North Atlantic stock.

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Family Kogiidae (sperm whales)							
Pygmy sperm whale	*Kogia breviceps*	Strategic	Western North Atlantic	395 (0.4) / 285[7]	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
			Gulf of Mexico Oceanic	453(0.35) / 340[7]	–	Gulf of Mexico, Caribbean Sea	–
Dwarf sperm whale	*Kogia sima*		Western North Atlantic	395 (0.4) / 285[7]	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf	–
			Gulf of Mexico Oceanic	453(0.35) / 340[7]	–	Gulf of Mexico, Caribbean Sea	–
Family Monodontidae (beluga whale and narwhal)							
Beluga whale	*Delphinapterus leucas*		NA[8]	NA[8]		Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Narwhal	*Monodon monoceros*		NA[9]	NA[9]		Newfoundland-Labrador Shelf, West Greenland Shelf	–
Family Ziphiidae (beaked whales)							
Cuvier's beaked whale	*Ziphius cavirostris*		Western North Atlantic	3,513 (0.63) / 2,154[10]	Gulf Stream, North Atlantic Gyre, Labrador Current	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
			Gulf of Mexico Oceanic	65 (0.67) / 39		Gulf of Mexico, Caribbean Sea	–

[7] Estimate may include both the pygmy and dwarf sperm whales.
[8] This species occurs in the Atlantic outside of the U.S. Exclusive Economic Zone; and therefore has no associated Stock Assessment Report. See the appropriate subsections below for details of populations that may be found within the Study Area.
[9] Narwhals in the Atlantic are not managed by NMFS and have no associated Stock Assessment Report.
[10] Estimate includes Cuvier's beaked whales and undifferentiated *Mesoplodon* species

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
True's beaked whale	*Mesoplodon mirus*		Western North Atlantic	3,513 (0.63) / 2,154[10]	Gulf Stream, North Atlantic Gyre, Labrador Current	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Gervais' beaked whale	*Mesoplodon europaeus*		Western North Atlantic	3,513 (0.63) / 2,154[10]	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf, Northeast United States Continental Shelf	–
			Gulf of Mexico Oceanic	57 (1.4) / 24[11]	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf	–
Sowerby's beaked whale	*Mesoplodon bidens*		Western North Atlantic	3,513 (0.63) / 2,154[10]	Gulf Stream, North Atlantic Gyre	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Blainville's beaked whale	*Mesoplodon densirostris*		Western North Atlantic	3,513 (0.63) / 2,154[10]	Gulf Stream, North Atlantic Gyre, Labrador Current	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
			Gulf of Mexico Oceanic	57 (1.4) / 24[11]	–	Gulf of Mexico, Caribbean Sea	–
Northern bottlenose whale	*Hyperoodon ampullatus*		Western North Atlantic	Unknown	Gulf Stream, North Atlantic Gyre, Labrador Current	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Family Delphinidae (dolphins)							
Rough-toothed dolphin	*Steno bredanensis*		Western North Atlantic	Unknown	Gulf Stream, North Atlantic Gyre	Caribbean Sea, Southeast U.S. Continental Shelf	–
			Gulf of Mexico (Outer continental shelf and Oceanic)	Unknown	–	Gulf of Mexico, Caribbean Sea	–

[10] Estimate includes Cuvier's beaked whales and undifferentiated *Mesoplodon* species

[11] Estimate includes Gervais' and Blainville's beaked whales.

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Bottlenose dolphin	*Tursiops truncatus*	Strategic, Depleted	Western North Atlantic, offshore[12]	81,588 (0.17) / 70,775	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf	–
		Strategic, Depleted	Western North Atlantic, coastal, northern migratory	9,604 (0.36) / 7,147	–	Southeast U.S. Continental Shelf	Island Sound, Sandy Hook Bay, Lower Chesapeake Bay, James River, Elizabeth River
		Strategic, Depleted	Western North Atlantic, coastal, southern migratory	12,482 (0.32) / 9,591	–	Southeast U.S. Continental Shelf	Lower Chesapeake Bay, James River, Elizabeth River, Beaufort Inlet, Cape Fear River, Kings Bay, St. Johns River
		Strategic, Depleted	Western North Atlantic, coastal, South Carolina/ Georgia	7,738 (0.23) / 6,399	–	Southeast U.S. Continental Shelf	Kings Bay, St. Johns River
		Strategic, Depleted	Western North Atlantic, coastal, Northern Florida	3,064 (0.24) / 2,511	–	Southeast U.S. Continental Shelf	Kings Bay, St. Johns River
		Strategic	Western North Atlantic, coastal, Central Florida	6,318 (0.26) / 5,094	–	Southeast U.S. Continental Shelf	Port Canaveral
		Strategic	Northern North Carolina Estuarine System	Unknown	–	Southeast U.S. Continental Shelf	Beaufort Inlet, Cape Fear River
		Strategic	Southern North Carolina Estuarine System	2,454 (0.53) / 1,614	–	Southeast U.S. Continental Shelf	Beaufort Inlet, Cape Fear River
		Strategic	Charleston Estuarine System	Unknown	–	Southeast U.S. Continental Shelf	–

[12] Estimate may include sightings of the coastal form.

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
		Strategic	Northern Georgia/ Southern South Carolina Estuarine System	Unknown	–	Southeast U.S. Continental Shelf	–
		Strategic	Southern Georgia Estuarine System	Unknown	–	Southeast U.S. Continental Shelf	Kings Bay, St. Johns River
		Strategic	Jacksonville Estuarine System	Unknown	–	Southeast U.S. Continental Shelf	Kings Bay, St. Johns River
		Strategic	Indian River Lagoon Estuarine System	Unknown	–	Southeast U.S. Continental Shelf	Port Canaveral
		Strategic	Biscayne Bay	Unknown	–	Southeast U.S. Continental Shelf	–
			Florida Bay	514 (0.17) / 447	–	Gulf of Mexico	–
			Gulf of Mexico Continental Shelf	Unknown	–	Gulf of Mexico	–
			Gulf of Mexico, eastern coastal	7,702 (0.19) / 6,551	–	Gulf of Mexico	–
			Gulf of Mexico, northern coastal	2,473 (0.25) / 2,004	–	Gulf of Mexico	St. Andrew Bay, Pascagoula River
		Strategic	Gulf of Mexico, western coastal	Unknown	–	Gulf of Mexico	Corpus Christi Bay, Galveston Bay,
			Gulf of Mexico Oceanic	3,708 (0.42) / 2,641	–	Gulf of Mexico	–
		Strategic	Gulf of Mexico bay, sound, and estuarine	Unknown	–	Gulf of Mexico	St. Andrew Bay, Pascagoula River, Sabine Lake, Corpus Christi Bay, and Galveston Bay

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Pantropical spotted dolphin	*Stenella attenuata*		Western North Atlantic	4,439 (0.49) / 3,010	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf	–
			Gulf of Mexico Oceanic	34,067 (0.18) / 29,311	–	Gulf of Mexico, Caribbean Sea	–
Atlantic spotted dolphin	*Stenella frontalis*		Western North Atlantic	50,978 (0.42) / 36,235	Gulf Stream	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
			Gulf of Mexico (Continental shelf and Oceanic)	Unknown	–	Gulf of Mexico, Caribbean Sea	–
Spinner dolphin	*Stenella longirostris*		Western North Atlantic	Unknown	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf	–
			Gulf of Mexico Oceanic	1,989 (0.48) / 1,356	–	Gulf of Mexico, Caribbean Sea	–
Clymene dolphin	*Stenella clymene*		Western North Atlantic	Unknown	Gulf Stream	Southeast U.S. Continental Shelf	–
			Gulf of Mexico Oceanic	6,575 (0.36) / 4,901	–	Gulf of Mexico, Caribbean Sea	–
Striped dolphin	*Stenella coeruleoalba*		Western North Atlantic	94,462 (0.4) / 68,558	Gulf Stream	-	–
			Gulf of Mexico Oceanic	3,325 (0.48) / 2,266	–	Gulf of Mexico, Caribbean Sea	–
Fraser's dolphin	*Lagenodelphis hosei*		Western North Atlantic	Unknown	North Atlantic Gyre	Southeast U.S. Continental Shelf	–
			Gulf of Mexico Oceanic	Unknown	–	Gulf of Mexico, Caribbean Sea	–
Risso's dolphin	*Grampus griseus*		Western North Atlantic	20,479 (0.59) / 12,920	Gulf Stream	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
			Gulf of Mexico Oceanic	1,589 (0.27) / 1,271	–	Gulf of Mexico, Caribbean Sea	–

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Atlantic white-sided dolphin	*Lagenorhynchus acutus*		Western North Atlantic	63,368 (0.27) / 50,883	Labrador Current	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
White-beaked dolphin	*Lagenorhynchus albirostris*		Western North Atlantic	2,003 (0.94) / 1,023	Labrador Current	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Long-beaked common dolphin	*Delphinus capensis*		NA[13]	Unknown[13]	–	Caribbean Sea[13]	–
Short-beaked common dolphin	*Delphinus delphis*		Western North Atlantic	120,743 (0.23) / 99,975	Gulf Stream	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Melon-headed whale	*Peponocephala electra*		Western North Atlantic	Unknown	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf	–
			Gulf of Mexico Oceanic	2,283 (0.76) / 1,293	–	Gulf of Mexico, Caribbean Sea	–
Pygmy killer whale	*Feresa attenuata*		Western North Atlantic	Unknown	Gulf Stream, North Atlantic Gyre	Southeast U.S. Continental Shelf	–
			Gulf of Mexico Oceanic	323 (0.6) / 203	–	Gulf of Mexico, Caribbean Sea, Southeast U.S. Continental Shelf	–
False killer whale	*Pseudorca crassidens*		Gulf of Mexico Oceanic	777 (0.56) / 501	Gulf Stream, North Atlantic Gyre	Gulf of Mexico, Caribbean Sea, Southeast U.S. Continental Shelf	–
Killer whale	*Orcinus orca*		Western North Atlantic	Unknown	Gulf Stream, North Atlantic Gyre, Labrador Current	Southeast U.S. Continental Shelf, Northeast U.S. Continental shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
			Gulf of Mexico Oceanic	49 (0.77) / 28	–	Gulf of Mexico, Caribbean Sea	–

[13] Long-beaked common dolphins are only known in the western Atlantic from a discrete population off the east coast of South America.

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Long-finned pilot whale	*Globicephala melas*		Western North Atlantic	12,619 (0.37) / 9,333	Gulf Stream	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Short-finned pilot whale	*Globicephala macrorhynchus*		Western North Atlantic	24,674 (0.45) / 17,190	Gulf Stream	Northeast U.S. Continental Shelf, Southeast U.S. Continental Shelf	–
			Gulf of Mexico Oceanic	716 (0.34) / 542	–	Gulf of Mexico, Caribbean Sea	–
Family Phocoenidae (porpoises)							
Harbor porpoise	*Phocoena phocoena*		Gulf of Maine/Bay of Fundy	89,054 (0.47) / 60,970	–	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, Long Island Sound, Piscataqua River, Thames River, Kennebec River
Order Carnivora							
Suborder Pinnipedia							
Family Phocidae (true seals)							
Ringed seal	*Pusa hispida*	Proposed[15]	NA[14]	Unknown	–	Newfoundland-Labrador Shelf, West Greenland Shelf	–
Bearded seal	*Erignathus barbatus*		NA[14]	Unknown	–	Scotian Shelf, Newfoundland-Labrador Shelf, West Greenland Shelf	–

[14] This species occurs in the Atlantic outside of the U.S. Exclusive Economic Zone; and therefore has no associated Stock Assessment Report. See the appropriate subsections below for details of populations that may be found within the Study Area.

[15] Arctic sub-species of ringed seal has been proposed as threatened under the ESA (75 Federal Register [FR] 77476).

Common Name	Scientific Name[1]	ESA/MMPA Status[2]	Stock[3]	Stock Abundance[3] Best (CV) / Min	Occurrence in Study Area[4]		
					Open Ocean	Large Marine Ecosystems	Bays, Rivers, and Estuaries
Hooded seal	*Cystophora cristata*		Western North Atlantic	592,100 / 512,000	–	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf, West Greenland Shelf	Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, Long Island Sound, Piscataqua River, Thames River, Kennebec River
Harp seal	*Pagophilus groenlandicus*		Western North Atlantic	Unknown	–	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	–
Gray seal	*Halichoerus grypus*		Western North Atlantic	Unknown	–	Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, Long Island Sound, Piscataqua River, Thames River, Kennebeck River
Harbor seal	*Phoca vitulina*		Western North Atlantic	Unknown[16]	–	Southeast U.S. Continental Shelf, Northeast U.S. Continental Shelf, Scotian Shelf, Newfoundland-Labrador Shelf	Narragansett Bay, Rhode Island Sound, Block Island Sound, Buzzards Bay, Vineyard Sound, Long Island Sound, Piscataqua River, Thames River, Kennebeck River

[16] 2010 Stock Assessment Report states that present data are insufficient to calculate a minimum population estimate for this stock, however, the 2009 Stock Assessment Report indicated the "best" population estimate was 99,340 (CV = .097) and minimum population estimate was 91,546.

4 AFFECTED SPECIES STATUS AND DISTRIBUTION

Four main types of marine mammals are generally recognized: cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees, dugongs, and sea cows), and other marine carnivores (sea otters and polar bears) (Jefferson et al. 2008b; Rice 1998). The order Cetacea is divided into two suborders – Odontoceti and Mysticeti. The toothed whales, dolphins, and porpoises (suborder Odontoceti) range in size from slightly longer than 3.3 ft. (1 m) to more than 60 ft. (18 m) and have teeth, which they use to capture and consume individual prey. The baleen whales (suborder Mysticeti) are universally large (more than 15 ft. [5 m] as adults). They are called baleen whales because, instead of teeth, they have a fibrous structure actually made of keratin, a type of protein like that found in human fingernails, in their mouths which enables them to filter or extract food from the water for feeding. They are batch feeders that use this baleen instead of teeth to engulf, suck, or skim large numbers of prey, such small schooling fish, shrimp, or microscopic sea animals (i.e. plankton) from the water or out of ocean floor sediments (Heithaus and Dill 2008). The baleen whales are further divided into two families – right whales and rorquals. Rorquals have a series of longitudinal folds of skin, often referred to as throat grooves, running from below the mouth back towards the navel. Rorquals are slender and streamlined in shape, compared with their relatives the right whales, and most have narrow, elongated flippers. Detailed reviews of the different groups of cetaceans can be found in Perrin et al. (2009). Most pinnipeds can be divided into two families: phocids (true seals) and the otariids (fur seals and sea lions). Species managed by the U.S. Fish and Wildlife Service, including the walrus, West Indian manatee, and polar bear, are not discussed in this document.

Cetaceans inhabit virtually every marine environment in the Study Area. Marine mammals in the Study Area occur from coastal and inland waters to the open Atlantic Ocean. Their distribution is influenced by many factors, primarily patterns of major ocean currents, which in turn affect prey productivity. The continuous movement of water from the ocean bottom to the surface creates a nutrient-rich, highly productive environment for marine mammal prey (Jefferson et al. 2008b). For most cetaceans, prey distribution, abundance, and quality largely determine where they occur at any specific time (Heithaus and Dill 2008). Most of the baleen whales are migratory, but many of the toothed whales do not migrate in the strictest sense. Instead, they undergo seasonal dispersal or shifts in density. Pinnipeds occur mostly in coastal habitats or within those regions over the continental shelf. They require land or shallow coastal waters as habitat for reproducing, resting, and, in some cases, feeding, so open ocean waters is not the primary range for any of these species.

4.1 CETACEANS

4.1.1 MYSTICETES

4.1.1.1 North Atlantic Right Whale (*Eubalaena glacialis*)

Right whales in the North Atlantic and North Pacific were once classified together as a single species, the northern right whale. However, genetic data have now determined them to represent two separate species: the North Atlantic right whale (*Eubalaena glacialis*) and the North Pacific right whale (*Eubalaena japonica*) (Rosenbaum et al. 2000).

4.1.1.1.1 Status and Management (Excerpts from Waring et al. [2010])

The North Atlantic right whale population is considered one of the most critically endangered populations of large whales in the world (Clapham et al. 1999). The size of this stock is considered extremely low relative to the Optimum Sustainable Population in the U.S. Atlantic Exclusive Economic

Zone, and this species is listed as endangered under the ESA. A recovery plan for the North Atlantic right whale is in effect (U.S. Department of Commerce 2005). The North Atlantic right whale was also protected from commercial whaling by the International Whaling Commission since 1927. A NMFS ESA status review in 1996 concluded that the western North Atlantic stock remains endangered. This conclusion was reinforced by the International Whaling Commission (Best et al. 2003), which expressed grave concern regarding the status of this stock. Relative to populations of southern right whales, there are also concerns about growth rate, percentage of reproductive females, and calving intervals in the North Atlantic right whale population. The total level of human-caused mortality and serious injury is unknown, but reported human-caused mortality and serious injury was a minimum of three right whales per year from 2003 through 2007. Any mortality or serious injury for this stock should be considered significant. This is a strategic stock because the average annual human-related mortality and serious injury exceeds potential biological removal and because the North Atlantic right whale is an endangered species.

Three critical habitats (Cape Cod Bay/Massachusetts Bay/Stellwagen Bank, Great South Channel, and the coastal waters of Georgia and Florida in the southeastern United States) were designated by NMFS in 1994 (National Marine Fisheries Service 1994) (Figure 4-1). Two additional critical habitat areas in Canadian waters, Grand Manan Basin and Roseway Basin, were identified in Canada's final recovery strategy for the North Atlantic right whale (Brown et al. 2009). A 12-month finding from NMFS on a 2002 petition to revise right whale critical habitat stated "a review of scientific information suggests that physical and biological features essential to the conservation of right whales may include, but are not necessarily limited to, the occurrence of copepods and the features that concentrate them in the water off of the northeast United States, as well as sea surface temperature and possibly bathymetry in the waters off of the southeast United States." In a more recent 12-month finding on a 2009 petition, NMFS stated they agree that revision of critical habitat is appropriate and that they would continue the ongoing rulemaking process (National Marine Fisheries Service 2010b).

4.1.1.1.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

The western North Atlantic right whale population ranges primarily from calving grounds in coastal waters of the southeastern United States to feeding grounds in New England waters and the Canadian Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence. Knowlton et al. (1992) reported several long-distance movements as far north as Newfoundland, the Labrador Basin, and southeast of Greenland. In addition, recent resightings of photographically identified individuals were made off Iceland, in the old Cape Farewell whaling ground east of Greenland (Hamilton et al. 2007) and northern Norway (Jacobsen et al. 2004). The September 1999 Norwegian sighting represents one of only two published sightings this century of a right whale in Norwegian waters, and the first since 1926. Together, these long-range matches indicate an extended range for at least some individuals and perhaps the existence of important habitat areas not presently well described. The few published records from the Gulf of Mexico (Moore and Clark 1963; Schmidly et al. 1972; Ward-Geiger et al. 2011) represent either distributional anomalies, normal wanderings of occasional animals, or a more extensive historic range beyond the sole known calving and wintering ground in the waters of the southeastern United States. Whatever the case, the location of much of the population is unknown during the winter.

Research results suggest the existence of six major habitats or congregation areas for western North Atlantic right whales: winter breeding grounds in the coastal waters of the southeastern United States within the Southeast U.S. Continental Shelf Large Marine Ecosystem and summer feeding grounds within the Northeast U.S. Continental Shelf Large Marine Ecosystem–Great South Channel, Georges Bank/Gulf of Maine, Cape Cod and Massachusetts Bays, the Bay of Fundy, and the Scotian Shelf.

However, movements within and between habitats are extensive. In 2000, one whale was photographed in Florida waters on 12 January, then again 11 days later (23 January) in Cape Cod Bay, less than a month later off Georgia (16 February), and back in Cape Cod Bay on 23 March, effectively making the round-trip migration to the southeast and back at least twice during the winter (Brown and Marx 2000). Results from satellite tags clearly indicate that sightings separated by perhaps two weeks should not necessarily be assumed to indicate a stationary or resident animal. Instead, telemetry data show rather lengthy and somewhat distant excursions, including into deep water off the continental shelf (Baumgartner and Mate 2005; Mate et al. 1997). Systematic surveys conducted off the coast of North Carolina during the winters of 2001 and 2002 sighted eight calves, suggesting the calving grounds may extend as far north as Cape Fear. Four of the calves were not sighted by surveys conducted further south. One of the cows photographed was new to researchers, having effectively eluded identification over the period of its maturation (McLellan et al. 2004).

Three right whale observations (four individuals) were recorded during aerial surveys sponsored by the Navy in the vicinity of the planned Undersea Warfare Training Range approximately 50 mi. (80 km) offshore of Jacksonville, Florida in 2009 and 2010, including a female that was observed giving birth (Foley et al. 2011). These sightings occurred well outside existing critical habitat for the right whale and suggest that the calving area may be broader than currently assumed (Foley et al. 2011; U.S. Department of the Navy 2010). Offshore (greater than 30 mi. [48.3 km]) surveys flown off the coast of northeastern Florida and southeastern Georgia from 1996 to 2001 documented 3 sightings in 1996, 1 in 1997, 13 in 1998, 6 in 1999, 11 in 2000 and 6 in 2001 (within each year, some were repeat sightings of previously recorded individuals). Several of the years that offshore surveys were flown were some of the lowest count years for calves and for numbers of right whales in the southeast recorded since comprehensive surveys in the calving grounds were initiated. Therefore, the frequency with which right whales occur in offshore waters in the southeastern United States remains unclear.

Since 2004, consistent aerial survey efforts have been conducted during the migration and calving season (15 November to 15 April) in coastal areas of Georgia and South Carolina, to the north of currently defined critical habitat (Glass and Taylor 2006; Khan and Taylor 2007; Sayre and Taylor 2008; Schulte and Taylor 2010). Results suggest that this region may not only be part of the migratory route but also a seasonal residency area. Results from an analysis by Schick et al. (2009) suggest that the migratory corridor of North Atlantic right whales is broader than initially estimated and that suitable habitat exists beyond the 20 nm coastal buffer presumed to represent the primary migratory pathway (National Marine Fisheries Service 2008b). Results were based on data modeled from two females tagged with satellite-monitored radio tags as part of a previous study.

New England waters are an important feeding habitat for right whales, which feed primarily on copepods in this area (largely of the genera *Calanus* and *Pseudocalanus*). Research suggests that right whales must locate and exploit extremely dense patches of zooplankton to feed efficiently (Mayo and Marx 1990). These dense zooplankton patches are likely a primary characteristic of the spring, summer and fall right whale habitats (Kenney et al. 1986; Kenney et al. 1995). While feeding in the coastal waters off Massachusetts has been better studied than in other areas, right whale feeding has also been observed on the margins of Georges Bank, in the Great South Channel, in the Gulf of Maine, in the Bay of Fundy, and over the Scotian Shelf. The characteristics of acceptable prey distribution in these areas are beginning to emerge (Baumgartner and Mate 2003; Baumgartner and Mate 2005). NMFS and Provincetown Center for Coastal Studies aerial surveys during springs of 1999–2006 found right whales along the northern edge of Georges Bank, in the Great South Channel, in Georges Basin, and in various locations in the Gulf of Maine including Cashes Ledge, Platts Bank and Wilkinson Basin. The consistency with which right whales occur in such locations is relatively high, but these studies also highlight the high interannual variability in right whale use of some habitats.

4.1.1.1.3 Population and Abundance (Excerpts from Waring et al. [2010])

The western North Atlantic minimum stock size is based on a census of individual whales identified using photo-identification techniques. Review of the photo-identification recapture database as it existed in July 2010 indicated that 396 individually recognized whales in the catalog were known to be alive during 2007. This value is a minimum and does not include animals alive prior to 2007, but not recorded in the individual sightings database as seen during from 01 December 2004 to 06 July 2010 (note that matching of photos taken during 2008-2010 was not complete at the time the data were received). It also does not include some calves known to be born during 2007, or any other individual whale seen during 2007 but not yet entered into the catalog. This estimate has no associated coefficient of variation. In 2010, the best estimate of catalogued North Atlantic right whales was 490 individuals (Hamilton et al. 2011). This estimate does not include potentially unphotographed whales and is an estimate of the cataloged population only. The western North Atlantic population size was estimated to be at least 345 individuals in 2005 based on a census of individual whales identified using photo-identification techniques.

The population growth rate reported for the period 1986–1992 by Knowlton et al. (1994) was 2.5 percent (CV=0.12), suggesting that the stock was showing signs of slow recovery. However, subsequent work suggested that survival declined from about 0.99 in the early 1980s to about 0.94 in the late 1990s (Best et al. 2001; Caswell et al. 1999; Clapham 2002). Recent mortalities, including those in the first half of 2005, suggest an increase in the annual mortality rate (Kraus et al. 2005). Despite the preceding, examination of the minimum number alive population index calculated from the individual sightings database as it existed on 10 October 2008, for the years 1990–2005 suggests a positive trend in numbers. These data reveal a significant increase in the number of catalogued whales alive during this period, but with significant variation due to apparent losses exceeding gains during 1998–99. Mean growth rate for the period 1990–2005 was 1.8 percent.

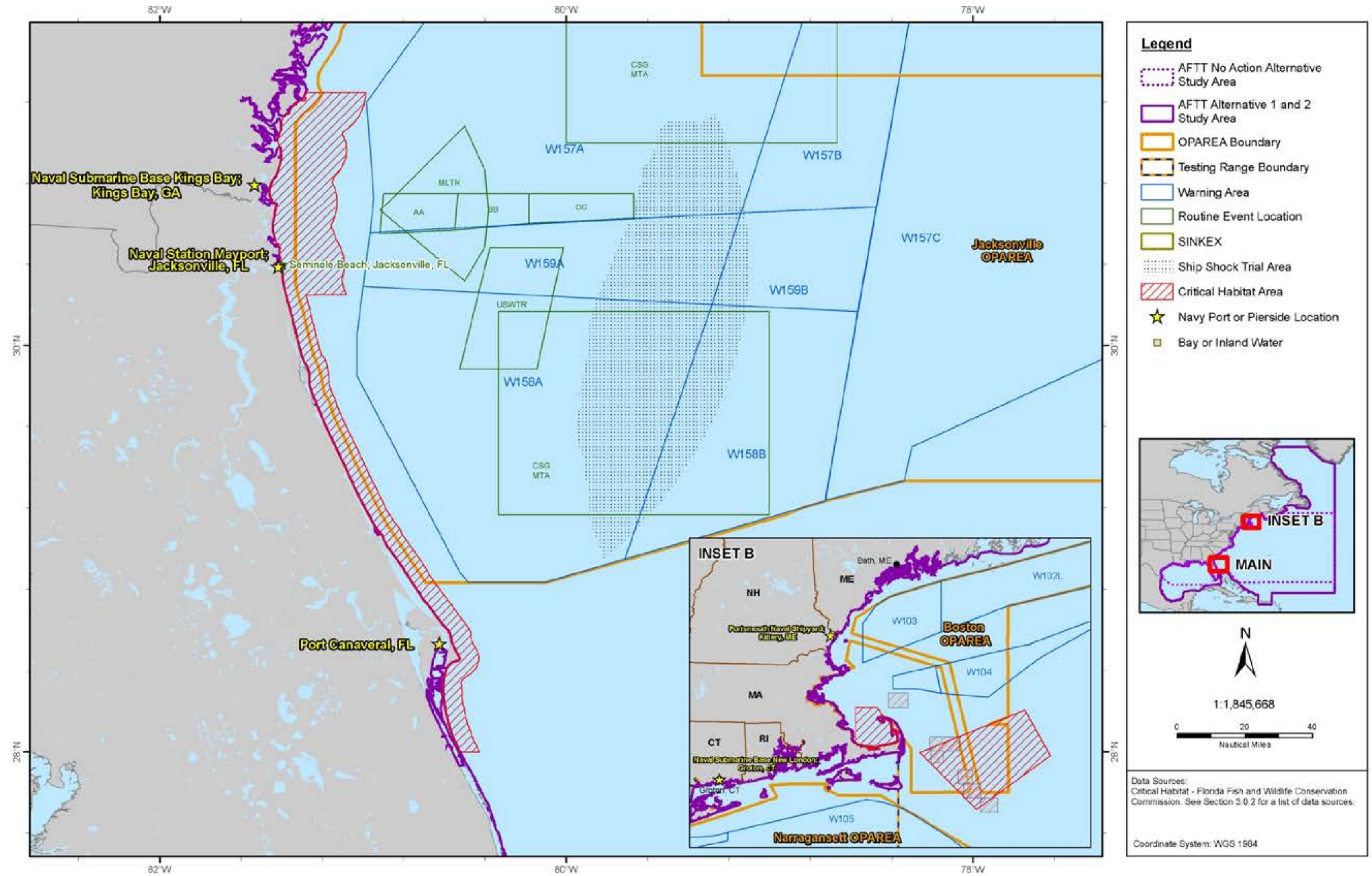


Figure 4-1. Designated Critical Habitat Areas for the North Atlantic Right Whale in the Study Area

AFTT: Atlantic Fleet Training and Testing; CT: Connecticut; FL: Florida; GA: Georgia; ME: Maine; OPAREA: Operating Area; SINKEX: Sinking Exercise

4.1.1.2 Bowhead Whale (*Balaena mysticetus*)

Bowhead whales are the northernmost of all whales, inhabiting only arctic and subarctic regions, often close to the ice edge.

4.1.1.2.1 Status and Management

The bowhead whale is listed as endangered under the ESA and is designated as depleted under the MMPA. Three geographically distinct bowhead whale stocks are recognized in the Atlantic – the Spitsbergen, Baffin Bay-Davis Straight, and Hudson Bay-Fox Basin stocks (Allen and Angliss 2010; Rugh et al. 2003; Wiig et al. 2007). Because these stocks do not occur within U.S. Atlantic waters, they are not managed under NMFS jurisdiction.

4.1.1.2.2 Habitat and Geographic Range

Bowhead whales are found in arctic and subarctic regions of the Atlantic and Pacific oceans (55° N to 85° N). They are also found in the Bering, Beaufort, Chukchi, and Okhotsk Seas, as well as in the northern parts of Hudson Bay (Wiig et al. 2007). Their range can expand and contract depending on access through ice-filled Arctic straits (Rugh et al. 2003). Habitat selection varies seasonally, although this is clearly the most polar species of whale. Bowheads are found in continental slope waters during spring and summer while feeding on abundant zooplankton (Wiig et al. 2007).

Migration occurs within the Arctic and is associated with ice edge movements. Bowheads reside in the high Arctic during summer and move south in fall as the ice edge grows, spending their winters in lower-latitude areas (Jefferson et al. 2008b). The Davis Strait stock spends winters from Labrador across to West Greenland and moves north to spend summers in the Canadian High Arctic and around Baffin Island (Heide-Jorgensen et al. 2003). Whales in the Beaufort Sea were observed changing their migratory routes in response to noise associated with oil production (Huntington 2009).

Newfoundland-Labrador Shelf and West Greenland Shelf Large Marine Ecosystem. The southernmost portion of the bowhead range includes the shelf areas of west Greenland and northern Labrador. Bowheads were sighted in the continental slope waters of west Greenland during April (Ledwell et al. 2007). From May 2002 to December 2003, satellite-tracked bowheads departed from west Greenland and moved northwest toward Lancaster Sound. Individuals remained within the Canadian High Arctic or along the east coast of Baffin Island in summer and early fall. By the end of October, whales moved rapidly south along the east coast of Baffin Island and entered Hudson Strait (Heide-Jorgensen et al. 2006). Two bowhead whales were stranded on Newfoundland in 1998 and 2007, from 45° N to 47° N and 52° W to 56° W, representing the southernmost records of this species in the western North Atlantic (Ledwell et al. 2007).

4.1.1.2.3 Population and Abundance

Aerial surveys were used to estimate the Davis Strait stock of bowheads (Wiig et al. 2007). The combined Davis Strait-Hudson Bay stocks are now thought to number at least 7,000 (Cosens et al. 2006). The International Whaling Commission estimates the bowhead stock off west Greenland at 490–2,940 individuals (95 percent confidence interval).

4.1.1.3 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale may be the best known and most recognizable of all the great whales (a descriptive term referring to the larger baleen whales and the sperm whale). It is the focus of many whale-watching operations worldwide.

4.1.1.3.1 Status and Management

Humpback whales are listed as endangered under the ESA and depleted under the MMPA. Critical habitat has not been designated for humpback whales. Based on overall evidence of population recovery in many areas, the species is being considered by NMFS for removal or down-listing from the ESA (National Marine Fisheries Service 2009a).

Although the western North Atlantic population was once treated as a single management stock, the Gulf of Maine stock is now considered separate based on strong fidelity of humpbacks to that region (Waring et al. 2010). The Gulf of Maine stock is the only stock of humpbacks in the Atlantic managed under NMFS jurisdiction.

4.1.1.3.2 Habitat and Geographic Range

Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al. 2001; Clapham and Mattila 1990). Their primary range in the Atlantic includes the nearshore waters of the Northeast U.S. Continental Shelf, Scotian Shelf, and Newfoundland-Labrador Shelf Large Marine Ecosystems. Their secondary range includes the Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems, as well as the Labrador Current, Gulf Stream and North Atlantic Gyre Open Ocean Areas.

Humpback feeding habitats are typically shallow banks or ledges with high seafloor relief (Hamazaki 2002; Payne et al. 1990). On breeding grounds, females with calves occur in much shallower waters than other groups of whales, and breeding adults use deeper more offshore waters (Ersts and Rosenbaum 2003; Smultea 1994). The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75° Fahrenheit [F] to 82° F [24° Celsius [C} to 28° C]) and relatively shallow, low-relief ocean bottom in protected areas, created by islands or reefs (Clapham 2000; Craig and Herman 2000; Smultea 1994).

Humpback whales typically migrate from the northern feeding areas such as the Gulf of Maine (including Georges Bank, southwestern Nova Scotia, and the Bay of Fundy) or the Scotian Shelf to calving/breeding areas in the West Indies, where the majority of whales are found, particularly off the Dominican Republic, north of the territory of Turks and Caicos on Silver Bank, Navidad Bank, and in Samana Bay, though some whales were sighted in the Cape Verde Islands off the west coast of Africa (Waring et al. 2010). Individual variability in the timing of migrations may result in the presence of individuals in high-latitude areas throughout the year (Straley 1990).

Newfoundland-Labrador and Scotian Shelf Large Marine Ecosystems. The Gulf of St. Lawrence, Newfoundland Grand Banks, and Scotian Shelf are summer feeding grounds for humpbacks (Cetacean and Turtle Assessment Program 1982; Kenney and Winn 1986; Stevick et al. 2006; Whitehead 1982).

Northeast U.S. Continental Shelf Large Marine Ecosystem. The Gulf of Maine is one of the principal summer feeding grounds for humpback whales in the North Atlantic. The largest numbers of humpback whales are present from mid-April to mid-November. Other feeding locations in this ecosystem are Stellwagen Bank, Jeffreys Ledge, the Great South Channel, the edges and shoals of Georges Bank, Cashes Ledge, and Grand Manan Banks (Cetacean and Turtle Assessment Program 1982; Kenney and Winn 1986; Stevick et al. 2006; Weinrich et al. 1997; Whitehead 1982). Humpbacks are most likely to occur in the Chesapeake Bay between January and March; however, they could be found in the area year-round, based on sighting and stranding data in both mid-Atlantic waters and the Chesapeake Bay itself (Barco et al. 2002; Swingle et al. 2007). Photo-identification data support the repeated use of the mid-Atlantic region by individual humpback whales (Barco et al. 2002). Barco et al.'s study suggests the mid-Atlantic region might be where some mother humpbacks wean and separate from their calves.

4.1.1.3.3 Population and Abundance (Excerpts from Waring et al. [2010])

The best available estimate for the entire North Atlantic population (including the Gulf of Maine stock) derived from photographic mark-recapture analyses from the Years of the North Atlantic Humpback project is 11,570. The best abundance estimate for the Gulf of Maine stock of 847 animals (CV=0.55) was derived from a line-transect sighting survey conducted during August 2006 covering from the 2,000-m depth contour on the southern edge of Georges Bank to the upper Bay of Fundy and to the Gulf of St. Lawrence. The minimum population estimate for this stock is 549 animals. Current data suggest that the Gulf of Maine humpback whale stock is steadily increasing in numbers. This is consistent with an estimated average trend of 3.1 percent (SE=0.005) in the North Atlantic population overall for the period 1979–1993 (Stevick et al. 2003).

4.1.1.4 Minke Whale (*Balaenoptera acutorostrata*)

Minke whales are the smallest species of mysticete and are classified as a single species with three subspecies recently recognized: *Balaenoptera acutorostrata davidsoni* in the North Atlantic, *Balaenoptera acutorostrata scammoni* in the North Pacific, and a subspecies that is formally unnamed but generally called the dwarf minke whale, which mainly occurs in the southern hemisphere (Jefferson et al. 2008b).

4.1.1.4.1 Status and Management (Excerpts from Waring et al. [2010])

The minke whale is protected under the MMPA but is not listed under the ESA. In the North Atlantic, there are four recognized populations: Canadian east coast, west Greenland, central North Atlantic, and northeastern North Atlantic (Donovan 1991). Minke whales off the eastern coast of the United States are considered to be part of the Canadian east coast stock, which inhabits the area from the western half of the Davis Strait (45°W) to the Gulf of Mexico. The relationship between this stock and the other three stocks is uncertain.

4.1.1.4.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Minke whales have a cosmopolitan distribution in temperate and tropical waters and generally occupy waters over the continental shelf, including inshore bays and even occasionally estuaries. However, records from whaling catches and research surveys worldwide indicate there may be an open ocean component to the minke whale's habitat (Ingram et al. 2007; Jefferson et al. 2008b) including the Labrador Current, Gulf Stream, and North Atlantic Gyre Open Ocean Areas. They have an extensive distribution in polar, temperate, and tropical waters in the northern and southern hemispheres (Jefferson et al. 2008b; Perrin and Brownell 2008); they are less common in the tropics than in cooler waters.

Minke whales generally participate in annual migrations between low-latitude breeding grounds in the tropics and subtropics in the winter and high-latitude feeding grounds (such as Gulf of Maine as well as the Saguenay-St. Lawrence region [Quebec]) in the summer (Kuker et al. 2005). Migration paths of the minke whale show they follow patterns of prey availability (Jefferson et al. 2008b).

The minke whale is common and widely distributed within the U.S. Exclusive Economic Zone in the Atlantic Ocean (Cetacean and Turtle Assessment Program 1982). There appears to be a strong seasonal component to minke whale distribution. Like most other baleen whales, minke whales generally occupy the continental shelf proper rather than the continental shelf edge region. Records summarized by Mitchell (1991) hint at a possible winter distribution in the West Indies, and in the mid-ocean south and east of Bermuda. As with several other cetacean species, the possibility of a deep-ocean component to the distribution of minke whales exists but remains unconfirmed.

Scotian Shelf Large Marine Ecosystem. The St. Lawrence Estuary is known as a summer feeding ground for the North Atlantic population of the minke whale (Edds-Walton 2000).

Northeast U.S. Continental Shelf Large Marine Ecosystem. During summer and early fall, minke whales are found throughout the lower Bay of Fundy (Ingram et al. 2007). Spring and summer are times of relatively widespread and common occurrence, and are the seasons when the whales are most abundant in New England waters. In New England waters during fall there are fewer minke whales, while during winter the species appears to be largely absent.

Southeast U.S. Continental Shelf and Gulf of Mexico Large Marine Ecosystems. Minke whales occur in the warmer waters of the southern United States during winter. Although they are not typically expected to occur within the Gulf of Mexico, observation records exist for mostly immature individuals in the Gulf of Mexico and Florida Keys (Stewart and Leatherwood 1985; Waring et al. 2010).

4.1.1.4.3 Population and Abundance

The minke whale is considered generally abundant in most areas of its range (Horwood 1990; Jefferson et al. 2008b). Although global population abundance is difficult to assess, estimates for the North Atlantic indicate that there are more than 100,000 whales in the region and possibly more than 180,000 in the northern hemisphere (Jefferson et al. 2008b; Perrin and Brownell 2008; Skaug et al. 2004). The best estimate of abundance for the Canadian east coast minke whale is 8,987, with a minimum population estimate of 6,909 (Waring et al. 2010).

4.1.1.5 Bryde's Whale (*Balaenoptera brydei/edeni*)

Bryde's whales are among the least known of the baleen whales. Their classification and true numbers remain uncertain (Alves et al. 2010). Some scientists suggest that there may be up to three species (Bryde's whale, *Balaenoptera brydei*; Bryde's/Eden's whale, *Balaenoptera edeni* (Olsen 1913); and Omura's whale, *Balaenoptera omurai* (Wada, Oishi, and Yamada, 2003) based on geographic distribution, inshore/offshore forms, and a pygmy form. For at least two of the species, the scientific name B. edeni is commonly used. The Bryde's whale's "pygmy form" has only recently been described and is now known as Omura's whale (Kato and Perrin 2008; Rice 1998). The International Whaling Commission continues to use the name *Balaenoptera edeni* for all Bryde’s-like whales, although at least two species are recognized.

4.1.1.5.1 Status and Management

Bryde’s whale is protected under the MMPA but not listed under the ESA. Current genetic research confirms that gene flow among Bryde’s whale populations is low and suggests that management actions treat each as a distinct entity to ensure survival of the species (Kanda et al. 2007). Bryde’s whales found in the northern Gulf of Mexico may represent a resident stock and are thus considered a separate stock for management purposes; however, there are no data to suggest genetic differentiation from the North Atlantic stock (Waring et al. 2010).

4.1.1.5.2 Habitat and Geographic Range

Unlike other baleen whale species, Bryde’s whales are restricted to tropical and subtropical waters and do not generally occur beyond latitude 40° in either the northern or southern hemisphere (Jefferson et al. 2008b; Kato and Perrin 2008). The primary range of Bryde’s whales in the Atlantic is in tropical waters south of the Caribbean, outside the Study Area, except for the Gulf of Mexico, where this species is thought to be the most common baleen (Würsig et al. 2000), although they may range as far north as Virginia (Kato and Perrin 2008). Long migrations are not typical of Bryde’s whales, although limited shifts in distribution toward and away from the equator in winter and summer were observed (Best 1996; Cummings 1985).

Gulf of Mexico Large Marine Ecosystem. In the Gulf of Mexico, Bryde’s whales were sighted near the shelf break in DeSoto Canyon (Davis et al. 2000; Davis and Fargion 1996; Jefferson and Schiro 1997). Most of the sighting records of Bryde's whales in the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico) are from NMFS abundance surveys, which were conducted during the spring (Davis et al. 2000; Davis and Fargion 1996; Hansen et al. 1996; Hansen et al. 1995; Jefferson and Schiro 1997; Maze-Foley and Mullin 2006; Mullin and Fulling 2004; Mullin and Hoggard 2000). However, there are stranding records from throughout the year (Würsig et al. 2000).

4.1.1.5.3 Population and Abundance

The best estimate of the northern Gulf of Mexico stock is 15 with a minimum of five. There are insufficient data to assess population trends for this species (Waring et al. 2010).

4.1.1.6 Sei Whale (*Balaenoptera borealis*)

The sei whale is one of at least three genetically distinct species of medium-sized rorquals, including the so-called pygmy or dwarf Bryde’s whale (Kato and Perrin 2008; Rice 1998) and a new species, Omura’s whale (*Balaenoptera omurai*). Many aspects of sei whale behavior and ecology are poorly understood, and this species is one of the least known rorquals.

4.1.1.6.1 Status and Management

The sei whale is listed as endangered under the ESA and depleted under the MMPA. Critical habitat is not designated for sei whales. A recovery plan for the sei whale is currently in draft and available for public comment (National Marine Fisheries Service 2010a). There are two stocks for the sei whale in the North Atlantic: a Nova Scotia stock and a Labrador Sea stock (Waring et al. 2010). The Nova Scotia stock is considered the management unit under NMFS jurisdiction; it includes the continental shelf waters of the northeastern United States, and extends northeastward to south of Newfoundland.

4.1.1.6.2 Habitat and Geographic Range

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° N to 23° N and during the summer from 35° N to 50° N (Horwood 2009; Masaki 1976, 1977; Smultea et al. 2010). They are considered absent or at very low densities in most equatorial areas and in the Arctic Ocean (U.S. Department of Commerce 2010).

Sei whales spend the summer feeding in subpolar high latitudes and return to lower latitudes to calve in winter. Whaling data provide some evidence of varied migration patterns, based on reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood 1987; Perry et al. 1999). Sei whales are known to swim at speeds greater than 15 mi. (25 km) per hour and may be the fastest cetacean, after the fin whale (Horwood 1987; Jefferson et al. 2008b).

Labrador Current, North Atlantic Gyre, and Gulf Stream Open Ocean Areas. Sei whales are typically found in the open ocean and are rarely observed near the coast (Horwood 2009; Jefferson et al. 2008b). They are generally found between 10° and 70° latitudes. Satellite tagging data indicate sei whales feed and migrate east to west across large sections of the North Atlantic (Olsen et al. 2009); they are not often seen within the equatorial Atlantic. In the Study Area, the open ocean range includes the Labrador Current, North Atlantic Gyre, and Gulf Stream Open Ocean Areas.

Scotian Shelf and Northeast U.S. Continental Shelf Large Marine Ecosystems. The range of the Nova Scotia stock includes the continental shelf waters of the northeastern United States and extends northeastward to south of Newfoundland. During the feeding season, a large portion of the Nova Scotia sei whale stock is centered in northerly waters of the Scotian Shelf (Waring et al. 2010).

The southern portion of the species' range during spring and summer includes the northern portions of the U.S. Exclusive Economic Zone in the Atlantic Ocean, including the Gulf of Maine and Georges Bank. During spring and summer, sei whales occur in waters from the Bay of Fundy to northern Narragansett Bay. High concentrations are often observed along the northern flank, eastern tip, and southern shelf break of Georges Bank. During the fall, sei whales may be found in limited shelf areas of the Northeast Channel and in the western Gulf of Maine (Cetacean and Turtle Assessment Program 1982; Stimpert et al. 2003). Spring is the period of greatest abundance in Georges Bank and into the Northeast Channel area, along the Hydrographer Canyon (Cetacean and Turtle Assessment Program 1982; Waring et al. 2010).

4.1.1.6.3 Population and Abundance (Excerpts from Waring et al. [2010])

Commercial whaling in the 19th and 20th centuries depleted populations in all areas throughout the species' range, though they appear to be recovering in the northern hemisphere as a result of legal protection. Current global abundance is considered a minimum of 80,000 (Horwood 1987; Jefferson et al. 2008b). However, the abundance of sei whales in the Atlantic Ocean remains unknown. An August 2004 abundance estimate of 386 individuals is considered the best available for the Nova Scotia stock of sei whales. However, this estimate must be considered conservative in view of the known range of the sei whale in the entire western North Atlantic and the uncertainties regarding population structure and whale movements between surveyed and unsurveyed areas. The Nova Scotia stock minimum population estimate is 208 (Waring et al. 2010).

4.1.1.7 Fin Whale (*Balaenoptera physalus*)

The fin whale is found in all of the world's oceans, except the Arctic Ocean, and is the second largest species of whale (Jefferson et al. 2008b). Fin whales have two recognized subspecies: *Balaoptera physalus physalus* occurs in the North Atlantic Ocean while *B. p***.** *quoyi* occurs in the Southern Ocean.

4.1.1.7.1 Status and Management (Excerpts from Waring et al. [2010])

The fin whale is endangered under the ESA and is depleted under the MMPA. A final recovery plan was published in July 2010 for fin whales in U.S. waters. In the North Atlantic Ocean, the International Whaling Commission recognizes seven management stocks of fin whales: (1) Nova Scotia, (2) Newfoundland-Labrador, (3) West Greenland, (4) East Greenland-Iceland, (5) North Norway, (6) West Norway-Faroe Islands, and (7) British Isles-Spain-Portugal (U.S. Department of Commerce 2010). The western North Atlantic fin whale stock was assessed for management.

Fin whales off the eastern United States, Nova Scotia and the southeastern coast of Newfoundland are believed to constitute a single stock under the present International Whaling Commission scheme (Donovan 1991) and are currently considered the management unit under NMFS jurisdiction. However, the stock identity of North Atlantic fin whales has received relatively little attention, and whether the current stock boundaries define biologically isolated units has long been uncertain.

4.1.1.7.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Fin whales prefer temperate and polar waters and are rarely seen in warm tropical waters (Reeves et al. 2002a). They typically congregate in areas of high productivity and spend most of their time in coastal and shelf waters but can often be found in waters approximately 2,000 m deep (Aissi et al. 2008; Reeves et al. 2002a). Fin whales are often seen closer to shore after periodic patterns of upwelling (underwater motion) and the resultant increased krill density (Azzellino et al. 2008). This species is not known to have specific habitat preferences and is highly adaptable, following prey, typically off the continental shelf (Azzellino et al. 2008; Panigada et al. 2008).

Fin whales are common in waters of the U.S. Atlantic Exclusive Economic Zone, principally from Cape Hatteras northward. In the Study Area, fin whales occur in summer foraging areas from the coast of North America to the Arctic, around Greenland, Iceland, northern Norway, and the Barents Sea. In the western Atlantic, they winter from the edge of sea ice south to the Gulf of Mexico and the West Indies (U.S. Department of Commerce 2010).

Hain et al. (1992) suggested that calving takes place during October to January in latitudes of the U.S. mid-Atlantic region; however, it is unknown where calving, mating, and wintering occur for most of the population. Results from the Navy's Sound Surveillance System program (Clark 1995) indicate a substantial deep-ocean distribution of fin whales. It is likely that fin whales occurring in the U.S. Exclusive Economic Zone in the Atlantic Ocean undergo migrations into Canadian waters, open-ocean areas, and perhaps even subtropical or tropical regions. However, the popular notion that entire fin whale populations make distinct annual migrations like some other mysticetes has questionable support in the data; in the North Pacific, year-round monitoring of fin whale calls found no evidence for large-scale migratory movements (Watkins et al. 2000).

Labrador Current, Gulf Steam, and North Atlantic Gyre Open Ocean Areas. The open ocean range of the fin whale includes the Gulf Stream, North Atlantic Gyre, and Labrador Current Open Ocean Areas.

Northeast U.S. Continental Shelf Large Marine Ecosystem. Fin whales are common off the Atlantic coast of the United States in waters immediately off the coast seaward to the continental shelf (about the 1,000-fathom contour). In this region, they tend to occur north of Cape Hatteras where they accounted for about 46 percent of the large whales observed in surveys conducted between 1978 and 1982 (U.S. Department of Commerce 2010). During the summer, fin whales in this region tend to congregate in feeding areas between 41°20' N and 51°00' N, from shore seaward to the 1,000-fathom contour.

In the summer, fin whales are observed in the Gulf of Maine, the Bay of Fundy, the Gulf of St. Lawrence and St. Lawrence Estuary, and in offshore areas of Nova Scotia (Coakes et al. 2005; Johnston et al. 2005). Near the Bay of Fundy, fin whales are known to congregate close to the tip of Campobello Island, where they feed within localized upwellings and fronts in the Northeast U.S. Continental Shelf Large Marine Ecosystem (Johnston et al. 2005). New England waters are considered a major feeding ground for fin whales, and there is evidence that females continually return to this site (Waring et al. 2010). Forty-nine percent of fin whales sighted in the feeding grounds of Massachusetts Bay were sighted again within the same year, and 45 percent were sighted again in multiple years (Waring et al. 2010). Aerial observations in Onslow Bay, North Carolina, from August 2009 through August 2010 resulted in the sighting of a single fin whale (U.S. Department of the Navy 2010).

4.1.1.7.3 Population and Abundance

The best abundance estimate for the western North Atlantic fin whale stock is 3,985 (CV=0.24). The minimum population estimate for the western North Atlantic fin whale is 3,269 (Waring et al. 2010).

4.1.1.8 Blue Whale (*Balaenoptera musculus*)

Blue whales are the largest species of animal on earth and are divided into three subspecies – northern hemisphere blue whale (*Balaenoptera musculus musculus*), Antarctic blue whale (*Balaenoptera musculus intermedia*), and the pygmy blue whale (*Balaenoptera musculus brevicauda*).

4.1.1.8.1 Status and Management

Blue whales are listed as endangered under the ESA and depleted under the MMPA. Critical habitat is not designated for blue whales. A recovery plan is in place for the blue whale in U.S. waters (Reeves 1998b). Blue whales in the western North Atlantic are classified as a single stock (Waring et al. 2010).

Widespread whaling over the last century is believed to have decreased the population to approximately 1 percent of its pre-whaling population size, although some authors have concluded that their population numbers were about 200,000 animals before whaling (Branch 2007; Sirovic et al. 2004). There was a documented increase in the blue whale population size between 1979 and 1994, but there is no evidence to suggest an increase in the population since then (Barlow 1994; Barlow and Taylor 2001; Carretta et al. 2010).

4.1.1.8.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

The distribution of the blue whale in the western North Atlantic generally extends from the Arctic to at least mid-latitude waters. Blue whales are most frequently sighted in the waters off eastern Canada, with the majority of recent records from the Gulf of St. Lawrence (Sears et al. 1987). The blue whale is best considered as an occasional visitor in U.S. Atlantic Exclusive Economic Zone waters, which may represent the current southern limit of its feeding range (Cetacean and Turtle Assessment Program 1982; Wenzel et al. 1988). All five sightings described in the foregoing two references were in August. Yochem and Leatherwood (1985) summarized records that suggested an occurrence of this species south to Florida and the Gulf of Mexico, although the actual southern limit of the species' range is unknown. Using the U.S. Navy's Sound Surveillance System program, blue whales were detected and tracked acoustically in much of the North Atlantic, including in subtropical waters north of the West Indies and in deep water east of the U.S. Atlantic Exclusive Economic Zone, indicating the potential for long-distance movements (Clark 1995). Most of the acoustic detections were around the Grand Banks area of Newfoundland and west of the British Isles. Historical blue whale observations collected by Reeves et al. (2004) show a broad longitudinal distribution in tropical and warm temperate latitudes during the winter months, with a narrower, more northerly distribution in summer.

Newfoundland-Labrador Shelf Large Marine Ecosystem. Members of the North Atlantic population spend much of their time on continental shelf waters from eastern Canada (near the Quebec north shore) to the St. Lawrence Estuary and Strait of Belle Isle. Sightings were reported along the southern coast of Newfoundland during late winter and early spring (Reeves et al. 2004).

Scotian Shelf Large Marine Ecosystem. Blue whales are most frequently sighted in the waters off eastern Canada. Most records come from the Gulf of St. Lawrence (Waring et al. 2010).

Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems. Although the exact extent of their southern boundary and wintering grounds are not well understood, blue whales are occasionally found in waters off of the U.S. Atlantic coast (Waring et al. 2010).

Caribbean Sea and Gulf of Mexico Large Marine Ecosystems. Blue whale strandings have been recorded as far south as the Caribbean and the Gulf of Mexico (Waring et al. 2010).

4.1.1.8.3 Population and Abundance (Excerpts from Waring et al. [2010])

Little is known about the population size of blue whales in the Northwest Atlantic except for the Gulf of St. Lawrence area, and current data do not allow for an estimate of abundance of this stock. Mitchell (1974) estimated that the blue whale population in the western North Atlantic may number only in the low hundreds. The photo identification catalogue count of 440 recognizable individuals from the Gulf of St. Lawrence is considered a minimum population estimate for the western North Atlantic stock.

4.1.2 ODONTOCETES

4.1.2.1 Sperm Whale (*Physeter macrocephalus*)

Sperm whales are the largest of the odontocetes (toothed whales) and the most sexually dimorphic cetaceans, with males considerably larger than females. Interestingly, the sperm whale's extremely large head takes up to 25 to 35 percent of its total body length.

4.1.2.1.1 Status and Management

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009b) and is depleted under the MMPA. Critical habitat is not designated for sperm whales. There are currently three stocks of sperm whales recognized within the Study Area managed under NMFS jurisdiction: North Atlantic, Gulf of Mexico, and Puerto Rico and U.S. Virgin Islands stocks.

4.1.2.1.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Sperm whales are found throughout the world's oceans in deep waters to the edge of the ice at both poles (Leatherwood and Reeves 1983; Rice 1989; Whitehead 2002). Sperm whales show a strong preference for deep waters (Rice 1989; Whitehead 2003). Their distribution is typically associated with waters over the continental shelf break, over the continental slope, and into deeper waters. However, in some areas, adult males are reported to consistently frequent waters with bottom depths less than 330 ft. (100 m) and as shallow as 40 m (Jefferson et al. 2008b; Romero et al. 2001). 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 and Praca 2007; Jefferson et al. 2008b).

The distribution of the sperm whale in the U.S. Exclusive Economic Zone occurs on the continental shelf edge, over the continental slope, and into mid-ocean regions. Waring et al. (1993; Waring et al. 2001) suggest that this offshore distribution is more commonly associated with the Gulf Stream edge and other features. However, the sperm whales that occur in the eastern U.S. Exclusive Economic Zone in the Atlantic Ocean likely represent only a fraction of the total stock. The nature of linkages of the U.S. habitat with those to the south, north, and offshore is unknown. Historical whaling records compiled by Schmidly (1981) suggested an offshore distribution off the southeast United States, over the Blake Plateau, and into deep ocean waters. In the southeast Caribbean, both large and small adults, as well as calves and juveniles of different sizes are reported (Watkins et al. 1985). Whether the northwestern Atlantic population is discrete from northeastern Atlantic is currently unresolved. The International Whaling Commission recognizes one stock for the North Atlantic, based on reviews of many types of stock studies (i.e., tagging, genetics, catch data, mark-recapture, biochemical markers, etc.).

In winter, sperm whales are concentrated east and northeast of Cape Hatteras. In spring, the center of distribution shifts northward to east of Delaware and Virginia and is widespread throughout the central portion of the mid-Atlantic Bight and the southern portion of Georges Bank. In summer, the distribution is similar but now also includes the area east and north of Georges Bank and into the Northeast Channel region, as well as the continental shelf (inshore of the 100-m isobath) south of New England. In the fall, sperm whale occurrence south of New England on the continental shelf is at its highest level, and there remains a continental shelf edge occurrence in the mid-Atlantic Bight. Similar inshore (less than 200 m) observations were made on the southwestern and eastern Scotian Shelf, particularly in the region of "the Gully" (Whitehead and Weilgart 1991).

Gulf Stream and North Atlantic Gyre Open Ocean Areas. Sperm whales are found throughout the Gulf Stream and North Atlantic Gyre. In 1972, extensive survey cruises covering much of the western and central North Atlantic Ocean found high densities of sperm whales in the Gulf Stream region, between 40° N and 50° N, over the North Atlantic Ridge (National Marine Fisheries Service 2006).

Newfoundland-Labrador Shelf Large Marine Ecosystem. High densities of sperm whales were found in the Grand Banks of Newfoundland (National Marine Fisheries Service 2006).

Scotian Shelf Large Marine Ecosystem. Off Nova Scotia, coastal whalers found sperm whales primarily in deep continental slope waters, especially in submarine canyons and around the edges of banks. During late spring and throughout the summer, this species is found on the continental shelf in waters less than 100 m deep on the southern Scotian Shelf and into the northeast United States (National Marine Fisheries Service 2006; Palka 2006).

Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems. Distribution along the east coast of the United States is centered along the shelf break and over the slope. During winter, high densities occur in inner slope waters east and northeast of Cape Hatteras, North Carolina (National Marine Fisheries Service 2006; Palka 2006; Waring et al. 2010). In spring, distribution shifts northward to Delaware and Virginia, and the southern portion of Georges Bank. Summer and fall distribution is similar, extending to the eastern and northern portions of Georges Bank and north into the Scotian Shelf. Occurrence south of New England on the continental shelf is highest in the fall (Waring et al. 2010). Aerial surveys in August 2009 off the Virginia coast resulted in the sighting of two sperm whales (U.S. Department of the Navy 2010). Aerial observations in Onslow Bay, North Carolina, from August 2009 through August 2010 resulted in the sighting of one sperm whale (U.S. Department of the Navy 2010). Aerial surveys conducted between August 2009 and August 2010 off Jacksonville, Florida resulted in the sighting of one sperm whale.

Gulf of Mexico Large Marine Ecosystem. The sperm whale is the most common large cetacean in the northern Gulf of Mexico (Palka and Johnson 2007). Sperm whales aggregate at the mouth of the Mississippi River and along the continental slope in or near cyclonic cold-core eddies (counterclockwise water movements in the northern hemisphere with a cold center) (Davis et al. 2007). O'Hern and Biggs (2009) showed that most sperm whale groups were found within regions of enhanced sea surface chlorophyll. The distribution of sperm whales in the Gulf of Mexico is strongly linked to surface oceanography, such as loop current eddies that locally increase production and availability of prey (O'Hern and Biggs 2009). In the north-central Gulf of Mexico, sperm whales are especially common near the Mississippi Canyon, where some are present year-round, and mixed groups of females and bachelor groups of males are found.

In the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico), systematic aerial and ship surveys indicate that sperm whales inhabit continental slope and oceanic waters where they are widely distributed (Fulling et al. 2003; Maze-Foley and Mullin 2006; Mullin and Fulling 2004; Mullin and Hoggard 2000; Mullin et al. 2004). Seasonal aerial surveys confirm that sperm whales are present in the northern Gulf of Mexico in all seasons (Hansen et al. 1996; Mullin et al. 1994a; Mullin and Hoggard 2000). The information for southern Gulf of Mexico waters is more limited, but there are sighting and stranding records from each season with sightings widely distributed in continental slope waters of the western Bay of Campeche (Ortega-Ortiz 2002).

Caribbean Sea Large Marine Ecosystem. In waters surrounding Puerto Rico and the U.S. Virgin Islands, NMFS winter ship surveys indicate that sperm whales inhabit continental slope and oceanic waters (Roden and Mullin 2000; Swartz and Burks 2000; Swartz et al. 2002). Earlier sightings from the northeastern Caribbean were reported by Erdman (1970), Erdman et al. (1973) and Taruski and Winn (1976), and these and other sightings from Puerto Rican waters are summarized by Mignucci-Giannoni (1988). Mignucci-Giannoni found 43 records for sperm whales up to 1989 for waters of Puerto Rico, U.S. Virgin Islands, and British Virgin Islands, and suggested they occur from late fall through winter and early spring but are rare from April to September. In addition, sperm whales are one of the most common species to strand in waters of Puerto Rico and the Virgin Islands (Mignucci-Giannoni et al. 1999).

4.1.2.1.3 Population and Abundance (Excerpts from Waring et al. [2010])

The number of sperm whales off the United States and Canadian Atlantic coasts is unknown. In 2004, a survey of waters from Maryland to the Bay of Fundy yielded an abundance estimate of 2,607, and a survey of waters from Florida to Maryland resulted in an abundance estimate of 2,197 (Palka 2006; Waring et al. 2010). The best abundance estimate for Atlantic sperm whales is 4,804 (CV=0.38), which is the sum of the estimates from these two U.S. Atlantic surveys (Waring et al. 2010). This joint estimate is considered best because together these two surveys have the most complete coverage of the species' habitat. Because all the sperm whale estimates presented here were not corrected for dive-time, they are likely downwardly biased and an underestimate of actual abundance. The minimum population estimate for the western North Atlantic sperm whale is 3,539.

The best abundance estimate available for northern Gulf of Mexico sperm whales is 1,665 (CV=0.20) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone. The minimum population estimate for the northern Gulf of Mexico is 1,409 sperm whales.

The best abundance estimate available for the Puerto Rico and U.S. Virgin Islands stock of sperm whales is unknown and data are currently insufficient to calculate a minimum population estimate for this stock of sperm whales.

4.1.2.2 Dwarf/Pygmy Sperm Whale (*Kogia sima* and *Kogia breviceps*)

Before 1966, dwarf and pygmy sperm whales were thought to be a single species, until form and structure distinction was shown (Handley 1966); misidentifications of these two species are still common (Jefferson et al. 2008b). *Kogia* species are not often observed at sea, but they are among the more frequently stranded cetaceans (Caldwell and Caldwell 1989; Jefferson et al. 2008b; McAlpine 2009). Rare sightings indicate they may avoid human activity, and they are rarely active at the sea surface. They usually appear slow and sluggish, often resting motionless at the surface with no visible blow (Baird 2005; Jefferson et al. 2008b).

4.1.2.2.1 Status and Management

Kogia species are protected under the MMPA but not listed under the ESA. Although virtually nothing is known of population status for these species, stranding frequency suggests they may not be as uncommon as sighting records would suggest (Jefferson et al. 2008b; Maldini et al. 2005). The western North Atlantic population and the northern Gulf of Mexico population are considered separate stocks for management purposes, but there is no genetic evidence that these two populations differ (Waring et al. 2010).

4.1.2.2.2 Habitat and Geographic Range

Dwarf and pygmy sperm whales appear to be distributed worldwide in temperate to tropical waters (Caldwell and Caldwell 1989; McAlpine 2002). *Kogia* can occur close to shore and sometimes over the outer continental shelf. However, several studies show that they may also generally occur beyond the continental shelf edge (Bloodworth and Odell 2008; MacLeod et al. 2004). The pygmy sperm whale may frequent more temperate habitats than the dwarf sperm whale, which is more of a tropical species.

Data from the Gulf of Mexico suggest that *Kogia* species may associate with frontal regions along the continental shelf break and upper continental slope, where squid densities are higher (Baumgartner et al. 2001; Jefferson et al. 2008b). Although deep oceanic waters may be the primary habitat for this species, there are very few oceanic sighting records offshore. The lack of sightings may have more to do with the difficulty of detecting and identifying these animals at sea and lack of effort, than with any real distributional preferences.

In the Study Area, this species is found primarily in the Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems, the Gulf of Mexico, and Caribbean Sea (Bloodworth and Odell 2008; Caldwell and Caldwell 1989; Cardona-Maldonado and Mignucci-Giannoni 1999). A stranded pygmy sperm on the north shore of the Gulf of St. Lawrence represents the northernmost record for this species in the western Atlantic (Measures et al. 2004).

Pygmy sperm whales were one of the most commonly sighted species in the northern Gulf of Mexico from 1992 to 1994 and from 1996 to 2001 (Mullin and Fulling 2004). Fulling and Fertl (2003)noted a concentration of sightings in continental slope waters near the Mississippi River Delta. The delta is considered an important area for cetaceans in the northern Gulf of Mexico because of its high levels of productivity associated with oceanographic features.

4.1.2.2.3 Population and Abundance

Due to the difficulty distinguishing between pygmy and dwarf sperm whales during surveys, abundance estimates are applied to both species. The best estimate for pygmy and dwarf sperm whales in the U.S. Atlantic is 395 (CV=0.40), which is the sum of estimates from two 2004 surveys, one in the northern U.S. Atlantic (358) and one in the southern U.S. Atlantic (37) (Waring et al. 2010). The best estimate for pygmy and dwarf sperm whales in the northern Gulf of Mexico is 453 (CV=0.35) (Waring et al. 2010).

4.1.2.3 Beluga Whale (*Delphinapterus leucas*)

The beluga whale is a member of the family Monodontidae, which it shares with the narwhal, *Monodon monoceros.* Belugas can be confused with female narwhals, which overlap with their range and are superficially similar in appearance.

4.1.2.3.1 Status and Management

Beluga whales are protected under the MMPA although the only stock that is managed under NMFS jurisdiction occurs outside of the Study Area, in Cook Inlet, Alaska. There are three recognized stocks of belugas that may occur within the Study Area: St. Lawrence, Eastern High Arctic/Baffin Bay, and West Greenland (Jefferson et al. 2008b). These stocks are endangered under Canada's Species at Risk Act (Her Majesty the Queen in Right of Canada 2003).

4.1.2.3.2 Habitat and Geographic Range

This species' distribution nearly spans the Arctic and is found only in high latitudes of the northern hemisphere. Belugas are found in Arctic and subarctic waters along the northern coasts of Canada, Alaska, Russia, Norway, and Greenland (O'Corry-Crowe 2008; Stewart and Stewart 1989). Distribution is centered mainly between 49° N and 80° N from the west coast of Greenland to eastern Scandinavia.

Belugas occur primarily in shallow coastal waters, as shallow as 1 to 3 m. They can also be found in offshore waters greater than 800 m deep (Jefferson et al. 2008a; Richard et al. 2001). During the winter, belugas are believed to occur in offshore waters associated with pack ice, but little is known about the distribution, ecology, or behavior in winter. In most regions, belugas are believed to migrate in the direction of the advancing polar ice front. However, in some areas they may remain behind this front and overwinter in enclosed areas of unfrozen water and ice leads. In the spring, they migrate to warmer shallow water in coastal estuaries, bays, and rivers for molting and calving (North Atlantic Marine Mammal Commission 2000).

West Greenland Shelf and Newfoundland-Labrador Shelf Large Marine Ecosystems. This species is known to occur in the extreme northwestern portion of the Study Area. The St. Lawrence Estuary is at the southern limit of the distribution of this species (Jefferson et al. 2008a; O'Corry-Crowe 2008). A population of greater than 1,100 is known to reside in the St. Lawrence Estuary year-round (Lebeuf et al. 2007). On the west coast of Greenland, belugas are found from Qaanaaq in the north to Paamiut in the south in the fall, winter, and spring. Belugas are rare along this coast in summer (North Atlantic Marine Mammal Commission 2000).

4.1.2.3.3 Population and Abundance

The global population is relatively well studied and is estimated at 150,000 (Jefferson et al. 2008a; O'Corry-Crowe 2008). The St. Lawrence stock is estimated at 900 to 1,000, the Eastern High Arctic/Baffin Bay stock at 21,213, and the West Greenland stock at 7,941 (Jefferson et al. 2008a).

4.1.2.4 Narwhal (*Monodon monoceros*)

Narwhals, along with beluga whales, are members of the Monodontidae family, sometimes referred to as the "white whales.” The most conspicuous characteristic of the male narwhal is its single 7–10 ft. (2–3 m) long tusk, an incisor tooth that projects from the left side of the upper jaw.

4.1.2.4.1 Status and Management

The narwhal is not listed under the ESA and is protected under the MMPA. There is no stock that occurs in the U.S. Exclusive Economic Zone in the Atlantic Ocean; however, populations from Hudson Strait and Davis Strait may extend into the Study Area at its northwest extreme (Heide-Jorgensen 2009).

4.1.2.4.2 Habitat and Geographic Range

Being the cetacean with the northernmost range, narwhals prefer cold Arctic waters. They are also known to be a deepwater species. In the summer, they are found in more northern areas, and as ice begins to form, they tend to follow the ice to more open waters for the winter. They are often found in deep fjords and cracks and leads in the ice (Heide-Jorgensen 2009; Reeves and Tracey 1980).

Newfoundland-Labrador Shelf Large Marine Ecosystem. Narwhals winter in the regions of Hudson Strait and Baffin Bay-Davis Strait, as well as Disko Bay. Narwhals wintering in Hudson Strait in smaller numbers are assumed to belong to the northern Hudson Bay summer population. Tagged narwhals in the summering grounds in Admiralty Inlet showed their annual migration following the ice during the autumn to more open waters of Melville Bay and Eclipse Sound in central and southern Baffin Bay and northern Davis Strait (Dietz et al. 2008; Heide-Jorgensen 2009). Before the fast ice forms in the fall, narwhals move into deep water along the edge of the continental shelf, with depths of up to 1,000 to 2,000 m (Heide-Jorgensen 2009).

4.1.2.4.3 Population and Abundance

Global population abundance is estimated at more than 50,000, including about 35,000 in northern Davis Strait and Baffin Bay, 1,300 in Hudson Strait, and 300 in Scoresby Sound (Heide-Jorgensen 2009; Jefferson et al. 2008b). Recent estimates of abundance for the wintering grounds of west Greenland are of about 7,819 (Heide-Jorgensen 2009).

4.1.2.5 Beaked Whales (Various Species)

Based upon available data, six beaked whales are known in the western North Atlantic Ocean: Cuvier's beaked whale (*Ziphius cavirostris*), northern bottlenose whale (*Hyperoodon ampullatus*), and four members of the genus *Mesoplodon* — True's (*M. mirus*), Gervais' (*M. europaeus*), Blainville's (*M. densirostris*), and Sowerby's (*M. bidens*) beaked whales, which, with the exception of *Ziphius* and *Hyperoodon*, are nearly indistinguishable at sea (Coles 2001). *Ziphius* and three species of *Mesoplodon* (Blainville's, Gervais', and Sowerby's) are known to occur in the Gulf of Mexico, based on stranding or sighting data (Hansen et al. 1995; Würsig et al. 2000). Sowerby's beaked whale in the Gulf of Mexico is considered extralimital because there is only one known stranding of this species (Bonde and O'Shea 1989) and because it normally occurs in northern temperate waters of the North Atlantic (Mead 1989a). Because of the scarcity of biological information available for individual species, the difficulty of species-level identifications for *Mesoplodon* species, and the lack of data on individual stock structure and abundance estimates, *Ziphius* and *Mesoplodon* species are presented collectively here with species-specific information if available.

4.1.2.5.1 Status and Management

All beaked whales are protected under the MMPA but none are listed under the ESA. Stock structure in the Atlantic and Gulf of Mexico is unknown; however, stocks in the Atlantic and Gulf of Mexico are assumed to be separate for management purposes.

4.1.2.5.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Collectively, beaked whales occur in all regions of the Study Area but may be most common in the Northeast and Southeast U.S. Continental Shelf, Caribbean Sea, and Gulf of Mexico Large Marine Ecosystems. The continental shelf margins from Cape Hatteras to southern Nova Scotia were recently identified as known key areas for beaked whales in a global review by MacLeod and Mitchell (2006). MacLeod and Mitchell (2006) also described the northern Gulf of Mexico continental shelf margin as "a key area" for beaked whales. Beaked whales were seen in all seasons during GulfCet aerial surveys of the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico) (Hansen et al. 1996; Mullin and Hoggard 2000). Some of the aerial survey sightings may have included Cuvier's beaked whale, but identification of beaked whale species from aerial surveys is problematic. Beaked whale sightings made during spring and summer vessel surveys were widely distributed in waters greater than 500 m deep.

Cuvier's beaked whale is one of the more commonly seen and the best known. Similar to other beaked whale species, this oceanic species generally occurs in waters past the edge of the continental shelf and occupies almost all temperate, subtropical, and tropical waters of the world, as well as subpolar and even polar waters in some areas. The distribution of Cuvier's beaked whales is poorly known, and is based mainly on stranding records (Leatherwood et al. 1976). Strandings were reported from Nova Scotia along the eastern U.S. coast south to Florida, around the Gulf of Mexico, and within the Caribbean (Cetacean and Turtle Assessment Program 1982; Heyning 1989; Houston 1990; Leatherwood et al. 1976; MacLeod 2006; Mignucci-Giannoni et al. 1999). Cuvier's beaked whale sightings have occurred principally along the continental shelf edge in the mid-Atlantic region off the northeast U.S. coast (Cetacean and Turtle Assessment Program 1982; Hamazaki 2002; Palka 2006; Waring et al. 1992; Waring et al. 2001) in late spring or summer, although strandings and sightings were reported in the Caribbean Sea and the Gulf of Mexico as well (Dalebout et al. 2006). Cuvier's beaked whales are generally sighted in waters with a bottom depth greater than 200 m and are frequently recorded in waters with bottom depths greater than 1,000 m (Falcone et al. 2009; Jefferson et al. 2008b).

True's beaked whales appear to occur only in temperate waters, and possibly only in warm temperate waters. Most records of it occurring in the northwest Atlantic suggest a probable relation with the Gulf Stream (MacLeod 2000; Mead 1989b).

Gervais' beaked whale occurs only in the Atlantic Ocean and Gulf of Mexico, within a range both north and south of the equator to a latitude of 40° (Jefferson et al. 2008b; MacLeod 2006). Although the distribution seems to range across the entire temperate and tropical Atlantic, most records are from the western North Atlantic waters from New York to Texas (more than 40 published records).

Sowerby's beaked whales appear to inhabit more temperate waters than many other members of the genus and are the most northerly distributed of Atlantic species of *Mesoplodon*, found in cold temperate waters of the North Atlantic Ocean, generally north of 30˚ N. In the Study Area, they range from Massachusetts to Labrador (MacLeod et al. 2006; Mead 1989a). There were several at-sea sightings off Nova Scotia and Newfoundland, from New England waters north to the ice pack (MacLeod et al. 2006; Waring et al. 2010). Sowerby's beaked whale may be found within the Northeast U.S. Continental Shelf, Newfoundland-Labrador Shelf, and Scotian Shelf Large Marine Ecosystems as well as the Labrador Current Open Ocean Area.

Blainville's beaked whales are one of the most widely distributed of the distinctive toothed whales in the *Mesoplodon* genus (Jefferson et al. 2008b; MacLeod et al. 2006). In the Study Area, this species is known to occur in enclosed deepwater seas, such as the Gulf of Mexico and Caribbean Sea. There are records for this species from the eastern coast of the United States and Canada, from as far north as Nova Scotia (Northeastern U.S. Continental Shelf and Newfoundland-Labrador Shelf Large Marine Ecosystems), and south to Florida and the Bahamas within the Southeastern U.S. Continental Shelf Large Marine Ecosystem (MacLeod and Mitchell 2006; Mead 1989a).

4.1.2.5.3 Population and Abundance (Excerpts from Waring et al. [2010])

The best abundance estimate for the undifferentiated complex of beaked whales (*Ziphius* and *Mesoplodon* species) in the northwest Atlantic is the sum of the estimates from two 2004 U.S. Atlantic surveys, 3,513 (CV=0.63), where the estimate from the northern U.S. Atlantic is 2,839 (CV=0.78) and from the southern U.S. Atlantic is 674 (CV=0.36). This joint estimate is considered to be the best because these two surveys cover most of the species' habitat (Waring et al. 2010).

The best abundance estimate available for Cuvier's beaked whales in the northern Gulf of Mexico is 65 (CV=0.67). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone. However, this abundance estimate is negatively biased because only sightings of beaked whales that could be positively identified to species were used. The best available abundance estimate for *Mesoplodon* species is a combined estimate for Blainville's beaked whale and Gervais' beaked whale. The estimate of abundance for *Mesoplodon* species in oceanic waters of the Gulf of Mexico, using data pooled from summer 2003 and spring 2004 oceanic surveys, is 57 (CV=1.40).

4.1.2.6 Northern Bottlenose Whale (*Hyperoodon ampullatus*)

4.1.2.6.1 Status and Management

The northern bottlenose whale is not listed under the ESA but is protected under the MMPA. There are two populations of northern bottlenose whales in the western north Atlantic: one in the area just north of Sable Island referred to as the Gully, and a second in Davis Strait off northern Labrador. The Gully is a unique ecosystem that appears to have long provided a stable year-round habitat for a distinct population of bottlenose whales (Dalebout et al. 2006).

4.1.2.6.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Northern bottlenose whales are distributed in the North Atlantic from Nova Scotia to about 70° in the Davis Strait, along the east coast of Greenland to 77° and from England to the west coast of Spitzbergen. It is largely a deep-water species and is very seldom found in waters less than 2,000 m deep (Mead 1989b). There are two main centers of bottlenose whale distribution in the western North Atlantic, the Gully and Davis Strait (Reeves et al. 1993). The northern bottlenose whale occurs from New England to Baffin Island and to southern Greenland. Strandings as far south as North Carolina were observed, although that is outside of the natural range or at the edge of the southern range for this more subarctic species (Jefferson et al. 2008b; MacLeod et al. 2006).

4.1.2.6.3 Population and Abundance

Current estimates of abundance are around 40,000 in the eastern North Atlantic, but population estimates for this species along the eastern U.S. coast are unknown (Jefferson et al. 2008b; Palka 2006; Waring et al. 2010). Abundance estimates for the Gully population, derived from studies at the entrance to the Gully from 1988 to 1995, estimated the population to be around 230 (Waring et al. 2010). Wimmer and Whitehead (2004) observed individuals moving between several Scotian Shelf canyons more than 62 mi. (100 km) from the Gully and estimated a population of 163 (Waring et al. 2010; Wimmer and Whitehead 2004).

4.1.2.7 Rough-Toothed Dolphin (*Steno bredanensis*)

4.1.2.7.1 Status and Management

This species is not listed under the ESA but is protected under the MMPA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available on population status (Jefferson 2009; Jefferson et al. 2008b). The east U.S. Atlantic and Gulf of Mexico populations of the rough-toothed dolphin are considered two separate stocks for management purposes, but there is insufficient genetic information to differentiate these stocks (Waring et al. 2010).

4.1.2.7.2 Population and Abundance (Excerpts from Waring et al. [2010])

The number of rough-toothed dolphins off the eastern United States and Canadian Atlantic coast is unknown, and seasonal abundance estimates are not available for this stock, since it was rarely seen during surveys. Three rough-toothed dolphins were observed from a ship in July 1998 during a line-transect sighting survey conducted from 6 July to 6 September 1998 by a ship and plane that surveyed 25,588.57 mi. (15,900 km) of track line in waters north of Maryland (38°N) (Palka 2006). An abundance estimate of 30 (CV=0.86) was calculated based on this one sighting.

4.1.2.7.3 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

The distribution of the rough-toothed dolphin is poorly understood worldwide. These dolphins are thought to be a tropical to warm-temperate species, and historically have been reported in deep oceanic waters in the Atlantic, Pacific, and Indian Oceans and the Mediterranean and Caribbean Seas (Gannier and West 2005; Leatherwood and Reeves 1983; Perrin and Walker 1975; Reeves et al. 2003). Rough-toothed dolphins were, however, observed in both shelf and oceanic waters in the northern Gulf of Mexico (Fulling et al. 2003; Mullin and Fulling 2003). In the western North Atlantic, tracking of five rough-toothed dolphins that were rehabilitated and released following a mass stranding on the east coast of Florida in 2005, demonstrated a variety of ranging patterns (Wells et al. 2008). All tagged rough-toothed dolphins moved through a large range of water depths averaging greater than 100 ft. (30 m), though each of the five tagged dolphins transited through very shallow waters at some point, with most of the collective movements recorded over a gently sloping sea floor.

4.1.2.8 Bottlenose Dolphin (*Tursiops truncatus*)

4.1.2.8.1 Status and Management

This species is not listed under the ESA but is protected under the MMPA. Along the U.S. east coast and northern Gulf of Mexico, the bottlenose dolphin stock structure is well studied. There are currently 52 management stocks identified by NMFS in the western North Atlantic and Gulf of Mexico, including oceanic, coastal, and estuarine stocks (Waring et al. 2010). Most stocks in the Study Area are designated as Strategic or Depleted under the MMPA. For a complete listing of currently identified stocks within the Study Area, see Table 3-1.

4.1.2.8.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

The bottlenose dolphin occurs in tropical to temperate waters of the Atlantic Ocean as well as inshore, nearshore, and offshore waters of the Gulf of Mexico and U.S. east coast. They generally do not range north or south of 45° latitude (Jefferson et al. 2008b; Wells and Scott 2008). They occur in most enclosed or semi-enclosed seas in habitats ranging from shallow, murky, estuarine waters to also deep, clear offshore waters in oceanic regions (Jefferson et al. 2008b; Wells et al. 2009). Bottlenose dolphins are also often found in bays, lagoons, channels, and river mouths and are known to occur in very deep waters of some ocean regions. Open ocean populations occur far from land; however, population density appears to be highest in nearshore areas (Scott and Chivers 1990).

There are two morphologically and genetically distinct bottlenose dolphin morphotypes (distinguished by physical differences)(Duffield 1987; Duffield et al. 1983) described as the coastal and offshore forms. Both inhabit waters in the western North Atlantic Ocean and Gulf of Mexico (Curry and Smith 1997; Hersh and Duffield 1990; Mead and Potter 1995) along the U.S. Atlantic coast. The coastal morphotype of bottlenose dolphin is continuously distributed along the Atlantic coast south of Long Island, New York, around the Florida peninsula, and along the Gulf of Mexico coast. North of Cape Hatteras, the two morphotypes are separated across bathymetry during summer months. Aerial surveys flown during 1979–1981 indicated a concentration of bottlenose dolphins in waters less than 7.6 ft. (25 m) deep corresponding to the coastal morphotype, and an area of high abundance along the shelf break corresponding to the offshore stock (Cetacean and Turtle Assessment Program 1982; Kenney 1990). However, during winter months and south of Cape Hatteras, North Carolina, the range of the coastal and offshore morphotypes overlap to some degree.

Seasonally, bottlenose dolphins occur over the outer continental shelf and inner slope as far north as Georges Bank (Cetacean and Turtle Assessment Program 1982; Kenney 1990). Sightings occurred along the continental shelf break from Georges Bank to Cape Hatteras during spring and summer (Cetacean and Turtle Assessment Program 1982; Kenney 1990). In Canadian waters, bottlenose dolphins were occasionally sighted on the Scotian Shelf, particularly in the Gully (Gowans and Whitehead 1995). The range of the offshore bottlenose dolphin includes waters beyond the continental slope (Kenney 1990), and offshore bottlenose dolphins may move between the Gulf of Mexico and the Atlantic (Wells et al. 1999). Dolphins with characteristics of the offshore type have stranded as far south as the Florida Keys.

Initially, a single stock of coastal morphotype bottlenose dolphins was thought to migrate seasonally between New Jersey (summer months) and central Florida based on seasonal patterns in strandings during a large scale mortality event occurring during 1987–1988 (Scott et al. 1988). However, reanalysis of stranding data (McLellan et al. 2002) and extensive analysis of genetic (Rosel et al. 2009), photo-identification (Zolman 2002), and satellite telemetry (Southeast Fisheries Science Center, unpublished data) data demonstrate a complex mosaic of coastal bottlenose dolphin stocks. Integrated analysis of these multiple lines of evidence suggests that there are five coastal stocks of bottlenose dolphins: the Northern Migratory stock and Southern Migratory stock, a South Carolina/Georgia Coastal stock, a Northern Florida Coastal stock, and a Central Florida Coastal stock (Waring et al. 2010). Similarly, five coastal or open ocean stocks are identified in the Gulf of Mexico: Continental Shelf, eastern coastal, northern coastal, western coastal, and oceanic (Waring et al. 2010).

Several lines of evidence support a distinction between dolphins inhabiting coastal waters near the shore and those present primarily in the inshore waters of the bays, sounds, and estuaries. Photo-identification and genetic studies support the existence of resident estuarine animals in several areas (Caldwell 2001; Gubbins 2002; Gubbins et al. 2003; Litz 2007; Mazzoil et al. 2005; Zolman 2002), and similar patterns were observed in bays and estuaries along the Gulf of Mexico coast (Balmer et al. 2008; Wells et al. 1987). There are 41 individual stocks resident in bays, sounds, and estuaries from North Carolina through the Gulf of Mexico, with 32 recognized in the Gulf of Mexico alone, although the structure of these stocks is uncertain but appears to be complex.

4.1.2.8.3 Population and Abundance

Although abundance is not estimated for all stocks that occur in U.S. Atlantic and Gulf of Mexico waters, there are estimated to be over 100,000 individuals in the U.S. Atlantic and 35,000–45,000 in the Gulf of Mexico (Waring et al. 2010). Current estimates used by NMFS for management are summarized in Table 3-1.

4.1.2.9 Pantropical Spotted Dolphin (*Stenella attenuata*)

4.1.2.9.1 Status and Management

This species is not listed under the ESA but is protected under the MMPA. The western North Atlantic and northern Gulf of Mexico populations are considered separate stocks for management purposes, although there is currently not enough information to distinguish them (Waring et al. 2010).

4.1.2.9.2 Geographic Range (Excerpts from Waring et al. [2010])

The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Atlantic Ocean between about 40° N and 40° S (Baldwin et al. 1999; Perrin 2008b). The species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al. 2008b; Perrin 2001). Most sightings of this species in the Gulf of Mexico and Caribbean occur over the lower continental slope (Mignucci-Giannoni et al. 2003; Moreno et al. 2005). Pantropical spotted dolphins in the offshore Gulf of Mexico do not appear to have a preference for any one specific habitat type, such as within the Loop Current, inside cold-core eddies, or along the continental slope (Baumgartner et al. 2001).

Northeast U.S. and Southeast U.S. Continental Shelf and Gulf of Mexico Large Marine Ecosystems. The pantropical spotted dolphin is the most commonly sighted species of cetacean in the oceanic waters of the northern Gulf of Mexico. Pantropical spotted dolphins were seen in all seasons during GulfCet aerial surveys of the northern Gulf of Mexico between 1992 and 1998 (Hansen et al. 1996; Mullin and Hoggard 2000). Along the U.S. Atlantic coast, sightings have concentrated in the slope waters north of Cape Hatteras, but in the shelf waters south of Cape Hatteras sightings extend into the deeper slope and offshore waters of the mid-Atlantic.

4.1.2.9.3 Population and Abundance (Excerpts from Waring et al. [2010])

The best recent abundance estimate for western North Atlantic stock of pantropical spotted dolphins is 4,439 (CV=0.49). This is the sum of estimates from two 2004 western U.S. Atlantic surveys and is considered best because these two surveys together have the most complete coverage of the species' habitat. The minimum population estimate for this stock is 3,010.

The best abundance estimate available for northern Gulf of Mexico pantropical spotted dolphins is 34,067 (CV=0.18) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobaths to the seaward extent of the U.S. Exclusive Economic Zone.

4.1.2.10 Atlantic Spotted Dolphin (*Stenella frontalis*)

4.1.2.10.1 Status and Management (Excerpts from Waring et al. [2010])

The Atlantic spotted dolphin is not listed under the ESA but is protected under the MMPA. The Atlantic spotted dolphin occurs in two forms that may be distinct subspecies (Perrin et al. 1994a; Perrin et al. 1987; Rice 1998): the large, heavily spotted form which inhabits the continental shelf and is usually found inside or near the 200-m isobath; and the smaller, less spotted island and offshore form which occurs in the Atlantic Ocean but is not known to occur in the Gulf of Mexico (Fulling et al. 2003; Mullin and Fulling 2003, 2004). The western North Atlantic population is provisionally being considered a separate stock from the Gulf of Mexico stock(s) for management purposes based on genetic analysis.

4.1.2.10.2 Habitat and Geographic Range

The Atlantic spotted dolphin is found in nearshore tropical to warm-temperate waters, predominantly over the continental shelf and upper slope. In the eastern Gulf of Mexico, for instance, the species often occurs over the mid-shelf (Griffin and Griffin 2003). In the western Atlantic, this species is distributed from New England to Brazil and is found in the Gulf of Mexico as well as the Caribbean Sea (Perrin 2008a).

In the Study Area, this species' primary range extends into the Gulf Stream Open Ocean Area and throughout the Southeast U.S. Continental Shelf, Gulf of Mexico, and Caribbean Sea Large Marine Ecosystems (Fulling et al. 2003; Mullin and Fulling 2003, 2004; Roden and Mullin 2000). The large, heavily spotted coastal form of the Atlantic spotted dolphin typically occurs over the continental shelf but usually at least 4.9 to 12.4 mi. (8 to 20 km) offshore (Davis et al. 1998; Perrin 2002; Perrin et al. 1994a). Higher numbers of spotted dolphins are reported over the west Florida continental shelf (Southeast U.S. Continental Shelf Large Marine Ecosystem) from November to May than during the rest of the year, suggesting that this species may migrate seasonally (Griffin and Griffin 2003).

4.1.2.10.3 Population and Abundance (Excerpts from Waring et al. [2010])

The best recent abundance estimate for western North Atlantic stock of Atlantic spotted dolphins is 50,978 (CV=0.42). This is the sum of estimates from two 2004 western U.S. Atlantic surveys and is considered best because these two surveys together have the most complete coverage of the species' habitat. The minimum population estimate for this stock is 36,235.

The current population size for the Atlantic spotted dolphin in the northern Gulf of Mexico is unknown because the survey data from the continental shelf that covers the majority of this stock's range are more than 8 years old (Wade and Angliss 1997). However, the previous abundance estimate for the Atlantic spotted dolphin in the northern Gulf of Mexico was 37,611 (CV=0.28), based on combined estimates of abundance for both the outer continental shelf (fall surveys, 2000–2001) and oceanic waters (spring and summer surveys, 2003–2004).

4.1.2.11 Spinner Dolphin (*Stenella longirostris*)

4.1.2.11.1 Status and Management

The spinner dolphin is protected under the MMPA but is not listed under the ESA. For management purposes, the western North Atlantic and Gulf of Mexico populations are considered separate stocks, although there is currently insufficient data to differentiate them (Waring et al. 2010).

4.1.2.11.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

This is presumably an offshore, deep-water species (Perrin and Gilpatrick 1994; Schmidly 1981), and its distribution in the Atlantic is very poorly known. In the western North Atlantic, these dolphins occur in deep water along most of the U.S. coast south to the West Indies and Venezuela, including the Gulf of Mexico. Spinner dolphin sightings have occurred exclusively in deeper (greater than 2,000 m) oceanic waters of the northeast U.S. coast (Cetacean and Turtle Assessment Program ; Waring et al. 1992). Stranding records exist from North Carolina, South Carolina, Florida, and Puerto Rico in the Atlantic and in Texas and Florida in the Gulf of Mexico. In the Study Area, the open ocean range of the spinner dolphin includes the southern portions of the Gulf Stream and North Atlantic Gyre as well as Caribbean Sea and Gulf of Mexico. Although spinner dolphins were sighted and stranded off the southeastern U.S. coast, they are not common in those waters, except perhaps off southern Florida (Waring et al. 2010).

Gulf of Mexico Large Marine Ecosystem. In the northern Gulf of Mexico, spinner dolphins are found mostly in offshore waters beyond the edge of the continental shelf (CV=0.48) (Waring et al. 2010). This species was seen during all seasons in the northern Gulf of Mexico during aerial surveys between 1992 and 1998 (Waring et al. 2010).

4.1.2.11.3 Population and Abundance

There is insufficient data to calculate an abundance estimate for the western North Atlantic stock of spinner dolphins (Waring et al. 2010). The best abundance estimate available for northern Gulf of Mexico spinner dolphins is 1,989 (CV=0.48) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone (Waring et al. 2010).

4.1.2.12 Clymene Dolphin (*Stenella clymene*)

4.1.2.12.1 Status and Management

The species is not listed under the ESA but is protected under the MMPA. The clymene dolphin has an extensive range in the tropical Atlantic Ocean. There are insufficient data to determine the population trends for this species (Waring et al. 2010).

4.1.2.12.2 Habitat and Geographic Range

Clymene dolphins are a tropical to subtropical species, primarily sighted in deep waters well beyond the edge of the continental shelf (Fertl et al. 2003). In the western North Atlantic, clymene dolphins were observed as far north as New Jersey, although sightings were primarily in offshore waters east of Cape Hatteras over the continental slope and are likely to be strongly influenced by oceanographic features of the Gulf Stream (Fertl et al. 2003; Moreno et al. 2005; Mullin and Fulling 2003). Clymene dolphins in the Gulf of Mexico are observed most frequently on the lower slope and deepwater areas, primarily west of the Mississippi River, in regions of cyclonic or confluent circulation (Davis et al. 2002; Mullin et al. 1994a). Clymene dolphins were seen in the winter, spring and summer during GulfCet aerial surveys of the northern Gulf of Mexico during 1992 to 1998 (Hansen et al. 1996; Mullin and Hoggard 2000).

4.1.2.12.3 Population and Abundance

Data are insufficient to estimate abundance for the western North Atlantic stock. The best abundance estimate available for northern Gulf of Mexico clymene dolphins is 6,575 (CV=0.36) (Mullin 2007) based on combined estimates from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone. The minimum population estimate for the northern Gulf of Mexico is 4,901 individuals (Waring et al. 2010).

4.1.2.13 Striped Dolphin (*Stenella coeruleoalba*)

4.1.2.13.1 Status and Management

This species is not listed under the ESA but is protected under the MMPA. For management purposes, the Gulf of Mexico population is provisionally considered a separate stock, although there are not sufficient genetic data to differentiate the Gulf of Mexico stock from the western North Atlantic stock (Waring et al. 2010). There is very little information on stock structure in the western North Atlantic and insufficient data to assess population trends of this species (Waring et al. 2010).

4.1.2.13.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

The striped dolphin is one of the most common and abundant dolphin species, with a worldwide range that includes both tropical and temperate waters.

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* (spotted, spinner, clymene, and striped dolphins); it is found in the western North Atlantic from Nova Scotia south to at least Jamaica as well as in the Gulf of Mexico. In general, striped dolphins appear to prefer continental slope waters offshore to the Gulf Stream (Leatherwood et al. 1976; Perrin et al. 1994b; Schmidly 1981).

Gulf Stream Open Ocean Area. Striped dolphins are relatively common in the cooler offshore waters of the U.S. east coast. Along the mid-Atlantic ridge in oceanic waters of the North Atlantic Ocean, striped dolphins are sighted in significant numbers south of 50° N (Waring et al. 2010). In waters off the northeastern U.S. coast, striped dolphins are distributed along the continental shelf edge from Cape Hatteras to the southern margin of Georges Bank and also occur offshore over the continental slope and rise in the mid-Atlantic region (Cetacean and Turtle Assessment Program 1982; Mullin and Fulling 2003). Continental shelf edge sightings in the Cetacean and Turtle Assessment Program (1982) were generally centered along the 1,000-m depth contour in all seasons. During 1990 and 1991 cetacean habitat-use surveys, striped dolphins were associated with the Gulf Stream north wall and warm-core ring features (Waring et al. 1992). Striped dolphins seen in a survey of the New England Sea Mounts (Palka 1997) were in waters that were between 20° and 27° C and deeper than about 3,000 ft. (900 m).

Gulf of Mexico Large Marine Ecosystem. Striped dolphins are also found throughout the deep, offshore waters of the northern Gulf of Mexico. Sightings of striped dolphins in the northern Gulf of Mexico typically occur in oceanic waters and during all seasons (Waring et al. 2010).

4.1.2.13.3 Population and Abundance

The best abundance estimate for western North Atlantic stock of striped dolphins is 94,462 (CV=0.40). This is the sum of the estimates from two 2004 U.S. Atlantic surveys that together have the most complete coverage of the species' habitat. The minimum population estimate for the western North Atlantic striped dolphin is 68,558 (Waring et al. 2010).

The best abundance estimate available for northern Gulf of Mexico striped dolphins is 3,325 (CV=0.48) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone (Waring et al. 2010).

4.1.2.14 Fraser's Dolphin (*Lagenodelphis hosei*)

4.1.2.14.1 Status and Management

This species is not listed under the ESA but is protected under the MMPA. The Gulf of Mexico population is provisionally being considered a separate stock for management purposes, although there are no genetic data to differentiate this stock from the western North Atlantic stock.

4.1.2.14.2 Habitat and Geographic Range

Fraser's dolphin is a tropical, oceanic species, except where deep water approaches the coast (Dolar 2008). This species is assumed to occur in the tropical western North Atlantic although only a single sighting of approximately 250 individuals was recorded in waters 3,300 m deep in the waters off Cape Hatteras during a 1999 vessel survey (National Marine Fisheries Service 1999).

Gulf of Mexico Large Marine Ecosystem. The first record for the Gulf of Mexico was a mass stranding in the Florida Keys in 1981 (Hersh and Odell 1986; Leatherwood et al. 1993). Since then, there have been documented strandings on the west coast of Florida and in southern Texas (Yoshida et al. 2010). Sightings of Fraser's dolphin in the northern Gulf of Mexico typically occur in oceanic waters greater than 656.2 ft. (200 m). This species was observed in the northern Gulf of Mexico during all seasons.

4.1.2.14.3 Population and Abundance

Current data are insufficient to calculate a population estimate for the western North Atlantic and Gulf of Mexico oceanic stocks of Fraser's dolphins (Waring et al. 2010).

4.1.2.15 Risso's Dolphin (*Grampus griseus*)

4.1.2.15.1 Status and Management

Risso's dolphin is not listed under the ESA but is protected under the MMPA. Risso's dolphins in the Atlantic Ocean are separated into the Gulf of Mexico and the North Atlantic stocks (Waring et al. 2010).

4.1.2.15.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Risso's dolphins are distributed worldwide in tropical and temperate waters along the continental shelf break and over the continental slope and outer continental shelf (Baumgartner 1997; Canadas et al. 2002; Cetacean and Turtle Assessment Program 1982; Davis et al. 1998; Green et al. 1992; Kruse et al. 1999; Mignucci-Giannoni 1998). Risso's dolphins were also found in association with submarine canyons (Mussi et al. 2004). In the northwest Atlantic, Risso's dolphins occur from Florida to eastern Newfoundland (Baird and Stacey 1991; Leatherwood et al. 1976).

North Atlantic Gyre and Gulf Stream Open Ocean Areas. The range of the Risso's dolphin distribution in open-ocean waters of the North Atlantic is known to include the Gulf Stream and the southwestern portions of the North Atlantic Gyre.

Northeast U.S. and Southeast U.S. Continental Shelf Large Marine Ecosystems. Off the northeast U.S. coast, Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras northward to Georges Bank during spring, summer, and autumn (Cetacean and Turtle Assessment Program 1982; Payne et al. 1984). In winter, the range is in the mid-Atlantic Bight and extends outward into oceanic waters (Payne et al. 1984). In general, the population occupies the mid-Atlantic continental shelf edge year round and is rarely seen in the Gulf of Maine (Payne et al. 1984). During 1990, 1991 and 1993, spring/summer surveys conducted along the continental shelf edge and in deeper oceanic waters sighted Risso's dolphins associated with strong bathymetric features, Gulf Stream warm core rings, and the Gulf Stream north wall (Hamazaki 2002; Waring et al. 1992, 1993).

Gulf of Mexico Large Marine Ecosystem. Risso's dolphins in the northern Gulf of Mexico occur throughout oceanic waters but are concentrated in continental slope waters (Baumgartner 1997; Maze-Foley and Mullin 2006). Risso's dolphins were seen in all seasons during GulfCet aerial surveys of the northern Gulf of Mexico between 1992 and 1998 (Hansen et al. 1996; Mullin and Hoggard 2000).

4.1.2.15.3 Population and Abundance

The best abundance estimate for the Western North Atlantic stock of Risso's dolphins is 20,479 (CV=0.59), which is the sum of the estimates from two 2004 surveys of the northern and southern U.S. Atlantic. This joint estimate is considered best because these two surveys together have the most complete coverage of the population's habitat. The minimum population estimate for the western North Atlantic Risso's dolphin is 12,920 (Waring et al. 2010).

The best abundance estimate available for northern Gulf of Mexico Risso's dolphins is 1,589 (CV=0.27)

(Mullin 2007). This estimate is a combination of summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone. The minimum population estimate for the northern Gulf of Mexico is 1,271 individuals (Waring et al. 2010).

4.1.2.16 Atlantic White-Sided Dolphin (*Lagenorhynchus acutus*)

4.1.2.16.1 Status and Management

The Atlantic white-sided dolphin is not listed under the ESA but is protected under the MMPA. Three stocks of the Atlantic white-sided dolphin in the western North Atlantic Ocean were suggested for conservation management: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea (Palka et al. 1997; Waring et al. 2004). However, genetic analysis indicates that no definite stock structure exists. The species is considered abundant in the North Atlantic (Jefferson et al. 2008b; Waring et al. 2010).

4.1.2.16.2 Habitat and Geographic Range

This species is found primarily in cold temperate to subpolar continental shelf waters to the 328 ft. (100 m) depth contour (Cetacean and Turtle Assessment Program 1982; Mate et al. 1994; Selzer and Payne 1988). Occurrence of Atlantic white-sided dolphins in the northeastern United States probably reflects fluctuations in food availability as well as oceanographic conditions (Palka et al. 1997; Selzer and Payne 1988). Before the 1970s, Atlantic white-sided dolphins were found primarily offshore in waters over the continental slope; however, since then, they occur primarily in waters over the continental shelf, replacing white-beaked dolphins, which were previously sighted in the area. This shift may have been the result of an increase in sand lance and a decline in herring in continental shelf waters (Payne et al. 1990). Areas of feeding importance are around Cape Cod and on the northwest edge of Georges Bank, in an area defined as the Great South Channel-Jeffreys Ledge corridor (Cetacean and Turtle Assessment Program 1982; Palka et al. 1997). Selzer and Payne (1988) sighted white-sided dolphins more frequently in areas of high seafloor relief and where sea surface temperatures and salinities were low, although these environmental conditions might be only secondarily influencing dolphin distribution; seasonal variation in sea surface temperature and salinity and local nutrient upwelling in areas of high seafloor relief may affect preferred prey abundances, which in turn might affect dolphin distribution (Selzer and Payne 1988).

Gulf Stream Open Ocean Area and Newfoundland-Labrador Shelf and Scotian Shelf Large Marine Ecosystems. This species' open ocean range includes the Gulf Stream. Atlantic white-sided dolphins are common in waters of the continental slope from New England in the west, north to southern Greenland (Cipriano 2008; Jefferson et al. 2008b). Along the Canadian and U.S. Atlantic coast, this species is most common from Hudson Canyon north to the Gulf of Maine (Palka et al. 1997).

Northeast U.S. Continental Shelf Large Marine Ecosystem. From January to April, low numbers of white-sided dolphins may be found from Georges Bank to Jeffreys Ledge. Even lower numbers are found south of Georges Bank (Palka et al. 1997; Payne et al. 1990; Waring et al. 2004). From June through September, large numbers of white-sided dolphins are found from Georges Bank to the lower Bay of Fundy (Payne et al. 1990; Waring et al. 2004). During this time, strandings occur from New Brunswick to New York (Palka et al. 1997). From October to December, white-sided dolphins occur at intermediate densities from southern Georges Bank to the southern Gulf of Maine. Sightings occur year-round south of Georges Bank, particularly around Hudson Canyon, but in low densities (Cetacean and Turtle Assessment Program 1982; Palka 1997; Payne et al. 1990; Waring et al. 2004).

Southeast U.S. Continental Shelf Large Marine Ecosystem. A few strandings were collected on Virginia and North Carolina beaches, which appear to represent the southern edge of the range for this species (Cipriano 2008; Testaverde and Mead 1980).

4.1.2.16.3 Population and Abundance

This species is quite abundant throughout its range, with numbers estimated to be in the hundreds of thousands. The number of white-sided dolphins along the U.S. and Canadian Atlantic coasts is not known, but at least 27,200 (CV=0.43) were estimated to occur from Virginia to the eastern Scotian Slope region (Palka et al. 1997). The best estimate of abundance for the western North Atlantic stock of Atlantic white-sided dolphins is 63,368 (CV=0.27) (Waring et al. 2010).

4.1.2.17 White-Beaked Dolphin (*Lagenorhynchus albirostris*)

4.1.2.17.1 Status and Management

The white-beaked dolphin is not listed under the ESA but is protected under the MMPA. There are at least two separate stocks of the white-beaked dolphin in the North Atlantic: one in the eastern and another in the western North Atlantic. Abundance has declined in some areas, such as the Gulf of Maine, but this may be more closely related to habitat shifts than to direct changes in population size.

4.1.2.17.2 Habitat and Geographic Range

White-beaked dolphins are found in cold-temperate and subarctic waters of the North Atlantic. In the western North Atlantic Ocean, the white-beaked dolphin occurs throughout northern waters of the east coast of the United States and eastern Canada, from eastern Greenland through the Davis Strait and south to Massachusetts (Lien et al. 2001).

Newfoundland-Labrador Shelf, Scotian Shelf, and Northeast U.S. Continental Shelf Large Marine Ecosystems. Within the Study Area, white-beaked dolphins are concentrated in the western Gulf of Maine and around Cape Cod (Cetacean and Turtle Assessment Program 1982; Palka et al. 1997). Before the 1970s, these dolphins were found primarily in waters over the continental shelf of the Gulf of Maine and Georges Bank; since then, they occur mainly in waters over the continental slope and are replaced by large numbers of Atlantic white-sided dolphins (Katona et al. 1993; Palka et al. 1997; Sergeant et al. 1980). This habitat shift might be a result of an increase in sand lance and a decline in herring in continental shelf waters (Payne et al. 1990).

Sightings are common in nearshore waters of Newfoundland and Labrador (Lien et al. 2001). They also occur in the Gulf of St. Lawrence (Waring et al. 2010). During Cetacean and Turtle Assessment Program (1982) surveys, white-beaked dolphins were typically sighted in shallow coastal waters near Cape Cod and along Stellwagen Bank, with a bottom depth ranging from 43 to 2,454 ft. (13 to 748 m) (Palka et al. 1997).

4.1.2.17.3 Population and Abundance

The number of white-beaked dolphins in U.S. and Canadian waters is unknown. The best and only recent abundance estimate for the western North Atlantic white-beaked dolphin is 2,003 (CV=0.94), an estimate derived from aerial survey data collected in August 2006. It is assumed this estimate is negatively biased because the survey only covered part of the species' habitat. The minimum population estimate for these white-beaked dolphins is 1,023 (Waring et al. 2010).

4.1.2.18 Common Dolphin (*Delphinus delphis/capensis*)

Because of the relatively recent discovery that common dolphins represent two distinct species (short-beaked common dolphin and long-beaked common dolphin), rather than a single species as previously thought, much of the biological information for dolphins of the genus *Delphinus* cannot be reliably applied to one or the other, especially in regions where the two species overlap (Heyning and Perrin 1994).

4.1.2.18.1 Status and Management

Common dolphins are protected under the MMPA but not listed under the ESA. Only the short-beaked common dolphin has occurrence within the Study Area. Only a discrete population of long-beaked common dolphins is known from the east coast of South America in the western Atlantic (Jefferson et al. 2008b). A single stock of short-beaked common dolphins is found within the Study Area: the western North Atlantic stock (Jefferson et al. 2009; Waring et al. 2010).

4.1.2.18.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

In the North Atlantic, common dolphins occur over the continental shelf along the 100–2,000-m isobaths and over prominent underwater topography and east to the mid-Atlantic Ridge (29˚W) (Doksaeter et al. 2008; Waring et al. 2008). The species is less common south of Cape Hatteras, although schools were reported as far south as the Georgia/South Carolina border (32° N) (Jefferson et al. 2009).

Gulf Stream Open Ocean Area. There is a well-studied population of short-beaked common dolphins in the western North Atlantic, associated with the Gulf Stream (Jefferson et al. 2009). It occurs mainly in offshore waters, ranging from Florida/Georgia to the Canada maritime provinces (Waring et al. 2010).

Newfoundland-Labrador Shelf, Scotian Shelf, and Northeast U.S. Continental Shelf Large Marine Ecosystems. In waters off the northeastern U.S. coast, common dolphins are distributed along the continental slope and are associated with Gulf Stream features (Cetacean and Turtle Assessment Program 1982; Hamazaki 2002; Selzer and Payne 1988; Stone et al. 1992). They primarily occur from Cape Hatteras northeast to Georges Bank (35° to 42°N) during mid-January to May (Cetacean and Turtle Assessment Program 1982; Hain et al. 1981; Payne et al. 1984). Common dolphins move onto Georges Bank and the Scotian Shelf from mid-summer to autumn. Selzer and Payne (1988) reported very large aggregations (greater than 3,000 animals) on Georges Bank in autumn. Common dolphins are occasionally found in the Gulf of Maine (Selzer and Payne 1988). Migration onto the Scotian Shelf and continental shelf off Newfoundland occurs during summer and autumn when water temperatures exceed 11°C (Gowans and Whitehead 1995; Sergeant et al. 1970).

4.1.2.18.3 Population and Abundance

The best available abundance estimate for the western North Atlantic stock is 120,743 (CV=0.23), derived from surveys conducted in 2004. The minimum population estimate for the western North Atlantic common dolphin is 99,975 (Waring et al. 2010).

4.1.2.19 Melon-Headed Whale (*Peponocephala electra*)

4.1.2.19.1 Status and Management

The melon-headed whale is not listed under the ESA but is protected under the MMPA. For management purposes, the western North Atlantic population and Gulf of Mexico population are considered separate stocks, although genetic data that differentiate these two stocks is lacking (Waring et al. 2010).

4.1.2.19.2 Habitat and Geographic Range

Melon-headed whales are found worldwide in tropical and subtropical waters. They are occasionally reported at higher latitudes, but these movements are considered to be beyond their typical range because the records indicate these movements occurred during incursions of warm water currents (Perryman et al. 1994). Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. In the Study Area, this species was observed in deep waters of the Gulf of Mexico, well beyond the edge of the continental shelf and in waters over the abyssal plain, primarily west of Mobile Bay, Alabama (Davis and Fargion 1996; Mullin et al. 1994b; Waring et al. 2010). Sightings of melon-headed whales in the northern Gulf of Mexico were documented in all seasons during GulfCet aerial surveys 1992 and 1998 (Hansen et al. 1996; Mullin and Hoggard 2000). Sightings of whales from the Western North Atlantic stock are rare, but a group of 20 whales was sighted during surveys in 1999, and a group of 80 whales was sighted off Cape Hatteras, North Carolina, in 2002, in waters greater than 8,202 ft. (2,500 m) deep (Waring et al. 2010).

4.1.2.19.3 Population and Abundance

The abundance of melon-headed whales off the eastern United States and Canadian Atlantic coast is unknown because of the rarity of sightings during surveys (Waring et al. 2010). The best abundance estimate available for northern Gulf of Mexico melon-headed whale stock is 2,283 (CV=0.76) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone (Waring et al. 2010).

4.1.2.20 Pygmy Killer Whale (*Feresa attenuata*)

4.1.2.20.1 Status and Management

The pygmy killer whale is not listed under the ESA but is protected under the MMPA. For management purposes, the Gulf of Mexico population is considered a separate stock although there is not yet sufficient genetic information to differentiate this stock from the western North Atlantic stocks (Waring et al. 2010).

4.1.2.20.2 Habitat and Geographic Range

Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and is therefore probably one of the least abundant pantropical delphinids. The pygmy killer whale is generally an open ocean deepwater species (Davis et al. 2000; Würsig et al. 2000). This species has a worldwide distribution in tropical and subtropical oceans. Pygmy killer whales generally do not range poleward of 40° N or of 35° S (Donahue and Perryman 2008; Jefferson et al. 2008b).

North Atlantic Gyre and Gulf Stream Open Ocean Areas. In the Study Area, this species occurs in the North Atlantic Gyre and the Gulf Stream, although sightings are rare. Most observations outside the tropics are associated with strong, warm western boundary currents that effectively extend tropical conditions into higher latitudes (Ross and Leatherwood 1994).

Gulf of Mexico Large Marine Ecosystem. In the northern Gulf of Mexico, the pygmy killer whale is found primarily in deeper waters off the continental shelf and in waters over the abyssal plain (Davis et al. 2000; Würsig et al. 2000).

4.1.2.20.3 Population and Abundance

There are no available abundance estimates for the western North Atlantic stock of pygmy killer whales and this species is relatively rare in the Gulf of Mexico. The best estimate available for northern Gulf of Mexico pygmy killer whales is 323 (CV=0.60) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone (Waring et al. 2010).

4.1.2.21 False Killer Whale (*Pseudorca crassidens*)

4.1.2.21.1 Status and Management

The false killer whale is not listed under the ESA but is protected under the MMPA. Little is known of the status of most false killer whale populations around the world. While the species is not considered rare, few areas of high density are known. The population found in the Gulf of Mexico is considered a separate stock for management purposes; however, there are no genetic data to differentiate this stock from the western North Atlantic stock.

4.1.2.21.2 Habitat and Geographic Range

False killer whales occur worldwide throughout warm temperate and tropical oceans in deep open-ocean waters and around oceanic islands and only rarely come into shallow coastal waters (Baird et al. 2008; Leatherwood and Reeves 1983; Odell and McClune 1999). Occasional inshore movements are associated with movements of prey and shoreward flooding of warm ocean currents (Stacey et al. 1994). In the Study Area, this species occurs rarely in the southwestern regions of the North Atlantic Gyre. Sightings of this species in the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico) occur in oceanic waters, primarily in the eastern Gulf (Maze-Foley and Mullin 2006; Mullin and Fulling 2004). False killer whales were seen only in the spring and summer during GulfCet aerial surveys of the northern Gulf of Mexico between 1992 and 1998 (Hansen et al. 1996; Mullin and Hoggard 2000) and in the spring during vessel surveys (Mullin et al. 2004).

4.1.2.21.3 Population and Abundance

The best abundance estimate available for northern Gulf of Mexico false killer whales is 777 (CV=0.56) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone (Waring et al. 2010).

4.1.2.22 Killer Whale (*Orcinus orca*)

4.1.2.22.1 Status and Management

The killer whales in the Atlantic and Gulf of Mexico are not listed under the ESA although, like all marine mammals, they are protected under the MMPA. Although some populations, particularly in the northwest Pacific, are extremely well studied, little is known about killer whale populations in most areas including the northwest Atlantic. Killer whales are apparently not highly abundant anywhere but are observed in higher concentration in Antarctic waters. For management purposes, the western North Atlantic population and Gulf of Mexico population are considered separate stocks (Waring et al. 2010).

4.1.2.22.2 Habitat and Geographic Range

Killer whales are found in all marine habitats, from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are generally most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999).

Labrador Current, Gulf Stream, and North Atlantic Gyre Open Ocean Areas. The open ocean range of the killer whale in the Study Area includes the Labrador Current, Gulf Stream, and North Atlantic Gyre.

Northeast and Southeast Large Marine Ecosystems. Killer whales are considered rare and uncommon in waters of the U.S. Exclusive Economic Zone in the Atlantic Ocean (Katona et al. 1988; Waring et al. 2010). During the 1978 to 1981 Cetacean and Turtle Assessment Program surveys, there were 12 killer whale sightings, which made up 0.1 percent of the 11,156 cetacean sightings in the surveys (Cetacean and Turtle Assessment Program 1982; Waring et al. 2010).

Nearshore observations are rare. Forty animals were observed in the southern Gulf of Maine in September 1979 and 29 animals in Massachusetts Bay in August 1986 (Katona et al. 1988; Waring et al. 2010).

Gulf of Mexico Large Marine Ecosystem. Sightings of killer whales in the Gulf of Mexico on surveys from 1951 to 1995 were in waters ranging from 840 to 8,700 ft. (256 to 2,652 m), with an average of 4,075 ft. (1,242 m), and were most frequent in the north-central region of the Gulf of Mexico. Killer whales are relatively uncommon in the northern Gulf of Mexico, with only 49 (CV=0.77) individuals estimated to occur there (CV=0.77) (Waring et al. 2010). Some previous estimates were much higher, but these suffered from low precision due to the relative rarity with which killer whales are sighted on Gulf of Mexico research cruises.

4.1.2.22.3 Population and Abundance

Killer whales are distributed worldwide but are not considered particularly abundant anywhere in the world. Research indicates there are well in excess of 50,000, and perhaps even more than 100,000 worldwide (Ford 2008). The number of killer whales in the waters of the east coast of the United States and eastern Canada is not known. However, killer whale abundance in these waters appears relatively low. Nonetheless, there are likely to be at least several hundred to several thousand in these waters (Waring et al. 2010).

Data are currently insufficient to calculate a population estimate for the western North Atlantic stock of killer whales. The best abundance estimate available for northern Gulf of Mexico killer whales is 49 (CV=0.77) (Mullin 2007). This estimate is pooled from summer 2003 and spring 2004 oceanic surveys covering waters from the 200-m isobath to the seaward extent of the U.S. Exclusive Economic Zone (Waring et al. 2010).

4.1.2.23 Long-Finned Pilot Whale (*Globicephala melas*)

There are two species of pilot whales in the western Atlantic—the long-finned pilot whale, *Globicephala melas melas*, and the short-finned pilot whale, *G. macrorhynchus*. These species are difficult to differentiate at sea; therefore, the ability to separately assess the two stocks in U.S. Atlantic waters is limited.

4.1.2.23.1 Status and Management (Excerpts from Waring et al. [2010])

Long-finned pilot whales are not listed under the ESA but are protected under the MMPA. The structure of the Western North Atlantic stock of long-finned pilot whales is uncertain (Fullard et al. 2000; International Council of the Exploration of the Sea 1993). Morphometric (Bloch and Lastein 1993) and genetic (Fullard et al. 2000; Siemann 1994) studies have provided little support for stock structure across the Atlantic (Fullard et al. 2000). However, Fullard et al. (2000) have proposed a stock structure that is related to sea-surface temperature: (1) a cold-water population west of the Labrador/North Atlantic Current and (2) a warm-water population that extends across the Atlantic in the Gulf Stream.

4.1.2.23.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Long-finned pilot whales inhabit temperate and subpolar zones from North Carolina to North Africa (and the Mediterranean) and north to Iceland, Greenland and the Barents Sea (Abend 1993; Abend and Smith 1999; Buckland et al. 1993; Leatherwood et al. 1976; Sergeant 1962). They occur along the continental shelf break, in continental slope waters, and in areas of high topographic relief (Olson 2009).

They occur in high densities over the continental slope in the western North Atlantic during winter and spring and inhabit waters over the continental shelf in summer and fall. They are associated with the Gulf Stream wall and thermal fronts along the continental shelf edge (Waring et al. 2010). In coastal areas, long-finned pilot whale distribution in the western Atlantic is known to extend essentially from Canada to Cape Hatteras, North Carolina (Waring et al. 2010).

Northeast U.S. Continental Shelf Large Marine Ecosystem. In U.S. Atlantic waters, pilot whales (*Globicephala* species [sp.]) are distributed principally along the continental shelf edge off the northeastern U.S. coast in winter and early spring (Abend and Smith 1999; Cetacean and Turtle Assessment Program 1982; Hamazaki 2002; Payne and Heinemann 1993). In late spring, pilot whales move onto Georges Bank and into the Gulf of Maine and more northern waters; they remain in these areas through late autumn (Cetacean and Turtle Assessment Program 1982; Payne and Heinemann 1993). Pilot whales tend to occupy areas of high relief or submerged banks. They are also associated with the Gulf Stream wall and thermal fronts along the continental shelf edge (Waring et al. 1992) and overlap spatially along the mid-Atlantic shelf break between Cape Hatteras, North Carolina, and New Jersey (Payne and Heinemann 1993).

4.1.2.23.3 Population and Abundance (Excerpts from Waring et al. [2010])

There are estimated to be approximately 31,100 long-finned pilot whales in the western North Atlantic (this estimate likely includes a small number of short-finned pilot whales) (Best 2007; Olson 2009). Off the east coast of the United States, long- and short-finned pilot whales overlap, and no reliable method of distinguishing these two very similar species has been identified for sightings at sea (with the exception of genetic analysis from biopsy samples, which is not often done). The best available abundance estimates are from surveys conducted during the summer of 2004. These survey data are combined with an analysis of the spatial distribution of the two species based on genetic analyses of biopsy samples to derive separate abundance estimates (L. Garrison, National Marine Fisheries Service Southeast Fisheries Science Center, personal communication). The resulting abundance estimate for long-finned pilot whales in U.S. waters is 12,619 (CV=0.37).

4.1.2.24 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

There are two species of pilot whales in the western Atlantic: the long-finned pilot whale, *Globicephala melas melas*, and the short-finned pilot whale, *G. macrorhynchus*. These species are difficult to differentiate at sea.

4.1.2.24.1 Status and Management

The short-finned pilot whale is not listed under the ESA but is protected under the MMPA. Studies are currently being conducted at the NMFS Southeast Fisheries Science Center to evaluate genetic population structure in short-finned pilot whales. The short-finned pilot whale population is managed as two stocks: the Western North Atlantic stock and Gulf of Mexico Oceanic stock. These two stocks are considered separate from the long-finned pilot whale stock.

4.1.2.24.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Short-finned pilot whales range throughout warm temperate to tropical waters of the world, generally in deep offshore areas. Thus, the species occupies waters over the continental shelf break, in slope waters, and in areas of high topographic relief (Olson 2009). While pilot whales are typically distributed along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern United States. Atlantic distribution in the open ocean is known to include the Gulf Stream and North Atlantic Gyre. Sightings of pilot whales (*Globicephala* species) in the western North Atlantic occur primarily near the continental shelf break ranging from Florida to the Nova Scotian Shelf (Mullin and Fulling 2003). Long-finned and short-finned pilot whales overlap spatially along the mid-Atlantic shelf break between Cape Hatteras, North Carolina, and New Jersey (Payne and Heinemann 1993). In addition, short-finned pilot whales are documented along the continental shelf and continental slope in the northern Gulf of Mexico (Hansen et al. 1996; Mullin and Fulling 2003; Mullin and Hoggard 2000), and in the Caribbean.

4.1.2.24.3 Population and Abundance (Excerpts from Waring et al. [2010])

The best available abundance estimates for the western North Atlantic stock of short-finned pilot whales are from surveys conducted during the summer of 2004 because these are the most recent surveys covering the full range of pilot whales in U.S. Atlantic waters. These survey data were combined with an analysis of the spatial distribution of the two species based on genetic analyses of biopsy samples to derive separate abundance estimates (L. Garrison, National Marine Fisheries Service Southeast Fisheries Science Center, personal communication). The resulting abundance estimate for short-finned pilot whales is 24,674 (CV=0.45). In the Gulf of Mexico, the current best estimate of abundance for short-finned pilot whales is 716 (CV=0.34) (Waring et al. 2010).

4.1.2.25 Harbor Porpoise (*Phocoena phocoena*)

4.1.2.25.1 Status and Management

The harbor porpoise is not listed under the ESA but is protected under the MMPA. The Gulf of Maine—Bay of Fundy stock is the only stock of harbor porpoise under NMFS management within the Study Area.

4.1.2.25.2 Habitat and Geographic Range (Excerpts from Waring et al. [2010])

Harbor porpoises inhabit cool temperate-to-subpolar waters, often where prey aggregations are concentrated (Watts and Gaskin 1985). Thus, they are frequently found in shallow waters, most often near shore, but they sometimes move into deeper offshore waters. Harbor porpoises are rarely found in waters warmer than 63°F (17°C) (Read 1999) and closely follow the movements of their primary prey, Atlantic herring (Gaskin 1992).

Northeast and Southeast U.S. Continental Shelf Large Marine Ecosystems. During summer (July to September), harbor porpoises are concentrated in the northern Gulf of Maine and southern Bay of Fundy region, generally in waters less than 46 ft. (150 m) deep (Gaskin 1977; Kraus et al. 1983; Palka 1995a; Palka 1995b), with a few sightings in the upper Bay of Fundy and on the northern edge of Georges Bank (Palka 2000). During fall (October to December) and spring (April to June), harbor porpoises are widely dispersed from New Jersey to Maine, with lower densities farther north and south. They are seen from the coastline to deep waters (greater than 5,906 ft. [1,800 m])(Westgate et al. 1998), although most of the population is found over the continental shelf. During winter (January to March), intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada. There does not appear to be a temporally coordinated migration or a specific migratory route to and from the Bay of Fundy region.

4.1.2.25.3 Population and Abundance

The best estimate of abundance for harbor porpoises is 89,054 (CV=0.47). The minimum population estimate for the Gulf of Maine/Bay of Fundy harbor porpoise is 60,970 (Waring et al. 2010).

4.1.3 PINNIPEDS

4.1.3.1 Ringed Seal (*Pusa hispida*)

4.1.3.1.1 Status and Management

The Arctic subsepecies of ringed seal is currently proposed for listed under the ESA and is protected under the MMPA. This species does not occur in the U.S. Exclusive Economic Zone in the Atlantic Ocean and therefore is not managed by NMFS. Although there is no genetic evidence or other data to differentiate stocks of ringed seals, the North Atlantic Marine Mammal Commission Scientific Committee has recognized three stock areas in the northwest Atlantic based primarily on the low likelihood of mixing between the areas. Area 1 is centered on Baffin Bay and includes northeastern Canada and West Greenland coincident with the northern extreme of the Study Area (North Atlantic Marine Mammal Commission 1997).

4.1.3.1.2 Habitat and Geographic Range

Ringed seal have a circumpolar distribution throughout the Arctic basin, Hudson Bay and straights, and the Bering, Okhotsk, and Baltic Seas. The distribution of ringed seals is strongly correlated with pack and land-fast ice (Born et al. 2002; Jefferson et al. 2008b) in areas over virtually any water depth (Reeves 1998a). In the western Atlantic, they occur as far south as northern Newfoundland, northward to the pole and throughout the Canadian Arctic. They also occur throughout the Greenland Large Marine Ecosystem and can be found south to as far as Labrador off the Canadian east coast in the Newfoundland-Labrador Shelf Large Marine Ecosystem (Hammill 2009).

4.1.3.1.3 Population and Abundance

Abundance of ringed seals is very difficult to estimate because of their inaccessible habitat and tendency to spend much of the breeding season hidden from view in dens or snow caves, when many pinniped estimates are made. Therefore, any estimates are of questionable accuracy and are probably underestimates. The North Atlantic Marine Mammal Commission Scientific Committee derived a rough estimate of the abundance of ringed seals in Area 1 (coincident with the northern extreme of the Study Area) of approximately 1.3 million seals, based on extending existing estimates to areas of similar habitat (North Atlantic Marine Mammal Commission 1997).

4.1.3.2 Bearded Seal (*Erignathus barbatus*)

4.1.3.2.1 Status and Management

The bearded seal is not listed under the ESA, although two Distinct Population Segments in the Pacific have been proposed as endangered. The bearded seal is protected under the MMPA. This species does not normally occur in the U.S. Atlantic Exclusive Economic Zone but does occur in waters of eastern Canada (Kovacs 2009). The population structure of this species is not well understood in the western North Atlantic.

4.1.3.2.2 Habitat and Geographic Range

Bearded seals have a circumpolar distribution in the Arctic, generally south of 80° N latitude and are subarctic in some areas, such as the western North Atlantic. While they are typically strongly tied to ice, bearded seals are known to haul out on land, swim up rivers, and live in open-ocean areas for extended periods (Cleator 1996; Jefferson et al. 2008b).

Newfoundland-Labrador Shelf Large Marine Ecosystem and Scotian Shelf Large Marine Ecosystem. The preferred habitat is drifting pack ice in shallow waters. Bearded seals are found in the Arctic realm, within the following marine regions: North Greenland, West Greenland Shelf, Northern Labrador, Baffin Bay-Davis Strait, Hudson Complex, and the High Arctic Archipelago. This species spends most of its time near where the coastal ice forms and in less than 656 ft. (200 m) of water (Jefferson et al. 2008b; Kovacs 2009). Sightings outside the species' typical range were reported as far south as Cape Cod, Massachusetts.

4.1.3.2.3 Population and Abundance

Due to the patchy distribution of individuals moving with ice floes, it is difficult to make accurate abundance estimates for this species (Kovacs 2009), and no estimates exist specifically for the western Atlantic. The best available global population estimate for the bearded seal is 450,000 to 500,000, approximately half of which inhabit the Bering and Chukchi Seas (Jefferson et al. 2008b). Rough estimates based on aerial surveys conducted over a 35-year period indicated densities in Canadian waters to be approximately 0.24 seal per square kilometer in preferred habitat. The population estimate for bearded seals in Canadian waters during the survey period was 190,000 (Cleator 1996).

4.1.3.3 Hooded Seal (*Cystophora cristata*)

4.1.3.3.1 Status and Management

Hooded seals are not listed under the ESA but are protected under the MMPA. The global hooded seal population was divided by the International Council for the Exploration of the Sea into three separate stocks based on specific breeding sites: Northwest Atlantic, Greenland Sea ("West Ice"), and White Sea ("East Ice"). The western North Atlantic stock (synonymous with the International Council for the Exploration of the Sea Northwest Atlantic Stock) give birth and nurse off the coast of eastern Canada in three specific areas: coastal Newfoundland and Labrador (an area that is known as the Front), the Gulf of St. Lawrence, and the Davis Strait (Waring et al. 2007).

4.1.3.3.2 Habitat and Geographic Range

Hooded seals are distributed in the Arctic and the cold temperate North Atlantic Ocean (Bellido et al. 2007). At sea, hooded seals stay primarily near continental coastlines but are known to wander widely. This species follows the seasonal movement of pack ice, on which it breeds. In the Study Area, its primary range is around the Newfoundland-Labrador Shelf and Scotian Shelf (Bellido et al. 2007).

Newfoundland-Labrador Shelf and Scotian Shelf Large Marine Ecosystems. Hooded seals remain on the Newfoundland continental shelf during winter/spring (Stenson et al. 1996). Breeding and pupping areas are in the Gulf of St. Lawrence and north of Newfoundland and east of Labrador, as well as in the Davis Strait and near Jan Mayen Island in the Arctic Ocean (Hammill et al. 1997; Jefferson et al. 2008b; Kovacs 2008).

Northeast and Southeast U.S. Continental Shelf and Caribbean Sea Large Marine Ecosystems. Hooded seals are highly migratory and may wander as far south as Puerto Rico (Mignucci-Giannoni and Odell 2001), with increased occurrences from Maine to Florida. These appearances usually occur between January and May in New England waters, and in summer and autumn off the southeast U.S. coast and in the Caribbean (Harris et al. 2001; McAlpine et al. 1999; Mignucci-Giannoni and Odell 2001). Six hooded seal strandings were also reported between 1975 and 1996 in North Carolina, Florida, Georgia, Puerto Rico, and the U.S. Virgin Islands (Mignucci-Giannoni and Odell 2001).

4.1.3.3.3 Population and Abundance

The number of hooded seals in the western North Atlantic is relatively well known and is derived from pup production estimates produced from whelping (birthing) pack surveys. The best estimate of abundance for western North Atlantic hooded seals is 592,100 (SE=94,800). The minimum population estimate based on the 2005 pup survey results is 512,000. Present data are insufficient to calculate the minimum population estimate for U.S. waters (Waring et al. 2007).

4.1.3.4 Harp Seal (*Pagophilus groenlandicus*)

4.1.3.4.1 Status and Management

The harp seal is not listed under the ESA but is protected under the MMPA. The harp seal is the most abundant pinniped in the western North Atlantic Ocean (Canada Department of Fisheries and Oceans 2003). The Western North Atlantic stock is the largest and is divided into two breeding herds: the Front herd, which breeds off the coast of Newfoundland and Labrador, and the Gulf herd, which breeds near the Magdalen Islands in the Gulf of St. Lawrence (Reeves et al. 2002b; Waring et al. 2004).

4.1.3.4.2 Habitat and Geographic Range

Harp seals are closely associated with drifting pack ice, where they breed and molt and forage in the surrounding waters (Lydersen and Kovacs 1993; Ronald and Healey 1981). Harp seals make extensive movements over much of the continental shelf within their winter range in the waters off Newfoundland (Bowen and Siniff 1999). The primary range of this species is throughout the Arctic, but the secondary range includes the western waters of the Scotian Shelf and the Northeast U.S. Continental Shelf.

Newfoundland-Labrador Shelf and Scotian Shelf Large Marine Ecosystems. Typically, harp seals are distributed in the pack ice of the North Atlantic segment of the Arctic Ocean and through Newfoundland and the Gulf of St. Lawrence (Reeves et al. 2002b). Most western North Atlantic harp seals congregate off the east coast of Newfoundland-Labrador (the Front) to pup and breed. The remainder (the Gulf herd) gathers to pup near the Magdalen Islands in the Gulf of St. Lawrence (Morissette et al. 2006; Ronald and Dougan 1982).

Northeast U.S. Continental Shelf Large Marine Ecosystem. The number of sightings and strandings of harp seals off the northeastern United States has been increasing (Harris et al. 2002; McAlpine and Walker 1999; Stevick and Fernald 1998). These occurrences are usually during January through May (Harris et al. 2002), when the Western North Atlantic stock of harp seals is at its most southern point in distribution (Waring et al. 2004). Harp seals occasionally enter the Bay of Fundy, but McAlpine and Walker (1999) suggested that winter ocean surface currents might limit the probability of occurrences in this bay.

4.1.3.4.3 Population and Abundance

The best estimate of abundance for western North Atlantic harp seals is 6.9 million (95 percent CI 6.0-7.7 million). The minimum population estimate based on the 2008 pup survey results is 6.5 million (CV=0.06) seals. Data are insufficient to calculate the minimum population estimate for U.S. waters (Waring et al. 2010).

4.1.3.5 Gray Seal (*Halichoerus grypus*)

4.1.3.5.1 Status and Management

The gray seal is not listed under the ESA but is protected under the MMPA. The gray seal is found on both sides of the North Atlantic, with three major populations: eastern Canada, northwestern Europe, and the Baltic Sea (Katona et al. 1993; Waring et al. 2010). These stocks are separated by geography, differences in the breeding season, and genetic variation (Waring et al. 2010). There are two breeding concentrations in eastern Canada: one at Sable Island and the other on the pack ice in the Gulf of St. Lawrence; they are treated as separate populations for management purposes (Mohn and Bowen 1996).

4.1.3.5.2 Habitat and Geographic Range

The Western North Atlantic stock is equivalent to the eastern Canada population and ranges from New York to Labrador (Waring et al. 2010). The gray seal is considered a coastal species and may forage far from shore but does not appear to leave the continental shelf regions (Lesage and Hammill 2001). Gray seals haul out on ice, exposed reefs, or beaches of undisturbed islands (Lesage and Hammill 2001). Haul-out sites are often near rough seas and riptides (Hall and Thompson 2008; Jefferson et al. 2008b; Katona et al. 1993). Remote uninhabited islands tend to have the largest gray seal haul-outs (Reeves et al. 1992). In the Study Area, the primary range of this species includes the northwestern waters of the Newfoundland-Labrador Shelf, the Scotian Shelf, and the Northeast U.S. Continental Shelf (Davies 1957; Hall and Thompson 2008). In the western North Atlantic Ocean, the gray seal population is centered in the Canadian maritimes, including the Gulf of St. Lawrence and the Atlantic coasts of Nova Scotia, Newfoundland, and Labrador.

Newfoundland-Labrador and Scotian Shelf Large Marine Ecosystems. The largest concentrations of gray seals are found in the southern half of the Gulf of St. Lawrence, where most seals breed on ice, and around Sable Island, where most seals breed on land (Davies 1957; Hammill and Gosselin 1995; Hammill et al. 1998).

Northeast U.S. Continental Shelf Large Marine Ecosystem. Gray seals range south into the northeastern United States, with strandings as far south as North Carolina (Hammill et al. 1998; Waring et al. 2004). Small numbers of gray seals and pupping have been observed on several isolated islands along the central coast of Maine and in Nantucket Sound (the southernmost breeding site is Muskeget Island) (Andrews and Mott 1967; Rough 1995; Waring et al. 2004). Resident colonies and pupping have been observed since 1994 on Seal and Green Islands in Penobscot Bay off the central coast of Maine (Waring et al. 2004). Spring and summer sightings off Maine are primarily on offshore ledges of the central coast of Maine (Richardson 1976). In the late 1990s, a year-round breeding population of approximately 400 animals was documented on outer Cape Cod and Muskeget Island (Barlas 1999; Waring et al. 2004).

4.1.3.5.3 Population and Abundance

A 2004 survey of the Canadian population obtained estimates ranging between 208,720 (SE=29,730) and 223,220 (SE=17,376). The herd on Sable Island is declining, but the Gulf of St. Lawrence population has changed little (Canada Department of Fisheries and Oceans 2003). This decline is attributed to a sharp decline in the quantity of suitable ice breeding habitat in the southern Gulf of St. Lawrence, possibly the result of global climate change (Hammill et al. 2003). A minimum of 1,000 pups were born in the northeastern United States during 2002 (Wood et al. 2003), but present data are insufficient to calculate the minimum population estimate for U.S. waters (Waring et al. 2010).

4.1.3.6 Harbor Seal (*Phoca vitulina*)

4.1.3.6.1 Status and Management

The harbor seal is not listed under the ESA but is protected under the MMPA. This is the most common and frequently reported seal in the northeastern United States (Agler et al. 1993). Currently, harbor seals along the coast of the eastern United States and Canada represent a single population (Temte et al. 1991; Waring et al. 2010).

4.1.3.6.2 Habitat and Geographic Range

The harbor seal is one of the most widely distributed seals, found in nearly all temperate coastal waters of the northern hemisphere (Jefferson et al. 2008b). Harbor seals are a coastal species, rarely found more than 7.7 mi. (20 km) from shore, and frequently occupy bays, estuaries, and inlets (Baird 2001). Individual seals were observed several kilometers upstream in coastal rivers (Baird 2001). Haul-out sites vary but include intertidal and subtidal rock outcrops, sandbars, sandy beaches, and even peat banks in salt marshes (Burns 2008; Gilbert and Guldager 1998; Prescott 1982; Schneider and Payne 1983; Wilson 1978). Harbor seals occur in the cold and temperate nearshore waters of the northwest Atlantic, typically above 30° N. In the Study Area, their distribution includes the Gulf of St. Lawrence, the Scotian Shelf, the Gulf of Maine, the Bay of Fundy, and the Northeast U.S. Continental Shelf.

Newfoundland-Labrador Shelf, Scotian Shelf, and Northeast U.S. Continental Shelf Large Marine Ecosystems. In U.S. waters, breeding and pupping normally occur in waters north of the New Hampshire and Maine borders, although breeding is recorded as far south as Cape Cod (Katona et al. 1993; Waring et al. 2010). Harbor seals are found year-round in the coastal waters of eastern Canada and Maine and occur from the southern New England coast to the New Jersey coast from September to May (Katona et al. 1993; Waring et al. 2010). A general southward movement from the Bay of Fundy to southern New England waters occurs in autumn and early winter (Barlas 1999; Jacobs and Terhune 2000; Rosenfeld et al. 1988; Whitman and Payne 1990). A northward movement from southern New England to Maine and eastern Canada occurs before the pupping season, which takes place from mid-May through June along the Maine coast (deHart 2002; Kenney 1994; Richardson 1976; Whitman and Payne 1990; Wilson 1978).

Southeast U.S. Continental Shelf Large Marine Ecosystem. Rare sightings and strandings were recorded through the Carolinas and as far south as Florida (Waring et al. 2010).

4.1.3.6.3 Population and Abundance

The NMFS 2010 Stock Assessment Report states that there is insufficient data to calculate a minimum population estimate for Western North Atlantic harbor seal stock; however, the NMFS 2009 Stock Assessment Report indicated the best estimate of abundance for this stock was 99,340 (CV=0.097)(Waring et al. 2009). An estimated 5,575 harbor seals overwintered in southern New England in 1999, increasing from an estimated 2,834 in 1981 (Barlas 1999).

4.2 Vocalization and Hearing of Marine Mammals

All marine mammals studied can use sound to forage, orient, socially interact with others, and detect and respond to predators. Measurements of marine mammal sound production and hearing capabilities provide some basis for assessment of whether exposure to a particular sound source may affect a marine mammal behaviorally or physiologically.

Marine mammal hearing abilities are quantified using live animals by either behavioral audiometry or electrophysiology. Behavioral audiograms, which are plots of animals' exhibited hearing threshold versus frequency, are obtained from captive, trained live animals using standard testing procedures with appropriate controls and are considered to be a more accurate representation of a subject's hearing abilities. Behavioral audiograms of marine mammals are difficult to obtain because many species are too large, too rare, and too difficult to acquire and maintain. Consequently, our understanding of a species' hearing ability may be based on the behavioral audiogram of a single individual or small group of animals. In addition, captive animals may be exposed to local ambient sounds and other environmental factors that could affect their hearing abilities and may not accurately reflect the hearing abilities of free-swimming animals. For animals not available in captive or stranded settings (including large whales and rare species) estimates of hearing capabilities are made based on physiological structures, vocal characteristics, and extrapolations from related species.

In comparison, electrophysiological audiometry measures small electrical voltages produced by neural activity when the auditory system is stimulated by sound. The technique is relatively fast, does not require a conscious response, and is routinely used to assess the hearing of newborn humans. Hearing response in relation to frequency for both methods of evaluating hearing ability is depicted as a U-shaped curve showing the frequency range of best sensitivity (lowest hearing threshold) and frequencies above and below with higher threshold values.

Direct measurements of hearing sensitivity exist for approximately 25 of the nearly 130 species of marine mammals. Table 4-1 summarizes of sound production and 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, mid-frequency cetaceans, low-frequency cetaceans (mysticetes), and phocid pinnipeds (true seals). Functional hearing is defined as the range of frequencies which are within 80 dB of an animal or group's best hearing sensitivity at any frequency (Southall et al. 2007). Note that frequency ranges for high-, mid-, and low-frequency cetacean hearing differ from the frequency ranges defined in similar terms to describe active sonar systems. For discussion of all marine mammal functional hearing groups and their derivation, refer to the Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report (Finneran and Jenkins 2012).

Table 4-1. Hearing and Vocalization Ranges for Marine Mammal Functional Hearing Groups and Species Potentially within the Study Area

Functional Hearing Group	Species	Sound Production		Functional Hearing Ability Frequency Range
		Frequency Range	Source Level (dB re 1 µPa @ 1 m)	
High-Frequency Cetaceans	Harbor porpoise, *Kogia* species (Dwarf and Pygmy Sperm Whales)	100 kHz to 200 kHz	120 to 205	200 Hz to 180 kHz
Mid-Frequency Cetaceans	Sperm Whale, Blainville's Beaked Whale, True's Beaked Whale, Gervais' Beaked Whale, Cuvier's Beaked Whale, Northern Bottlenose Whale, Sowerby's Beaked Whale, Bottlenose Dolphin, Clymene Dolphin, Short-beaked Common Dolphin, Long-beaked Common Dolphin, Fraser's Dolphin, Killer Whale, False Killer Whale, Pygmy Killer Whale, Melon-headed Whale, Short-finned Pilot Whale, Long-finned Pilot Whale, Risso's Dolphin, Rough-toothed Dolphin, Spinner Dolphin, Atlantic Spotted Dolphin, Pantropical Spotted Dolphin, Striped Dolphin, White-beaked Dolphin, Atlantic White-sided Dolphin, Narwhal, Beluga Whale	100 Hz to >100 kHz	137 to 236	150 Hz to 160 kHz
Low-Frequency Cetaceans	Bowhead Whale, North Atlantic Right Whale, Blue Whale, Bryde's Whale, Fin Whale, Humpback Whale, Minke Whale, Sei Whale	10 Hz to 20 kHz	137 to 192	7 Hz to 22 kHz
Phocid Seals	Ringed Seal, Bearded Seal, Hooded Seal, Gray Seal, Harbor Seal	100 Hz to 120 kHz	103 to 180	In-water: 75 Hz to 75 kHz In-air: 75 Hz to 30 kHz

This table was adapted and derived from Southall et al. (2007)

dB re 1 µPa @ 1 m: decibels (dB) referenced to (re) 1 micro (µ) Pascal (Pa) at 1 meter; Hz: Hertz; kHz: kilohertz

4.2.1.1.1 High-Frequency Cetaceans

Marine mammals within the high-frequency cetacean functional hearing group are all odontocetes (toothed whales; suborder Odontoceti) and includes eight species and subspecies of porpoises (family Phocoenidae), dwarf and pygmy sperm whales (family Kogiidae), six species and subspecies of river dolphins, the franciscana, and four species of cephalorhynchids. Only the following members of the high-frequency cetacean group are present in the Study Area: harbor porpoise, dwarf sperm whale, and pygmy sperm whale. Functional hearing in high-frequency cetaceans occurs between approximately 200 Hertz (Hz) and 180 kilohertz (kHz) (Southall et al. 2007).

Sounds produced by high-frequency cetaceans range from approximately 100 kHz to 200 kHz with source levels of 120 to 205 dB referenced to (re) 1 micro (µ) Pascal (Pa) at 1 m (Madsen et al. 2005; Richardson et al. 1995; Verboom and Kastelein 2003; Villadsgaard et al. 2007). Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type. Porpoises, unlike most other odontocetes, do not produce whistles or do not whistle often (Awbrey et al. 1979; Bassett et al. 2009; Houck and Jefferson 1999; Thomson and Richardson 1995; Verboom and Kastelein 2003). High-frequency cetaceans also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz that are used to detect, localize, and characterize underwater objects such as prey (Richardson et al. 1995).

An auditory brainstem response study on a stranded pygmy sperm whale indicated best sensitivity between 90 to 150 kHz (Ridgway and Carder 2001). From a harbor porpoise audiogram using behavioral methods, detection thresholds were estimated from 250 Hz to 180 kHz, with the range of best hearing from 16 to 140 kHz and maximum sensitivity between 100 to 140 kHz (Kastelein et al. 2002a). While no empirical data on the hearing ability for Dall's porpoise are available, data on the morphology of the cochlea allow for estimation of the upper hearing threshold at about 170 to 200 kHz (Awbrey et al. 1979).

4.2.1.1.2 Mid-Frequency Cetaceans

Marine mammals within the mid-frequency cetacean functional hearing group are all odontocetes, and include the sperm whale (family Physetereidae), 32 species and subspecies of dolphins (family Delphinidae), the beluga and narwhal (family Monodontidae), and 19 species of beaked and bottlenose whales (family Ziphiidae). The following members of the mid-frequency cetacean group are present or have a reasonable likelihood of being present in the Study Area: sperm whale, beaked whales (*Hyperoodon*, *Mesoplodon*, and *Ziphius* species), bottlenose dolphin, clymene dolphin, short-beaked common dolphin, long-beaked common dolphin, Fraser's dolphin, killer whale, false killer whale, pygmy killer whale, melon-headed whale, short-finned pilot whale, long-finned pilot whale, Risso's dolphin, rough-toothed dolphin, spinner dolphin, Atlantic spotted dolphin, pantropical spotted dolphin, striped dolphin, white-beaked dolphin, Atlantic white-sided dolphin, narwhal, and beluga whale. Functional hearing in mid-frequency cetaceans is conservatively estimated to be between approximately 150 Hz and 160 kHz (Southall et al. 2007).

Hearing studies on cetaceans have focused primarily on odontocete species (see Kastelein, Bunskoek et al. 2002; Nachtigall et al. 2005; Szymanski et al. 1999; Yuen et al. 2005a). Hearing sensitivity has been directly measured for a number of mid-frequency cetaceans, including Atlantic bottlenose dolphins (Johnson 1967), belugas (Finneran et al. 2005b; White et al. 1977), Indo-Pacific bottlenose dolphins (Houser et al. 2008), Black Sea bottlenose dolphins (Popov et al. 2007), striped dolphins (Kastelein et al. 2003), white-beaked dolphins (Nachtigall et al. 2008), Risso's dolphins (Nachtigall et al. 2005), killer whales (Szymanski et al. 1999), false killer whales (Yuen et al. 2005b), common dolphins (Houser et al. 2010), Atlantic white-sided dolphins (Houser et al. 2010), Gervais' beaked whales (Finneran et al. 2009), and Blainville's beaked whales (Pacini et al. 2011). All audiograms exhibit the same general U-shape, with a functional hearing range between approximately 150 Hz and 160 kHz.

In general, odontocetes (including mid-frequency cetaceans) produce sounds across the widest band of frequencies. Their social vocalizations range from a few hundreds of Hz to tens of kHz with source levels in the range of 100 to 170 dB re 1 µPa (Richardson et al. 1995). As mentioned earlier, they also generate specialized clicks used in biosonar (echolocation) at frequencies above 100 kHz to detect, localize, and characterize underwater objects such as prey (Au 1993). Echolocation clicks have source levels that can be as high as 229 dB re 1 µPa peak-to-peak (Au et al. 1974).

4.2.1.1.3 Low-Frequency Cetaceans

Marine mammals within the low-frequency functional hearing group are all mysticetes. This group comprises 13 species and subspecies of mysticete whales in five genera: *Balaena, Caperea, Eschrichtius, Megaptera,* and *Balaenoptera*. The following members of the low-frequency cetacean group (mysticetes) are present or have a reasonable likelihood of being present in the Study Area: bowhead whale, North Atlantic right whale, blue whale, Bryde's whale, fin whale, humpback whale, minke whale, and sei whale. Functional hearing in low-frequency cetaceans is conservatively estimated to be between about 7 Hz and 22 kHz (Southall et al. 2007).

Because of animal size and the availability of specimens, direct measurements of mysticete whale hearing are unavailable, although there was one effort to measure hearing thresholds in a stranded gray whale (Ridgway and Carder 2001). Because hearing ability has not been directly measured in these species, it is inferred from vocalizations, ear structure, and field observations.

Mysticete cetaceans produce low-frequency sounds that range in the tens of Hz to several kHz that most likely serve social functions such as reproduction but may serve an orientation function as well (Green 1994; Green et al. 1994). Humpback whales are the notable exception within the mysticetes, with some calls exceeding 10 kHz. These sounds can be generally categorized as low-frequency moans; bursts or pulses; or more complex songs (Edds-Walton 1997). Source levels of most mysticete cetacean sounds range from 150 to 190 dB re 1 µPa (Richardson et al. 1995).

4.2.1.1.4 Pinnipeds

Pinnipeds are divided into three functional hearing groups: otariids (sea lions and fur seals), phocid seals (true seals), and odobenids (walrus) with different in-air and in-water hearing ranges. The Study Area contains phocid seals that are managed by NMFS. Otariid pinnipeds (sea lions and fur seals) are notably absent from the North Atlantic Ocean. Measurements of hearing sensitivity have been conducted on species representing all of the families of pinnipeds (Phocidae, Otariidae, Odobenidae) (see Kastelein et al. 2002b; Kastelein et al. 2005b; Moore and Schusterman 1987; Schusterman et al. 1972; Terhune 1988; Thomas et al. 1990a; Turnbull and Terhune 1990; Wolski et al. 2003).

Pinnipeds produce sounds both in air and water that range in frequency from approximately 100 Hz to 120 kHz and it is believed that these sounds only serve social functions (Miller 1991) such as mother-pup recognition and reproduction. Source levels for pinniped vocalizations range from approximately 95 to 190 dB re 1 µPa (Richardson et al. 1995).

4.2.1.1.4.1 Phocid Seals

Phocid seals (true seals) present or which have a reasonable likelihood of being present in the Study Area include the ringed seal, bearded seal, hooded seal, harp seal, gray seal, and harbor seal. Hearing in phocids has been tested in the following species: gray seals (Ridgway et al. 1975); harbor seals (Kastak and Schusterman 1998; Kastelein et al. 2009a; Richardson et al. 1995; Southall et al. 2007; Terhune and Turnbull 1995; Wolski et al. 2003); harp seals (Terhune and Ronald 1971, 1972); Hawaiian monk seals (Thomas et al. 1990a); northern elephant seal (Kastak and Schusterman 1998; Kastak and Schusterman 1999); and ringed seals (Terhune and Ronald 1975, 1976).

Phocid functional hearing limits are estimated to be 75 Hz to 30 kHz in air and 75 Hz to 75 kHz in water (Kastak and Schusterman 1999; Kastelein et al. 2009a; Kastelein et al. 2009b; Møhl 1968a, b; Reichmuth 2008; Terhune and Ronald 1971, 1972).

5 TAKE AUTHORIZATION REQUESTED

The United States (U.S.) Department of the Navy (Navy) requests regulations and two Letters of Authorization for the take of marine mammals incidental to proposed activities in the Atlantic Fleet Training and Testing (AFTT) Study Area (the Study Area) for the period from 22 January 2014 through 21 January 2019: (1) a 5-year LOA for training activities and (2) a 5-year LOA for testing activities. The term "take," as defined in Section 3 (16 USC § 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 USC § 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). The Proposed Action constitutes military readiness activities as that term is defined in Public Law 107-314 because activities constitute "training and operations of the armed forces that relate to combat" and constitute "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 USC § 1362(18)(B)(i) and (ii)].

The AFTT Draft EIS/OEIS considered all training and testing activities undertaken in the Study Area that have the potential to result in the MMPA defined take of marine mammals. The stressors associated with these activities included the following:

- Impulsive and non-impulsive sounds (underwater sounds sources including sonar and other active acoustic sources, explosives, swimmer defense airguns, pile driving, weapons firing noise, aircraft noise, and vessel noise)
- Energy (electromagnetic devices and lasers)
- Physical disturbance or strikes (vessels and in-water devices, military expended materials, seafloor devices)
- Entanglement (fiber optic cables and guidance wires, parachutes)
- Ingestion (munitions, and military expended materials other than munitions)
- Indirect stressors

The Navy determined that three stressors could potentially result in the incidental taking of a marine mammal from training and testing activities within the Study Area: (1) non-impulsive stressors (sonar and other active acoustic sources), (2) impulsive stressors (explosives, and pile driving and removal), and (3) vessel strikes. Impulsive and non-impulsive stressors 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 and/or mortality. The acoustic and explosive analysis in the AFTT EIS/OEIS and in this request for LOAs attempts to quantify potential exposures of marine mammals to acoustic and explosive energy that could result in mortality, injury, or behavioral disturbance.

5.1 Incidental Take Request for Training Activities

5.1.1 Impulsive and Non-impulsive Sources

A detailed analysis of effects due to marine mammal exposures to impulsive and non-impulsive sources in the AFTT study area is shown in Chapter 6 (Numbers and Species Taken). Table 5-1 summarizes the Navy's final take request for training activities on an annual maximum year (a notional 12-month period when all annual and non-annual events could occur) and the summation over a 5-year period (with consideration of the varying schedule of non-annual activities). Table 5-3 summarizes the Navy's final take request (Level A and Level B harassment) for training activities by species.

Based on the analysis in Chapter 6 (Numbers and Species Taken), the Navy requests 17 annual mortalities applicable to all small odontocetes (any combination of species known to be present in the Study Area) from training activities involving explosives, with a total of 85 mortalities predicted over the 5-year period. Over the 5-year LOA period being requested, the Navy requests 1,753 total Level A harassments and 10,263,631 total Level B harassments for all marine mammals combined for training activities. While the Navy does not anticipate any marine mammal strandings or mortalities from sonar or other active acoustic sources, the Navy requests authorization for additional take by mortality of up to 10 beaked whales in any given year and no more than 10 animals over the 5-year LOA period as part of training activities involving the use of sonar and other active acoustic sources.

5.1.2 Vessel Strikes

A detailed analysis of vessel strike data is contained in Section 6.1.9, Estimated Take of Marine Mammals by Vessel Strike. Vessel strike to marine mammals is not associated with any specific training activity but rather a limited, sporadic, and accidental result of Navy ship movement within the Study Area. Based on the probabilities of whale strikes suggested by the data from the National Marine Fisheries Service (NMFS) and the Navy, and the calculations provided by the Navy in Section 6.1.9 (Estimated Take of Marine Mammals by Vessel Strike) of this application, the Navy requests authorization of the take of no more than 10 marine mammals, by injury or mortality, resulting from vessel strike incidental to the Navy training activities within any portion of the Study Area over the course of the 5 years of the AFTT regulations. Since species identification has not been possible in most recorded cases of vessel strikes, the Navy cannot quantifiably predict that the proposed takes will be of any particular species, and therefore seeks take authorization for any combination of marine mammal species (e.g., fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species), except the North Atlantic right whale.

The Navy proposes to implement mitigation measures in the North Atlantic right whale foraging, calving, and migration habitats (see Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). These measures (e.g., increased awareness, funding of and communication with sightings systems, and specialized training on North Atlantic right whale observations) have helped the Navy avoid striking a North Atlantic right whale during training activities in the past; and therefore, are likely to eliminate the potential for future strikes to occur as a result of the proposed training activities.

The take of no more than 10 marine mammals over the 5 years of the AFTT regulations includes the following restrictions for number of takes allowed within any given year:

- The take, by injury or mortality, of no more than three marine mammals total (of any combination of species) in any given year from training activities. This represents the maximum number of large whales the Navy struck in any given year between 1995 and 2012.
- The take, by injury or mortality, of no more than the following number of individual Endangered Species Act (ESA)-listed marine mammals in any given year: three humpback whales, two fin whales, one sei whale, one blue whale, and one sperm whale from training activities. Based on historical ship strike data, these are considered maximum levels for ESA-listed species, not actual predicted levels.
- The Navy does not anticipate that it will strike a North Atlantic right whale because of the extensive measures in place to reduce the risk of a strike to that species.

5.2 Incidental Take Request for Testing Activities

5.2.1 Impulsive and Non-impulsive Sources

A detailed analysis of effects due marine mammal exposures to impulsive and non-impulsive sources in the AFTT Study Area is in Chapter 6 (Numbers and Species Taken). Table 5-1 summarizes the Navy's final take request for testing activities on an annual maximum year (a notional 12-month period when all annual and non-annual events could occur) and the summation over a 5-year period (with consideration of the varying schedule of non-annual activities), excluding Ship Shock Trials. Table 5-2 summarizes the Navy's final take request for Ship Shock Trials annually and over a 5-year period. Table 5-4 summarizes the Navy's final take request (Level A and Level B harassment) for testing activities by species.

Over the 5-year LOA period being requested, the Navy requests 11 mortalities annually applicable to any small odontocetes (any combination of species known to be present in the Study Area) from testing activities involving explosives, with a total of 55 mortalities predicted over the 5-year period. Over the 5-year LOA period being requested, the Navy requests 1,735 total Level A harassments and 11,559,236 total Level B harassments for all marine mammals combined for testing activities, excluding ship shock trials.

For one CVN ship shock trial, the Navy's requests a maximum of 6,591 Level A harassments and 4,607 Level B harassments over the 5-year LOA period. While the Navy does not anticipate the mortalities predicted by the acoustic analysis based on no observation of mortalities during monitoring of past ship shock trials, the Navy requests authorization for take by mortality of up to 10 small odontocetes (any combination of species known to be present in the Study Area).

For the DDG ship shock trial and the two LCS ship shock trials (three events total), the Navy requests a maximum of 1,188 Level A harassments and 867 Level B harassments over the 5-year LOA period. While the Navy does not anticipate the mortalities predicted by the acoustic analysis based on no observation of mortalities during monitoring of past ship shock trials, the Navy requests authorization for take by mortality of up to 15 small odontocetes (any combination of species known to be present in the Study Area).

5.2.2 Vessel Strikes

A detailed analysis of vessel strike data is contained in Section 6.1.9, Estimated Take of Marine Mammals by Vessel Strike. Most testing conducted in the Study Area that involves surface ships is conducted in conjunction with training activities. Therefore, the vessel strike take request for training activities will cover those activities. For the smaller number of testing activities not conducted in conjunction with fleet training, the Navy requests a smaller number of takes resulting incidental to vessel strike. The Navy requests authorization of the take of no more than one marine mammal, by injury or mortality, resulting from vessel strike incidental to the Navy testing activities within any portion of the Study Area over the course of the 5 years of the AFTT regulations. Since species identification has not been possible in most recorded cases of vessel strikes, the Navy cannot quantifiably predict that the proposed take will be of any particular species, and therefore seeks the take authorization for any marine mammal species (e.g., fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species), except the North Atlantic right whale.

As described above for training activities, the Navy's proposed mitigation measures in the North Atlantic right whale foraging, calving, and migration habitats (see Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) are likely to eliminate the potential for a strike to occur as a result of the proposed testing activities.

5.3 Summary of Training and Testing Take Request

Table 5-1 through Table 5-4 summarize the categories of Navy take request for AFTT.

Table 5-1. Summary of Annual and 5-Year Take Request for AFTT Training and Testing Activities (Excluding Ship Shock Trials)

MMPA Category	Source	Annual Authorization Sought		5-Year Authorization Sought	
		Training Activities[4]	Testing Activities[3]	Training Activities	Testing Activities[3]
Mortality	Impulsive	17 mortalities applicable to any small odontocete in any given year	11 mortalities applicable to any small odontocete in any given year[3]	85 mortalities applicable to any small odontocete over 5 years	55 mortalities applicable to any small odontocete over 5 years
	Unspecified	10 mortalities to beaked whales in any given year[1]	None	10 mortalities to beaked whales over 5 years[1]	None
	Vessel strike	No more than three large whale mortalities in any given year[2]	No more than one large whale mortality in any given year[2]	No more than 10 large whale mortalities over 5 years[2]	No more than one large whale mortality over 5 years[2]
Level A	Impulsive and Non-Impulsive	351 Species specific shown in Table 5-3	375 Species specific shown in Table 5-4	1,753 Species specific shown in Table 5-3	1,735 Species specific shown in Table 5-4
Level B	Impulsive and Non-Impulsive	2,053,473 Species specific shown in Table 5-3	2,441,640 Species specific shown in Table 5-4	10,263,631 Species specific shown in Table 5-3	11,559,236 Species specific shown in Table 5-4

[1] Ten Ziphiidae beaked whale to include any combination of Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, northern bottlenose whale, and Sowerby's beaked whale, and True's beaked whale (not to exceed 10 beaked whales total over the 5-year length of requested authorization)

[2] <u>For Training</u>: Because of the number of incidents in which the species of the stricken animal has remained unidentified, Navy cannot predict that proposed takes (either 3 per year or the 10 over the course of 5 years) will be of any particular species, and therefore seeks take authorization for any combination of large whale species (e.g., fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species), excluding the North Atlantic right whale

<u>For Testing</u>: Because of the number of incidents in which the species of the stricken animal has remained unidentified, the Navy cannot predict that the proposed takes (one over the course of 5 years) will be of any particular species, and therefore seeks take authorization for any large whale species (e.g., fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species), excluding the North Atlantic right whale

[3] Excluding ship shock trials.

[4] Predictions shown are for the theoretical maximum year, which would consist of all annual training and one Civilian Port Defense activity. Civilian Port Defense training would occur biennially.

Table 5-2. Summary of **Annual and 5-Year Take Request for AFTT Ship Shock Trials**

MMPA Category	Annual Authorization Sought[1]	5-Year Authorization Sought
Mortality	20 mortalities applicable to any small odontocete in any given year	25 mortalities applicable to any small odontocete over 5 years
Level A	7,383 Species specific shown in Table 5-4	7,779 Species specific shown in Table 5-4
Level B	5,185 Species specific shown in Table 5-4	5,474 Species specific shown in Table 5-4

[1] Up to three ship shock trials could occur in any one year (one CVN and two DDG/LCS ship shock trials), with one CVN, one DDG, and two LCS ship shock trials over the 5-year period. Ship shock trials could occur in either the VACAPES (year-round, except a CVN ship shock trial would not occur in the winter) or JAX (spring, summer, and fall only) Range Complexes. Actual location and time of year of a ship shock trial would depend on platform development, site availability, and availability of ship shock trial support facilities and personnel. For the purpose of requesting Level and Level B takes, the maximum predicted effects to a species for either location in any possible season are included in the species' total predicted effects.

Table 5-3. Species Specific Level A and Level B Takes for Training Activities

Species	Annual[1]		Total over 5-year period	
	Level B	Level A	Level B	Level A
Mysticetes				
Blue Whale*	147	0	735	0
Bryde's Whale	955	0	4,775	0
Minke Whale	60,402	16	302,010	80
Fin Whale*	4,490	1	22,450	5
Humpback Whale*	1,643	1	8,215	5
North Atlantic Right Whale*	112	0	560	0
Sei Whale*	10,188	1	50,940	5
Odontocetes - Delphinids				
Atlantic Spotted Dolphin	177,570	12	887,550	60
Atlantic White-Sided Dolphin	31,228	3	156,100	15
Bottlenose Dolphin	284,728	8	1,422,938	40
Clymene Dolphin	19,588	1	97,938	5
Common Dolphin	465,014	17	2,325,022	85
False Killer Whale	713	0	3,565	0
Fraser's Dolphin	2,205	0	11,025	0
Killer Whale	14,055	0	70,273	0
Melon-headed Whale	20,876	0	104,380	0
Pantropical Spotted Dolphin	70,968	1	354,834	5
Pilot Whale	101,252	3	506,240	15
Pygmy Killer Whale	1,487	0	7,435	0
Risso's Dolphin	238,528	3	1,192,618	15
Rough Toothed Dolphin	1,059	0	5,293	0
Spinner Dolphin	20,414	0	102,068	0
Striped Dolphin	224,305	7	1,121,511	35
White-Beaked Dolphin	1,613	0	8,027	0
Odontocetes – Sperm Whales				
Sperm Whale*	14,749	0	73,743	0
Odontocetes – Beaked Whales				
Blainville's Beaked Whale	28,179	0	140,893	0
Cuvier's Beaked Whale	34,895	0	174,473	0
Gervais' Beaked Whale	28,255	0	141,271	0
Northern Bottlenose Whale	18,358	0	91,786	0
Sowerby's Beaked Whale	9,964	0	49,818	0
True's Beaked Whale	16,711	0	83,553	0
Odontocetes – Kogia Species and Porpoises				
Kogia spp.	5,090	15	25,448	75
Harbor Porpoise	142,811	262	711,727	1,308
Phocid Seals				
Bearded Seal	0	0	0	0
Gray Seal	82	0	316	0
Harbor Seal	83	0	329	0
Harp Seal	4	0	12	0
Hooded Seal	5	0	25	0
Ringed Seal**	0	0	0	0

[1] Predictions shown are for the theoretical maximum year, which would consist of all annual training and one Civilian Port Defense activity. Civilian Port Defense training would occur biennially.

* ESA-Listed Species; ** ESA-proposed; PTS: permanent threshold shift; TTS: temporary threshold shift

Table 5-4. Species Specific Level A and Level B Takes for Testing Activities (Including Ship Shock Trials)

Species	Annual[1,2]		Total over 5-year period	
	Level B	Level A	Level B	Level A
Mysticetes				
Blue Whale*	18	0	82	0
Bryde's Whale	64	0	304	0
Minke Whale	7,756	15	34,505	28
Fin Whale*	599	0	2,784	0
Humpback Whale*	200	0	976	0
North Atlantic Right Whale*	87	0	395	0
Sei Whale*	796	0	3,821	0
Odontocetes - Delphinids				
Atlantic Spotted Dolphin	24,429	1,854	104,647	1,964
Atlantic White-Sided Dolphin	10,330	147	50,133	166
Bottlenose Dolphin	33,708	149	146,863	190
Clymene Dolphin	2,173	80	10,169	87
Common Dolphin	52,546	2,203	235,493	2,369
False Killer Whale	109	0	497	0
Fraser's Dolphin	171	0	791	0
Killer Whale	1,540	2	7,173	2
Melon-headed Whale	1,512	28	6,950	30
Pantropical Spotted Dolphin	7,985	71	38,385	92
Pilot Whale	15,701	153	74,614	163
Pygmy Killer Whale	135	3	603	3
Risso's Dolphin	24,356	70	113,682	89
Rough Toothed Dolphin	138	0	618	0
Spinner Dolphin	2,862	28	13,208	34
Striped Dolphin	21,738	2,599	97,852	2,751
White-Beaked Dolphin	1,818	3	8,370	3
Odontocetes – Sperm Whales				
Sperm Whale*	1,786	5	8,533	6
Odontocetes – Beaked Whales				
Blainville's Beaked Whale	4,753	3	23,561	3
Cuvier's Beaked Whale	6,144	1	30,472	1
Gervais' Beaked Whale	4,764	4	23,388	4
Northern Bottlenose Whale	12,096	5	60,409	6
Sowerby's Beaked Whale	2,698	0	13,338	0
True's Beaked Whale	3,133	1	15,569	1
Odontocetes – Kogia Species and Porpoises				
Kogia spp.	1,163	12	5,536	36
Harbor Porpoise	2,182,872	216	10,358,300	1,080
Phocid Seals				
Bearded Seal	33	0	161	0
Gray Seal	3,293	14	14,149	46
Harbor Seal	8,668	78	38,860	330
Harp Seal	3,997	14	16,277	30
Hooded Seal	295	0	1,447	0
Ringed Seal**	359	0	1,795	0

[1] Predictions shown are for the theoretical maximum year, which would consist of all annual testing; one CVN ship shock trial and two other ship shock trials (DDG or LCS); and Unmanned Underwater Vehicle (UUV) Demonstrations at each of three possible sites. One CVN, one DDG, and two LCS ship shock trials could occur within the 5-year period. Typically, one UUV Demonstration would occur annually at one of the possible sites.
[2] Ship shock trials could occur in either the VACAPES (year-round, except a CVN ship shock trial would not occur in the winter) or JAX (spring, summer, and fall only) Range Complexes. Actual location and time of year of a ship shock trial would depend on platform development, site availability, and availability of ship shock trial support facilities and personnel. For the purpose of requesting takes, the maximum predicted effects to a species for either location in any possible season are included in the species' total predicted effects.
* ESA-Listed Species; ** ESA-proposed; PTS: permanent threshold shift; TTS: temporary threshold shift

6 NUMBERS AND SPECIES TAKEN

6.1 ESTIMATED TAKE OF MARINE MAMMALS BY IMPULSIVE AND NON-IMPULSIVE 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, reproductive condition of the various species of marine mammals predicted to be taken as a result of the proposed Navy training and testing. There are 45 marine mammal species known to exist in the Study Area that are managed by NMFS (Table 3-1). 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 and Webb 1971) and summarized by the National Academies of Science, human-generated sound could possibly harm marine mammals or significantly interfere with their normal activities (National Research Council 2005). 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 sound, 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). 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 no standard definitions exist, sounds may be broadly categorized as impulsive or non-impulsive. Impulsive sounds feature a very rapid increase to high pressures, followed by a rapid return to the static pressure. Impulsive sounds are often produced by processes involving a rapid release of energy or mechanical impacts (Hamernik and Hsveh 1991). Explosions, airgun detonations, and impact pile driving are examples of impulsive sound sources. Non-impulsive sounds lack the rapid rise time and can have longer durations than impulsive sounds. Non-impulsive sound can be continuous or intermittent. Sonar pings, vessel noise, and underwater transponders are all examples of non-impulsive sound sources.

6.1.1 CONCEPTUAL FRAMEWORK FOR ASSESSING EFFECTS FROM SOUND-PRODUCING ACTIVITIES

This conceptual framework describes the different types of effects that are possible and the potential relationships between sound stimuli and long-term consequences for the individual and population. The conceptual framework is central to the assessment of acoustic-related effects and is consulted multiple times throughout the process. It describes potential effects and the pathways by which an acoustic stimulus or sound-producing activity can potentially affect animals. The conceptual framework qualitatively describes costs to the animal (e.g., expended energy or missed feeding opportunity) that may be associated with specific reactions. Finally, the conceptual framework outlines the conditions that may lead to long-term consequences for the individual and population if the animal cannot fully recover from the short-term effects.

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 sound-producing activities. The severity of these effects can vary greatly between minor effects that have no real cost to the animal, to more severe effects that may have lasting consequences. Whether a marine animal is significantly affected must be determined from the best available scientific data regarding the potential physiological and behavioral responses to sound-producing activities and the possible costs and long-term consequences of those responses.

The major categories of potential effects are:

- Direct trauma
- Auditory fatigue
- Auditory masking
- Behavioral reactions
- Physiological stress

Direct trauma refers to injury to organs or tissues of an animal as a direct result of an intense sound wave or shock wave impinging upon or passing through its body. Potential impacts on an animal's internal tissues and organs are assessed by considering the characteristics of the exposure and the response characteristics of the tissues. Trauma can be mild and fully recoverable, with no long-term repercussions to the individual or population, or more severe, with the potential for lasting effects or, in some cases, mortality.

Auditory fatigue may result from over-stimulation of the delicate hair cells and tissues within the auditory system. The most familiar effect of auditory fatigue is hearing loss, also called a noise-induced threshold shift, meaning an increase in the hearing threshold.

Audible natural and artificial sounds can potentially result in auditory masking, a condition that occurs when noise interferes with an animal's ability to hear other sounds. Masking occurs when the perception of a sound is interfered with by a second sound, and the probability of masking increases as the two sounds increase in similarity and the masking sound increases in level. It is important to distinguish auditory fatigue, which persists after the sound exposure, from masking, which only occurs during the sound exposure.

Marine animals naturally experience physiological stress as part of their normal life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with conspecifics (members of the same species), and interactions with predators all contribute to the stress a marine animal naturally experiences. The physiological response to a stressor, often termed the stress response, is an adaptive process that helps an animal cope with changing external and internal environmental conditions. However, too much of a stress response can be harmful to an animal, resulting in physiological dysfunction. In some cases, naturally occurring stressors can have profound impacts on animals. Sound-producing activities have the potential to provide additional stress, which must be considered, not only for its direct impact on an animal's behavior but also for contributing to an animal's chronic stress level.

A sound-producing activity can cause a variety of behavioral reactions in animals ranging from very minor and brief, to more severe reactions such as aggression or prolonged flight. The acoustic stimuli can cause a stress reaction (i.e., startle or annoyance); they may act as a cue to an animal that has experienced a stress reaction in the past to similar sounds or activities, or that acquired a learned behavioral response to the sounds from conspecifics. An animal may choose to deal with these stimuli or ignore them based on the severity of the stress response, the animal's past experience with the sound, and the other stimuli that are present in the environment. If an animal chooses to react to the acoustic stimuli, then the behavioral responses fall into two categories: alteration of natural behavior patterns or avoidance. The specific type and severity of these reactions helps determine the costs and ultimate consequences to the individual and population.

6.1.1.1 Flowchart

Figure 6-1 is a flowchart that diagrams the process used to evaluate the potential effects on marine animals from 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 acoustic waves but also shock waves generated from explosive sources. The supporting text clarifies those instances where it is necessary to distinguish between the two phenomena.

Box A1, the *Sound-Producing Activity*, is the source of the sound stimuli and therefore the starting point in the analysis. Each of the five major categories of potential effects (i.e., direct trauma, auditory fatigue, masking, behavioral response, and stress) are presented as pathways that flow from left to right across the diagram. Pathways are not exclusive, and each must be followed until it can be concluded that an animal is not at risk for that specific effect. The vertical columns show the steps in the analysis used to examine each of the effects pathways. These steps proceed from the *Stimuli,* to the *Physiological Responses*, to any potential *Behavioral Responses*, to the *Costs to the Animal*, to the *Recovery* of the animal, and finally to the *Long-Term Consequences* to the *Individual* and *Population*.

6.1.1.2 Stimuli

The first step in predicting whether a sound-producing activity is capable of causing an effect on a marine animal is to define the *Stimuli* experienced by the animal. The *Stimuli* include the *Sound-Producing Activity*, the surrounding acoustical environment, the characteristics of the sound when it reaches the animal, and whether the animal can detect the sound.

Sounds emitted from a *sound-producing Activity* (Box A1) travel through the environment to create a spatially variable sound field. There can be any number of individual sound sources in a given activity, each with its own unique characteristics. For example, a Navy training exercise may involve several ships and aircraft, several types of sonar, and several types of ordnance. Each of the individual sound sources has unique characteristics: source level, frequency, duty cycle, duration, and rise-time (i.e., impulsive vs. non-impulsive). Each source also has a range, depth/altitude, bearing and directionality, and movement relative to the animal. Environmental factors such as temperature, salinity, bathymetry, bottom type, and sea state all impact how sound spreads through the environment and how sound decreases in amplitude between the source and the receiver (individual animal). Mathematical calculations and computer models are used to predict how the characteristics of the sound will change between the source and the animal under a range of realistic environmental conditions for the locations where sound-producing activities occur.

The details of the overall activity may also be important to place the potential effects into context and help predict the range of severity of the probable reactions. The overall activity level (e.g., number of ships and aircraft involved in exercise); the number of sound sources within the activity; the activity duration; and the range, bearing, and movement of the activity relative to the animal are all considered.

The *received sound at the animal* and the number of times the sound is experienced (i.e., repetitive exposures) (Box A2) determines the range of possible effects. Sounds that are higher than the ambient noise level and within an *animal's hearing sensitivity* range (Box A3) have the potential to cause effects. Very high exposure levels may have the potential to cause trauma; high-level exposures, long-duration exposures, or repetitive exposures may potentially cause auditory fatigue; lower-level exposures may potentially lead to masking; all perceived levels may lead to stress; and many sounds, including sounds that are not detectable by the animal, will have *no* e*ffect* (Box A4).

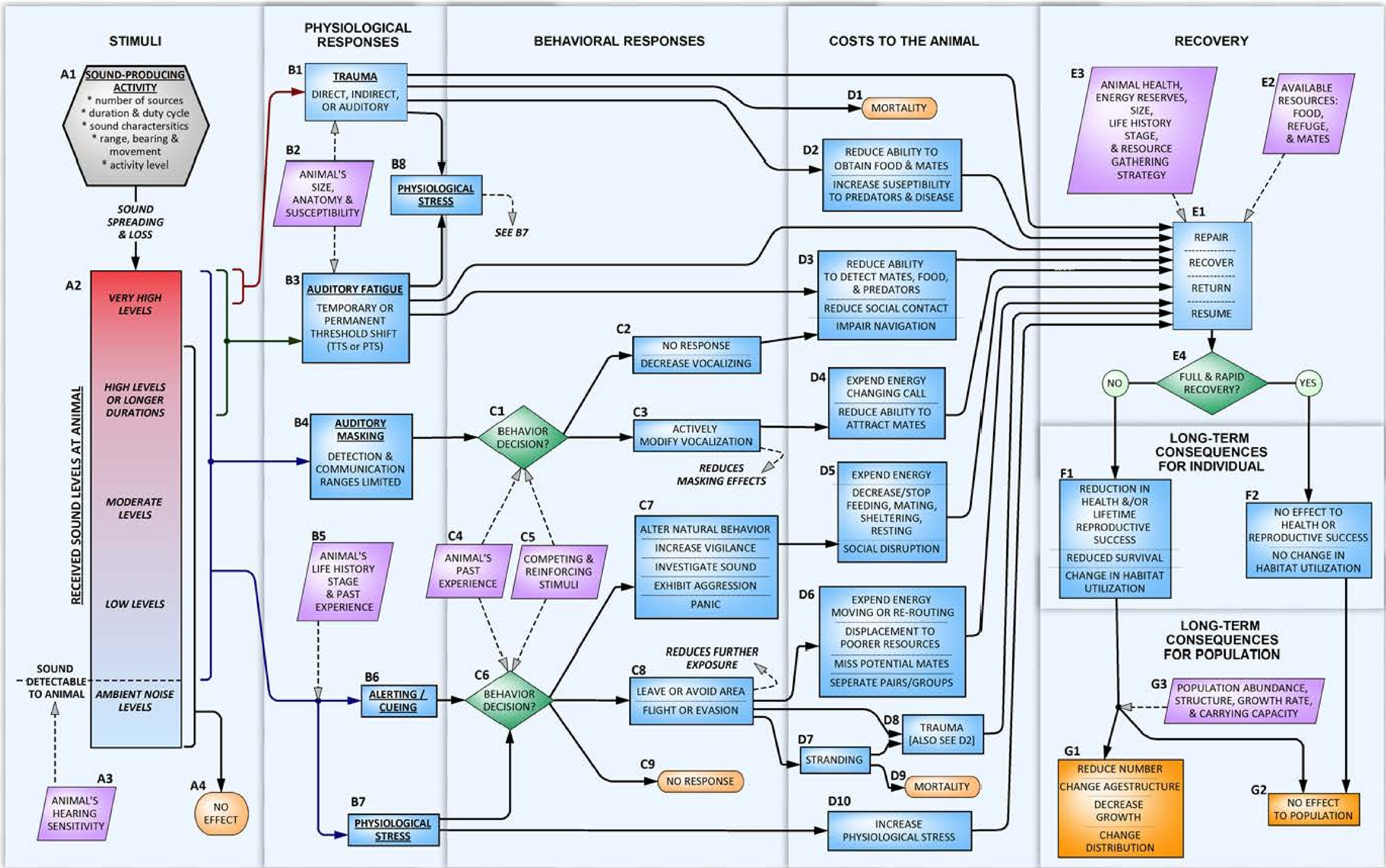


Figure 6-1. Flow Chart of the Evaluation Process of Sound-Producing Activities

6.1.1.3 Physiological Responses

Physiological responses include direct trauma, hearing loss, auditory masking, and stress. The magnitude of the involuntary response is predicted based on the characteristics of the acoustic stimuli and the characteristics of the animal (species, susceptibility, life history stage, size, and past experiences).

6.1.1.3.1 Trauma

Physiological responses to sound stimulation may range from mechanical vibration (with no resulting adverse effects) to tissue trauma (injury). Direct *trauma* (Box B1) refers to the direct injury of tissues and organs by sound waves impinging upon or traveling through an animal's body. Marine animals' bodies, especially their auditory systems, are well adapted to large hydrostatic pressures and large, but relatively slow, pressure changes that occur with changing depth. However, mechanical trauma may result from exposure to very-high-amplitude sounds when the elastic limits of the auditory system are exceeded or when animals are exposed to intense sounds with very rapid rise times, such that the tissues cannot respond adequately to the rapid pressure changes. Trauma to marine animals from sound exposure requires high received levels. Trauma effects therefore normally only occur with very-high-amplitude, often impulsive, sources, and at relatively close range, which limits the number of animals likely exposed to trauma-inducing sound levels.

Direct trauma includes both auditory and non-auditory trauma. Auditory trauma is the direct mechanical injury to hearing-related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma differs from auditory fatigue in that the latter involves the overstimulation of the auditory system at levels below those capable of causing direct mechanical damage. Auditory trauma is always injurious but can be temporary. One of the most common consequences of auditory trauma is hearing loss (see below).

Non-auditory trauma can include hemorrhaging of small blood vessels and the rupture of gas-containing tissues such as the lung, swim bladder, or gastrointestinal tract. After the ear (or other sound-sensing organs), these are usually the most sensitive organs and tissues to acoustic trauma. An *animal's size and anatomy* are important in determining its *susceptibility to trauma* (Box B2), especially non-auditory trauma. Larger size indicates more tissue to protect vital organs that might be otherwise susceptible (i.e., there is more attenuation of the received sound before it impacts non-auditory structures). Therefore, larger animals should be less susceptible to trauma than smaller animals. In some cases, acoustic resonance of a structure may enhance the vibrations resulting from noise exposure and result in an increased susceptibility to trauma. Resonance is a phenomenon that exists when an object is vibrated at a frequency near its natural frequency of vibration, or the particular frequency at which the object vibrates most readily. The size, geometry, and material composition of a structure determine the frequency at which the object will resonate. The potential for resonance is determined by comparing the sound frequencies with the resonant frequency and damping of the tissues. Because most biological tissues are heavily damped, the increase in susceptibility from resonance is limited.

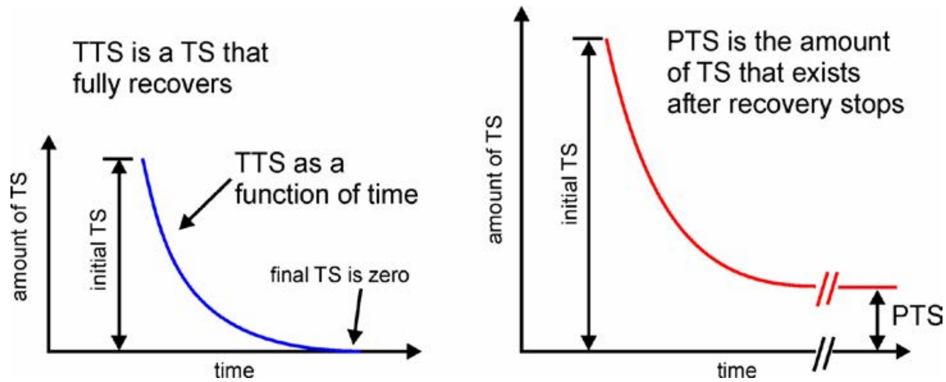
Vascular and tissue bubble formation resulting from sound exposure is a hypothesized mechanism of indirect trauma to marine animals. The risk of bubble formation from one of these processes, called rectified diffusion, is based on the amplitude, frequency, and duration of the sound (Crum and Mao 1996) and an animal's tissue nitrogen gas saturation at the time of the exposure. Rectified diffusion is the growth of a bubble that fluctuates in size because of the changing pressure field caused by the sound wave. 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 gas-supersaturated tissues. Bubbles have also been hypothesized to result from changes in the dive behavior of marine mammals as a result of sound exposure (Jepson et al. 2003). Vascular bubbles produced by this mechanism would not be a physiological response to the sound exposure, but a cost to the animal because of the change in behavior (see Costs to the Animal in this section). Under either of these hypotheses, several things could happen: (1) bubbles could grow to the extent that vascular blockage (emboli) and tissue hemorrhage occur; (2) bubbles could 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; or (3) the bubbles could be cleared by the lung without negative consequence to the animal. Although rectified diffusion is a known phenomenon, its applicability to diving marine animals exposed to sound is questionable; animals would need to be highly supersaturated with gas and very close to a high-level sound source (Crum et al. 2005). The other two hypothesized phenomena are largely theoretical and have not been demonstrated under realistic exposure conditions.

6.1.1.3.2 Auditory Fatigue

Auditory fatigue is a reduction in hearing ability resulting from overstimulation to sounds. The mechanisms responsible for auditory fatigue differ from auditory trauma and may consist of a variety of mechanical and biochemical processes, including physical damage or distortion of the tympanic membrane and cochlear hair cell stereocilia, oxidative stress-related hair cell death, changes in cochlear blood flow, and swelling of cochlear nerve terminals resulting from glutamate excitotoxicity (Henderson et al. 2006; Kujawa and Liberman 2009). Although the outer hair cells are the most prominent target for fatigue effects, severe noise exposures may also result in inner hair cell death and loss of auditory nerve fibers (Henderson et al. 2006). Auditory fatigue is possibly the best studied type of effect from sound exposures in marine and terrestrial animals, including humans. The characteristics of the received sound stimuli are used and compared to the *animal's hearing sensitivity* and susceptibility to noise (Box A3) to determine the potential for auditory fatigue.

Auditory fatigue manifests itself as hearing loss, called a noise-induced threshold shift. A threshold shift may be either permanent threshold shift (PTS), or temporary threshold shift (TTS). Note that the term "auditory fatigue" is often used to mean a TTS; however, in this analysis, a more general meaning to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from auditory trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure) is used.

The distinction between PTS and TTS is based on whether there is a complete recovery of hearing sensitivity following a sound exposure. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 6-2 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.



TTS – temporary threshold shift
TS – threshold shift
PTS – permanent threshold shift

Figure 6-2. Two Hypothetical Threshold Shifts

The relationship between TTS and PTS is complicated and poorly understood, even in humans and terrestrial mammals, where numerous studies failed to delineate a clear relationship between the two. Relatively small amounts of TTS (e.g., less than 40–50 dB measured 2 minutes after exposure) will recover with no apparent long-term effects; however, terrestrial mammal studies revealed that large amounts of TTS (e.g., approximately 40 dB measured 24 hours after exposure) can result in permanent neural degeneration, despite the hearing thresholds returning to normal (Kujawa and Liberman 2009). The amounts of TTS induced by Kujawa and Liberman were described as being "at the limits of reversibility." It is unknown whether smaller amounts of TTS can result in similar neural degeneration, or if effects would translate to other species such as marine animals.

The amplitude, frequency, duration, and temporal pattern of the sound exposure are important parameters for predicting the potential for auditory fatigue. Duration is particularly important because auditory fatigue is exacerbated with prolonged exposure time. The frequency of the sound also plays an important role in susceptibility to hearing loss. Experiments show that animals are most susceptible to *fatigue* (Box B3) within their most sensitive hearing range. Sounds outside of an animal's audible frequency range do not cause fatigue.

The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds and communicate. This is referred to as reducing an animal's "acoustic space." This reduction can be estimated given the amount of threshold shift incurred by an animal.

6.1.1.3.3 Auditory Masking

Auditory masking occurs if the noise from an activity interferes with an animal's ability to detect, understand, or recognize biologically relevant sounds of interest (Box B4). "Noise" refers to unwanted or unimportant sounds that mask an animal's ability to hear "sounds of interest." A sound of interest refers to a sound that is potentially being detected. Sounds of interest include those from conspecifics such as offspring, mates, and competitors; echolocation clicks; sounds from predators; natural, abiotic sounds that may aid in navigation; and reverberation, which can give an animal information about its location and orientation within the ocean.

The frequency, received level, and duty cycle of the sound determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the ocean space within which an animal can detect biologically relevant sounds.

6.1.1.3.4 Physiological Stress

If a sound is detected (i.e., heard or sensed) by an animal, a *stress* response can occur (Box B7); or the sound can *cue or alert* the animal (Box B6) without a direct, measurable stress response. If an animal suffers trauma or auditory fatigue, a *physiological stress* response will occur (Box B8). A stress response is a physiological change resulting from a stressor that is meant to help the animal deal with the stressor. The generalized stress response is characterized by a release of hormones (Reeder and Kramer 2005); however, it is now acknowledged that other chemicals produced in a stress response (e.g., stress markers) exist. For example, a release of reactive oxidative compounds, as occurs in noise-induced hearing loss (Henderson et al. 2006), occurs in response to some acoustic stressors. Stress hormones include those produced by the sympathetic nervous system, norepinephrine and epinephrine (i.e., the catecholamines), which produce elevations in the heart and respiration rate, increase awareness, and increase the availability of glucose and lipid for energy. Other stress hormones are the glucocorticoid steroid hormones cortisol and aldosterone, which are produced by the adrenal gland. These hormones are classically used as an indicator of a stress response and to characterize the magnitude of the stress response (Hennessy et al. 1979). Oxidative stress occurs when reactive molecules, called reactive oxygen species, are produced in excess of molecules that counteract their activity (i.e., antioxidants).

An acute stress response is traditionally considered part of the startle response and is hormonally characterized by the release of the catecholamines. Annoyance type reactions may be characterized by the release of either or both catecholamines and glucocorticoid hormones. Regardless of the physiological changes that make up the stress response, the stress response may contribute to an animal's decision to alter its behavior. Alternatively, a stimulus may not cause a measurable stress response but may act as an alert or cue to an animal to change its behavior. This response may occur because of learned associations; the animal may have experienced a stress reaction in the past to similar sounds or activities (Box C4), or it may have learned the response from conspecifics. The severity of the stress response depends on the *received sound level* at the animal (Box A2); the details of the *sound-producing activity* (Box A1); the *animal's life history stage* (e.g., juvenile or adult; breeding or feeding season) (Box B5); and the *animal's past experience* with the stimuli (Box B5). These factors will be subject to individual variation, as well as variation within an individual over time.

An *animal's life history stage* is an important factor to consider when predicting whether a stress response is likely (Box B5). An animal's life history stage includes its level of physical maturity (i.e., larva, infant, juvenile, sexually mature adult) and the primary activity in which it is engaged such as mating, feeding, or rearing/caring for young. Animals engaged in a critical life activity such as mating or feeding may have a lesser stress response than an animal engaged in a more flexible activity such as resting or migrating (i.e., an activity that does not necessarily depend on the availability of resources). The animal's past experiences with the stimuli or similar stimuli are another important consideration. Prior experience with a stressor may be of particular importance because repeated experience with a stressor may dull the stress response via acclimation (St.Aubin and Dierauf 2001) or increase the response via sensitization.

6.1.1.4 Behavioral Responses

Any number of behavioral responses can result from a physiological response. An animal "decides" how it will behave in response to the stimulus based on a number of factors in addition to the severity of the physiological response. An animal's experience with the sound (or similar sounds), the context of the acoustic exposure, and the presence of other stimuli contribute to determining its reaction from a suite of possible behaviors.

Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and many overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary drastically between minor and brief reorientations of the animal to investigate the sound, to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the cost to the animal.

6.1.1.4.1 Trauma and Auditory Fatigue

Direct trauma and auditory fatigue increases the animal's *physiological stress* (Box B8), which feeds into the *stress* response (Box B7). Direct trauma and auditory fatigue increase the likelihood or severity of a behavioral response and *increase* an animal's overall physiological stress level (Box D10).

6.1.1.4.2 Auditory Masking

A behavior decision is made by the animal when the animal detects increased background noise, or possibly when the animal recognizes that biologically relevant sounds are being masked (Box C1). An *animal's past experience* with the sound -producing activity or similar acoustic stimuli can affect its choice of behavior during auditory masking (Box C4). *Competing and reinforcing stimuli* may also affect its decision (Box C5).

An animal can choose a passive behavioral response when coping with auditory masking (Box C2). It may simply not respond and keep conducting its current natural behavior. An animal may also decide to stop calling until the background noise decreases. These passive responses do not present a direct energetic cost to the animal; however, auditory masking will continue, depending on the acoustic stimuli.

An animal can choose to actively compensate for auditory masking (Box C3). An animal can vocalize more loudly to make its signal heard over the masking noise. An animal may also shift the frequency of its vocalizations away from the frequency of the masking noise. This shift can actually reduce the masking effect for the animal and other animals that are "listening" in the area. For example, in marine mammals, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying. Changes included mimicry of the sound, cessation of vocalization, increases and decreases in vocalization length, increases and decreases in vocalization rate, and increases in vocalization frequency and level, while other animals showed no significant changes in the presence of anthropogenic sound.

An *animal's past experiences* can be important in determining what behavior decision it may make when dealing with auditory masking (Box C4). Past experience can be with the sound-producing activity itself or with similar acoustic stimuli. For example, an animal may learn over time the best way to modify its vocalizations to reduce the effects of masking noise.

Other *stimuli* present in the environment can influence an animal's behavior decision (Box C5). These stimuli can be other acoustic stimuli not directly related to the sound-producing activity; they can be visual, olfactory, or tactile stimuli; the stimuli can be conspecifics or predators in the area; or the stimuli can be the strong drive to engage in a natural behavior. Competing stimuli tend to suppress any potential behavioral reaction. For example, an animal involved in mating or foraging may not react with the same degree of severity as it may have otherwise. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, awareness of a predator in the area coupled with the acoustic stimuli may illicit a stronger reaction than the acoustic stimuli itself otherwise would have. The visual stimulus of seeing ships and aircraft, coupled with the acoustic stimuli, may also increase the likelihood or severity of a behavioral response.

6.1.1.4.3 Behavioral Reactions and Physiological Stress

A *physiological stress* response (Box B7) such as an annoyance or startle reaction, or a *cueing or alerting* reaction (Box B6) may cause an animal to make a *behavior decision* (Box C6). Any exposure that produces an injury or auditory fatigue is also assumed to produce a *stress* response (Box B7) and increase the severity or likelihood of a behavioral reaction. Both an animal's past experience (Box C4) and *competing and reinforcing stimuli* (Box C5) can affect an animal's behavior decision. The decision can result in three general types of behavioral reactions: *no response* (Box C9), *area avoidance* (Box C8), or *alteration of a natural behavior* (Box C7).

Little data exist that correlate specific behavioral reactions with specific stress responses. Therefore, in practice the likely range of behavioral reactions is estimated from the acoustic stimuli instead of the magnitude of the stress response. It is assumed that a stress response must exist to alter a natural behavior or cause an avoidance reaction. Estimates of the types of behavioral responses that could occur for a given sound exposure can be determined from the literature.

An *animal's past experiences* can be important in determining what behavior decision it may make when dealing with a stress response (Box C4). Past experience can be with the sound-producing activity itself or with similar sound stimuli. Habituation is the process by which an animal learns to ignore or tolerate stimuli over some period of time and return to a normal behavior pattern, perhaps after being exposed to the stimuli with no negative consequences. A habituated animal may have a lesser behavioral response than the first time it encountered the stimuli. Sensitization is when an animal becomes more sensitive to a set of stimuli over time, perhaps as a result of a past, negative experience with the stimuli or similar stimuli. A sensitized animal may have a stronger behavioral response than the first time it encountered the stimuli.

Other *stimuli* (Box C5) present in the environment can influence an animal's *behavior decision* (Box C6). These stimuli can be other acoustic stimuli not directly related to the sound-producing activity, such as visual stimuli; the stimuli can be conspecifics or predators in the area, or the stimuli can be the strong drive to engage or continue in a natural behavior. Competing stimuli tend to suppress any potential behavioral reaction. For example, an animal involved in mating or foraging may not react with the same degree of severity as an animal involved in less-critical behavior. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, the awareness of a predator in the area coupled with the acoustic stimuli may elicit a stronger reaction than the acoustic stimuli themselves otherwise would have.

The visual stimulus of seeing human activities such as ships and aircraft maneuvering, coupled with the acoustic stimuli, may also increase the likelihood or severity of a behavioral response. It is difficult to separate the stimulus of the sound from the stimulus of the ship or platform creating the sound. The sound may act as a cue, or as one stimulus of many that the animal is considering when deciding how to react. An activity with several platforms (e.g., ships and aircraft) may elicit a different reaction than an activity with a single platform, both with similar acoustic footprints. The total number of vehicles and platforms involved, the size of the activity area, and the distance between the animal and activity are important considerations when predicting behavioral responses.

An animal may reorient or become more *vigilant* if it detects a sound-producing activity (Box C7). Some animals may *investigate* the sound using other sensory systems (e.g., vision), and perhaps move closer to the sound source. *Reorientation, vigilance, and investigation* all require the animal to divert attention and resources and therefore slow or stop their presumably beneficial natural behavior. This can be a very brief diversion, after which the animal continues its natural behavior, or an animal may not resume its natural behaviors until after a longer period when the animal has habituated to the sound or the activity has concluded. An attentional change via an orienting response represents behaviors that would be considered mild disruption. More severe alterations of natural behavior would include *aggression or panic*.

An animal may choose to *leave or avoid an area* where a sound-producing activity is taking place (Box C8). Avoidance is the displacement of an individual from an area. A more severe form of this comes in the form of flight or evasion. A flight response is a dramatic change in normal movement to a directed and rapid movement away from the detected location of a sound source. Avoidance of an area can help the animal avoid further acoustic effects by avoiding or reducing further exposure.

An animal may choose *not to respond* to a sound-producing activity (Box C9). The physiological stress response may not rise to the level that would cause the animal to modify its behavior. The animal may have habituated to the sound or simply learned through past experience that the sound is not a threat. In this case a behavioral effect would not be predicted. An animal may choose not to respond to a sound-producing activity in spite of a physiological stress response. Some combination of competing stimuli may be present such as a robust food patch or a mating opportunity that overcomes the stress response and suppresses any potential behavioral responses. If the noise-producing activity persists over long periods or reoccurs frequently, the acute stress felt by animals could increase their overall chronic stress levels.

6.1.1.5 Costs to the Animal

The potential costs to a marine animal from an involuntary or behavioral response include no measurable cost, expended energy reserves, increased stress, reduced social contact, missed opportunities to secure resources or mates, displacement, and stranding or severe evasive behavior (which may potentially lead to secondary trauma or death). Animals suffer costs on a daily basis from a host of natural situations such as dealing with predator or competitor pressure. If the costs to the animal from an acoustic-related effect fall outside of its normal daily variations, then individuals must recover from significant costs to avoid long-term consequences.

6.1.1.5.1 Trauma

Trauma or injury to an animal may *reduce its ability to secure food* by *reducing its mobility* or the efficiency of its sensory systems, make the injured individual *less attractive to potential mates*, or increase *an individual's chances of contracting diseases or falling prey to a predator* (Box D2). A severe trauma can lead to the *death* of the individual (Box D1).

6.1.1.5.2 Auditory Fatigue and Auditory Masking

Auditory fatigue and masking can impair an animal's ability to hear biologically important sounds (Box D3), especially fainter and distant sounds. Sounds could belong to conspecifics such as other individuals in a social group (i.e., pod, school, etc.), potential mates, potential competitors, or parents/offspring. Biologically important sounds could also be an animal's own biosonar echoes used to detect prey, predators, and the physical environment. Therefore, auditory masking or a hearing loss could reduce an animal's ability to contact social groups, offspring, or parents; and reduce opportunities to detect or attract more distant mates. Animals may also use sounds to gain information about their physical environment by detecting the reverberation of sounds in the underwater space or sensing the sound of crashing waves on a nearby shoreline. These cues could be used by some animals to migrate long distances or navigate their immediate environment. Therefore, an animal's ability to navigate may be impaired if the animal uses acoustic cues from the physical environment to help identify its location. Auditory masking and fatigue both effectively reduce the animal's acoustic space and the ocean volume in which detection and communication are effective.

An animal that *modifies its vocalization* in response to auditory masking could incur a cost (Box D4). Modifying vocalizations may cost the animal energy from its finite energy budget. Additionally, shifting the frequency of a call can make an animal appear to be less-fit to conspecifics. Animals that are larger are typically capable of producing lower-frequency sounds than smaller conspecifics. Therefore, lower-frequency sounds are usually an indicator of a larger and presumably more fit and experienced potential mate.

Auditory masking or auditory fatigue may also lead to no measurable costs for an animal. Masking could be of short duration or intermittent such that biologically important sounds that are continuous or repeated are received by the animal between masking noise. Auditory fatigue could also be inconsequential for an animal if the frequency range affected is not critical for that animal to hear within, or the auditory fatigue is of such short duration (e.g. a few minutes) that there are no costs to the individual.

6.1.1.5.3 Behavioral Reactions and Physiological Stress

An animal that alters its natural behavior in response to stress or an auditory cue may slow or cease its presumably beneficial natural behavior and instead *expend energy* reacting to the sound-producing activity (Box D5). Beneficial natural behaviors include *feeding, breeding, sheltering, and migrating*. The cost of feeding disruptions depends on the energetic requirements of individuals and the potential amount of food missed during the disruption. Alteration in breeding behavior can result in delaying reproduction. The costs of a brief interruption to migrating or sheltering are less clear. Most behavior alterations also require the animal to expend energy for a nonbeneficial behavior. The amount of energy expended depends on the severity of the behavioral response.

An animal that avoids a sound-producing activity may expend additional energy moving around the area, be displaced to poorer resources, miss potential mates, or have social interactions affected (Box D6). Avoidance reactions can cause an animal to expend energy. The amount of energy expended depends on the severity of the behavioral response. Missing potential mates can result in delaying reproduction. Social groups or pairs of animals, such as mates or parent/offspring pairs, could be separated during a severe behavioral response such as flight. Offspring that depend on their parents may die if they are permanently separated. Splitting up an animal group can result in a reduced group size, which can have secondary effects on individual foraging success and susceptibility to predators.

Some severe behavioral reactions can lead to *stranding* (Box D7) or secondary *trauma* (Box D8). Animals that take prolonged flight, a severe avoidance reaction, may injure themselves or strand in an environment for which they are not adapted. Some *trauma* is likely to occur to an animal that strands (Box D8). Trauma can *reduce the animal's ability to secure food and mates*, and *increase the animal's susceptibility to predation and disease* (Box D2). An animal that strands and does not return to a hospitable environment quickly will likely *die* (Box D9).

Elevated stress levels may occur whether or not an animal exhibits a behavioral response (Box D10). Even while undergoing a stress response, competing stimuli (e.g., food or mating opportunities) may overcome an animal's initial stress response during the behavior decision. Regardless of whether the animal displays a behavioral reaction, this tolerated stress could incur a cost to the animal. Reactive oxygen species produced during normal physiological processes are generally counterbalanced by enzymes and antioxidants; however, excess stress can result in an excess production of reactive oxygen species, leading to damage of lipids, proteins, and nucleic acids at the cellular level (Berlett and Stadtman 1997; Sies 1997; Touyz 2004)

6.1.1.6 Recovery

The predicted recovery of the animal (Box E1) is based on the cost of any masking or behavioral response and the severity on any involuntary physiological reactions (e.g., direct trauma, hearing loss, or increased chronic stress). Many effects are fully recoverable upon cessation of the sound-producing activity, and the vast majority of effects are completely recoverable over time; whereas a few effects may not be fully recoverable. The availability of resources and the characteristics of the animal play a critical role in determining the speed and completeness of recovery.

Available resources fluctuate by season, location, and year and can play a major role in an animal's rate of recovery (Box E2). Plentiful *food* can aid in a quicker recovery, whereas recovery can take much longer if food resources are limited. If many potential *mates* are available, an animal may recover quickly from missing a single mating opportunity. *Refuge* or shelter is also an important resource that may give an animal an opportunity to recover or repair after an incurred cost or physiological response.

An *animal's health, energy reserves, size, life history stage, and resource gathering strategy* affect its speed and completeness of recovery (Box E3). Animals that are in good health and have abundant energy reserves before an effect will likely recover more quickly. Adult animals with stored energy reserves (e.g., fat reserves) may have an easier time recovering than juveniles that expend their energy growing and developing and have less in reserve. Large individuals and large species may recover more quickly, also due to having more potential for energy reserves. Animals that gather and store resources, perhaps fasting for months during breeding or offspring rearing seasons, may have a more difficult time recovering from being temporarily displaced from a feeding area than an animal that feeds year round.

Damaged tissues from mild to moderate trauma may heal over time. The predicted recovery of direct trauma is based on the severity of the trauma, availability of resources, and characteristics of the animal. After a sustained injury an animal's body attempts to *repair* tissues. The animal may also need to *recover* from any potential costs due to a decrease in resource gathering efficiency and any secondary effects from predators or disease (Box E1). Moderate to severe trauma that does not cause mortality may never fully heal.

Small to moderate amounts of hearing loss may recover over a period of minutes to days, depending on the nature of the exposure and the amount of initial threshold shift. Severe noise-induced hearing loss may not fully recover, resulting in some amount of permanent hearing loss.

Auditory masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity (Box E1). Natural behaviors may *resume* shortly after or even during the acoustic stimulus after an initial assessment period by the animal. Any energetic expenditures and missed opportunities to find and secure resources incurred from masking or a behavior alteration may take some time to *recover*.

Animals displaced from their normal habitat due to an avoidance reaction may *return* over time and *resume* their natural behaviors, depending on the severity of the reaction and how often the activity is repeated in the area. In areas of repeated and frequent acoustic disturbance, some animals may habituate to the new baseline or fluctuations in noise level. More sensitive species, or animals that may have been sensitized to the stimulus over time due to past negative experiences, may not return to an area. Other animals may return but not resume use of the habitat in the same manner as before the acoustic-related effect. For example, an animal may return to an area to feed or navigate through it to get to another area, but that animal may no longer seek that area as refuge or shelter.

Frequent milder physiological responses to an individual may accumulate over time if the time between sound-producing activities is not adequate to give the animal an opportunity to fully recover. An increase in an animal's chronic stress level is also possible if stress caused by a sound-producing activity does not return to baseline between exposures. Each component of the stress response is variable in time, and stress hormones return to baseline levels at different rates. For example, adrenaline is released almost immediately and is used or cleared by the system quickly, whereas glucocorticoid and cortisol levels may take long periods (i.e., hours to days) to return to baseline.

6.1.1.7 Long-Term Consequences to the Individual and the Population

The magnitude and type of effect and the speed *and completeness of recovery* must be considered in predicting long-term consequences to the individual animal and its population (Box E4). Animals that recover quickly and completely from explosive or acoustic-related effects will likely *not suffer reductions in their health or reproductive success, or experience changes in habitat utilization* (Box F2). *No population-level effects* would be expected if individual animals do not suffer reductions in their lifetime reproductive success or change their habitat utilization (Box G2).

Animals that do not recover quickly and fully could suffer *reductions in their health and lifetime reproductive success*; they could be permanently displaced or *change how they utilize the environment*; or they could *die* (Box F1). Severe injuries can lead to reduced survivorship (longevity), elevated stress levels, and prolonged alterations in behavior that can reduce an animal's lifetime reproductive success.

An animal with decreased energy stores or a lingering injury may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring produced over its lifetime.

An animal whose hearing does not recover quickly and fully could suffer a reduction in lifetime reproductive success (Box F1). An animal with decreased energy stores or a PTS may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring it can produce over its lifetime.

As mentioned above, the involuntary reaction of masking ends when the acoustic stimuli conclude. The direct effects of auditory masking could have long-term consequences for individuals if the activity was continuous or occurred frequently enough; however, most of the proposed training and testing activities are normally spread over vast areas and occur infrequently in a specific area.

Missed mating opportunities can have a direct effect on reproductive success. Reducing an animal's energy reserves over longer periods can directly reduce its health and reproductive success. Some species may not enter a breeding cycle without adequate energy stores, and animals that do breed may have a decreased probability of offspring survival. Animals displaced from their preferred habitat, or utilize it differently, may no longer have access to the best resources. Some animals that leave or flee an area during a noise-producing activity, especially an activity that is persistent or frequent, may not return quickly or at all. This can further reduce an individual’s health and lifetime reproductive success.

Frequent disruptions to natural behavior patterns may not allow an animal to fully recover between exposures, which increases the probability of causing long-term consequences to individuals. Elevated chronic stress levels are usually a result of a prolonged or repeated disturbance. Excess stress produces reactive molecules in an animal's body that can result in cellular damage (Berlett and Stadtman 1997, Sies 1997; Touyz 2004). Chronic elevations in the stress levels (e.g., cortisol levels) may produce long-term health consequences that can reduce in lifetime reproductive success.

These long-term consequences to the individual can lead to consequences for the *population* (Box G1). Population *dynamics and abundance* play a role in determining how many individuals would need to suffer long-term consequences before there was an effect on the population (Box G1). Long-term abandonment or a change in the utilization of an area by enough individuals can *change the distribution* of the population. Death has an immediate effect in that no further contribution to the population is possible, which reduces the animal's lifetime reproductive success.

Carrying capacity describes the theoretical maximum number of animals of a particular species that the environment can support. When a population nears its carrying capacity, the lifetime reproductive success in individuals may decrease due to finite resources or predator-prey interactions. *Population growth* is naturally limited by available resources and predator pressure. If one, or a few animals, in a population are removed or gather fewer resources, then other animals in the population can take advantage of the freed resources and potentially increase their health and lifetime reproductive success. Abundant populations that are near their carrying capacity (theoretical maximum abundance) that suffer effects on a few individuals may not be affected overall.

Populations that are reduced well below their carrying capacity may suffer greater consequences from any lasting effects on even a few individuals. Population-level consequences can include a change in the population dynamics, a decrease in the growth rate, or a change in geographic distribution. Changing the dynamics of a population (the proportion of the population within each age/growth) or their geographic distribution can also have secondary effects on population growth rates.

6.1.2 Analysis Background and Framework

The acoustic stressors that are estimated to result in Level B harassment, Level A harassment, or mortality of marine mammals in the Study Area include the following:

- Sonar and other active sound sources (non-impulsive sources)- Level A and Level B
- Explosives (impulsive sources)- Mortality, Level A, and Level B
- Pile driving and removal (impulsive sources)- Level A and Level B

In this analysis, marine mammal species are grouped together based on similar biology (such as hearing) or behaviors (such as feeding or expected reaction to stressors) when most appropriate for the discussion. In addition, for some stressors, species are grouped based on their taxonomic relationship and discussed as follows: mysticetes (baleen whales), odontocetes (toothed whales), and pinnipeds (seals).

Methods used to predict acoustic effects on marine mammals build on the Conceptual Framework for Assessing Effects from Sound Producing Activities (Section 6.1.1). Additional research specific to marine mammals is presented where available.

6.1.2.1 Direct Injury

The potential for direct injury to marine mammals is inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973; Yelverton et al. 1973a). Additionally, non-injurious effects on marine mammals are extrapolated to injurious effects based on data from terrestrial mammals to estimate the potential for injury (Southall et al. 2007). Actual effects on marine mammals may differ due to anatomical and physiological adaptations to the marine environment; e.g., some characteristics such as a reinforced trachea and flexible thoracic cavity (Ridgway and Dailey 1972) may or may not decrease the risk of lung injury.

Potential direct injury from non-impulsive sound sources, such as sonar, is unlikely due to lower peak pressures and slower rise times than potentially injurious sources such as explosives. Non-impulsive sources lack the strong shock wave associated with an explosion. Therefore, primary blast injury and barotrauma (i.e., injuries caused by large, rapid pressure changes) would not occur due to exposure to non-impulsive sources such as sonar. The theories of sonar-induced acoustic resonance and bubble formation are discussed below. Although these phenomena are feasible under extreme, controlled laboratory conditions, they are difficult to replicate in the natural environment and are, therefore, unlikely to occur.

6.1.2.1.1 Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotrauma after exposure to high amplitude impulsive sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (Craig and Hearn 1998a; Craig Jr. 2001; Phillips and Richmond 1990). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of lung contusions (lung bruises), pneumothorax (collapsed lung), pneumomediastinum (air in the chest between the lungs), traumatic lung cysts, or interstitial or subcutaneous emphysema (collection of air outside of the lungs) (Phillips and Richmond 1990). These injuries may be fatal, depending on the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions (bruises) and lacerations (cuts) from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma (collection of blood outside of a blood vessel), bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera (organs). Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

The only known occurrence of mortality or injury to a marine mammal due to a U.S. Navy training or testing event involving impulsive sources occurred in March 2011, when a group of long-beaked common dolphins entered the 640-m mitigation zone surrounding an explosive with a net explosive weight of 3.97 kg (8.8 lb.) set at a depth of 48 feet, approximately 0.5-0.75 nm from shore. One minute after detonation, three animals were observed at the surface, and a fourth animal stranded 42.3 miles (68 km) to the north of the detonation site three days later. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Ledger 2011).

6.1.2.1.2 Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kg (11,023 lb.) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonars or other non-impulsive sound sources. The potential for auditory trauma in marine mammals exposed to impulsive sources (e.g., explosions) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973; Yelverton et al. 1973a).

6.1.2.1.3 Acoustic Resonance

In 2002, NMFS convened a panel of government and private scientists to address the issue of mid-frequency sonar-induced resonance of gas-containing structures (Evans 2002). It modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding (U.S. Department of Commerce and U.S. Department of the Navy 2001). The conclusions of that group were that resonance in air-filled structures was not likely to have caused a mass stranding event in the Bahamas in 2000 (Evans 2002). The frequencies at which resonance was predicted to occur were below the frequencies used by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations were not considered to be of sufficient magnitude to cause tissue damage, even at the worst-case resonant frequencies that would lead to the greatest vibratory response. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance leading to tissue damage is not likely under realistic conditions during training and testing, and this type of impact is not considered further in this analysis.

6.1.2.1.4 Bubble Formation

A suggested indirect cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field. The process depends on many factors, including the sound pressure level and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs; (2) bubbles develop to the extent that an immune response is triggered or nervous system 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. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based on what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate nitrogen gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (for example, beaked whales) are theoretically predicted to induce greater nitrogen gas supersaturation (Houser et al. 2001). If rectified diffusion were possible in marine mammals exposed to a high level of 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 (e.g., nausea, disorientation, localized pain, breathing problems, etc.).

It is unlikely that the short duration of sonar or explosion sounds would last long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis is also suggested: stable microbubbles could be destabilized by high-level sound exposures so bubble growth would occur through static diffusion of gas out of the 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. Recent research with *ex vivo* supersaturated bovine tissues suggests that for a 37 kHz signal, a sound exposure of approximately 215 dB re 1 µPa would be required before microbubbles became destabilized and grew (Crum et al. 2005). Assuming spherical spreading loss and a nominal sonar source level of 235 dB re 1 µPa, a whale would need to be within 33 ft. (10 m) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400 to 700 kiloPascals (kPa) for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400 to 700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001). It is improbable that this mechanism would be responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert.

There is considerable disagreement among scientists as to the likelihood of bubble formation in diving marine mammals (Evans and Miller 2003; Piantadosi and Thalmann 2004). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernández 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. Prior experimental work demonstrates that the postmortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980). Also, variations in diving behavior or avoidance responses can possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular bubble formation (Jepson et al. 2003). The mechanism for bubble formation would be different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the scientific community. The hypothesis speculates that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernández et al. 2005; Jepson et al. 2003). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Recent modeling suggests that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Tyack et al. (Tyack et al. 2006) suggested that emboli observed in animals exposed to mid-frequency active sonar (Fernández et al. 2005; Jepson et al. 2003) could stem instead from a behavioral response that involves repeated dives, shallower than the depth of lung collapse. A bottlenose dolphin was trained to repetitively dive to specific depths 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).

More recently, 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 (e.g. fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Hooker et al. 2009). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation has been demonstrated in bycatch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser et al. 2009).

A fat embolic syndrome 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. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009-2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of 22 live-stranded dolphins and in the liver of two of 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 can be tolerates since the majority of stranded dolphins released did not re-strand. As a result, no marine mammals addressed in this analysis are given differential treatment due to the possibility for acoustically mediated bubble growth.

6.1.2.2 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1974). The distinction between permanent threshold shift (PTS) and temporary threshold shift (TTS) is based on whether there is complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is a TTS. The recovery to pre-exposure threshold from studies of marine mammals is usually on the order of minutes to hours for the small amounts of TTS induced (Finneran et al. 2005a; Nachtigall et al. 2004). The recovery time is related to the exposure duration, sound exposure level, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005a; Mooney et al. 2009a). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 6-2 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

Although both auditory trauma and fatigue may result in hearing loss, the mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. The term "auditory fatigue" is often used to mean "TTS"; however, in this analysis the Navy uses a more general meaning to differentiate between fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) and trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure).

Hearing loss due to auditory fatigue in marine mammals was studied by numerous investigators (Kastak et al. 2007; Mann et al. 2010; Popov et al. 2011; Southall et al. 2007; Finneran et al. 2010a, b; Finneran et al. 2005a; Finneran and Schlundt 2010; Finneran et al. 2007; Finneran et al. 2000; Finneran et al. 2002; Lucke et al. 2009; Mooney et al. 2009a; Mooney et al. 2009b; Nachtigall et al. 2003; Nachtigall et al. 2004; Schlundt et al. 2000). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicates the amount of TTS. Species studied include the bottlenose dolphin (total of nine individuals), beluga (2), harbor porpoise (1), finless porpoise (2), California sea lion (3), harbor seal (1), and northern elephant seal (1). Some of the more important data obtained from these studies are onset-TTS levels–exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example Schlundt et al. 2000).

Primary findings of the marine mammal TTS studies discussed above (unless otherwise cited) are:

- The growth and recovery of TTS are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure.
- The amount of TTS increases with exposure sound pressure level and the exposure duration.
- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with

the same energy (some recovery will occur during the quiet period between exposures) (Kryter et al. 1965; Ward 1997).

- The Sound Exposure Level is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (1958; 1959a). However, for longer duration sounds, beyond 16 – 32 seconds, the relationship between TTS and sound exposure levels breaks down and duration becomes a more important contributor to TTS (Finneran et al. 2010a).
- The maximum TTS after tonal exposures occurs one-half to one octave above the exposure frequency (Finneran et al. 2007; Schlundt et al. 2000). Thus, TTS from tonal exposures can extend over a large (greater than one octave) frequency range.
- For bottlenose dolphins, non-impulsive sounds with frequencies above 10 kHz are more hazardous than those at lower frequencies (i.e., lower sound exposure levels required to affect hearing) (Finneran and Schlundt 2010).
- The amount of observed TTS tends to decrease at differing rates following noise exposure; however, the relationship is not monotonic. The amount of 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) require several days for recovery.
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same sound exposure level. This means that predictions based on total, cumulative sound exposure level will overestimate the amount of TTS from intermittent exposures.

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, ototoxic drug-induced hearing loss, masking, and frequency selectivity. Therefore, in the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated by assuming some upper limit of TTS that equates to the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS.

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS, have not been studied; however, it is likely that a relationship between the duration, magnitude, and frequency range of hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction.

6.1.2.3 Auditory Masking

As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Critical ratios, the lowest ratio of signal-to-noise at which a signal can be detected, were determined for pinnipeds (Southall et al. 2000; Southall et al. 2003). Detections of signals under varying masking conditions were determined for active echolocation and passive listening tasks in odontocetes (Au and Pawloski 1989; Erbe 2000; Johnson 1971). These studies provide baseline information from which the probability of masking can be estimated. Clark et al. (Clark et al. 2009) developed a method for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a right whale's optimal communication space (estimated as a sphere of water with a diameter of 10.8 nm [20 km]), that space is decreased by 84 percent. This method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes may result from a need to compete with an increase in background noise. In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying.

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. Right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007) as well as increasing the amplitude (intensity) of their calls (Parks 2009). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz at up to 220 dB re 1 µPa (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Differential vocal responses in marine mammals were documented in the presence of seismic survey noise. An overall decrease in vocalization 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 and Clark 2010), indicative of a compensatory response to the increased noise level. Melcon et al. (2012) recently documented blue whales decreased the proportion of time spent producing D calls when mid-frequency sonar was present. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors.

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls. The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

6.1.2.4 Physiological Stress

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), was demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006). Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally.

Although sample sizes are small, the data collected to date suggest that different types of sounds potentially cause variable degrees of stress in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990b) but showed an 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 an elevation in aldosterone, a hormone suggested as being a significant indicator of stress in odontocetes (St.Aubin and Dierauf 2001; St.Aubin and Geraci 1989). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Many cetaceans exhibit an apparent vulnerability in the face of these particular situations when taken to the extreme. A recent study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate harm to multiple systems caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage or tissue death. This extreme response to a major stressor(s) is thought to be mediated by the overactivation of the animal's normal physiological adaptations to diving or escape. Pursuit, capture, and short-term holding of belugas resulted in a decrease in thyroid hormones (St.Aubin and Geraci 1988) and increases in epinephrine (St.Aubin and Dierauf 2001). In bottlenose dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (Ortiz and Worthy 2000; St.Aubin 2002; St.Aubin et al. 1996). Male gray seals subjected to capture and short-term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enables the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart or respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). Taken together, these studies illustrate the wide variations in the level of response that can occur when faced with these stressors.

Factors to consider when trying to predict a stress or cueing response include the mammal's life history stage and whether they are naïve or experienced with the sound. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St.Aubin and Dierauf 2001).

The sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice, a stress response is assumed if a physiological reaction such as a hearing loss or trauma is predicted; or if a significant behavioral response is predicted.

6.1.2.5 Behavioral Reactions

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The distance from the sound source and whether it is perceived as 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 and others (Richardson et al. 1995). More recent reviews (Nowacek et al. 2007; Southall et al. 2007) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes in response to auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response; however, stress responses cannot be predicted directly due to a lack of scientific data (see preceding section). Responses can overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecologies of individual species are unlikely to completely overlap.

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). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions, consistent avoidance reactions were noted at higher sound levels depending on the marine mammal species or group allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa. Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulsive sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Phocid seals showed avoidance reactions at or below 190 dB re 1 µPa; thus, seals may actually receive levels adequate to produce TTS before avoiding the source. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during three playbacks of sound breaking off foraging dives at levels below 142 dB sound pressure level, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB sound pressure level (Tyack et al. 2011).

6.1.2.5.1 Behavioral Reactions to Sonar and other Active Acoustic Sources

6.1.2.5.1.1 Mysticetes

Specific to U.S. Navy systems using low-frequency sound, studies were undertaken in 1997–98 pursuant to the Navy's Low-Frequency Sound Scientific Research Program. These studies found only short-term responses to low-frequency sound by mysticetes (fin, blue, and humpback whales), including changes in vocal activity and avoidance of the source vessel (Clark and Fristrup 2001; Croll et al. 2001; Fristrup et al. 2003; Miller et al. 2000; Nowacek et al. 2007). Baleen whales exposed to moderate low-frequency signals demonstrated no variation in foraging activity (Croll et al. 2001). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives, although the alarm signal was long in duration, lasting several minutes, and purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek 2004). Although the animal's received sound pressure level was similar in the latter two studies (133–150 dB sound pressure level), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the right whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction.

Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000) or to overtly affect elephant seal dives (Costa et al. 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

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 (Melcón et al. 2012). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this result was not statistically significant (Melcón et al. 2012). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110 to 120 dB re 1 µPa (Melcón et al. 2012). Preliminary results from the 2010–2011 field season of the ongoing behavioral response study in southern California waters indicated that in some cases and at low received levels, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2011). These preliminary findings from Melcón et al. (2012) and Southall et al. (2011) are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other active acoustic sources used in the quantitative acoustic effects analysis (see Section 6.1.5, Quantitative Analysis). The behavioral risk function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

6.1.2.5.1.2 Odontocetes

From 2007 to 2011, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, the Mediterranean, Cape Hatteras, and Norwegian waters. These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007–2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Tyack et al. 2011). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface. Preliminary results from a similar behavioral response study in southern California waters have been presented for the 2010–2011 field season (Southall et al. 2011). Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville's beaked whale. Similarly, beaked whales exposed to sonar during British training exercises stopped foraging (DSTL 2007), and preliminary results of controlled playback of sonar may indicate feeding/foraging disruption of killer whales and sperm whales (Miller et al. 2011).

In the 2007–2008 Bahamas study, playback sounds of a potential predator–a killer whale–resulted in a similar but more pronounced reaction, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area. The authors noted, however, that the magnified reaction to the predator sounds could represent a cumulative effect of exposure to the two sound types since killer whale playback began approximately 2 hours after mid-frequency source playback. Pilot whales and killer whales off Norway also exhibited horizontal avoidance of a transducer with outputs in the mid-frequency range (signals in the 1 kHz – 2 kHz and 6 kHz to 7 kHz ranges) (Miller et al. 2011). Additionally, separation of a calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al. 2011). In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009).

Through analysis of the behavioral response studies, a preliminary overarching effect of greater sensitivity to all anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al. 2009). Therefore, recent studies have focused specifically on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge and Durban 2009; DSTL 2007; McCarthy et al. 2011; Moretti et al. 2009; Tyack et al. 2011). In the Bahamas, Blainville's beaked whales located on the range will move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; McCarthy et al. 2011; Moretti et al. 2009; Tyack et al. 2011).

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 (U.S. Department of the Navy 2003; Fromm 2009; National Marine Fisheries Service 2005) estimated a mean received sound pressure level of approximately 169.3 dB re 1µPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1µPa).

Research on sperm whales near the Grenadines (Caribbean) in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins et al. 1985; Watkins and Schevill 1975). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull. It was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general. Additionally, sperm whales In the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975).

Researchers at the Navy's Marine Mammal Program facility in San Diego, California have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Finneran et al. 2003a; Finneran et al. 2001; Finneran et al. 2005a; Finneran and Schlundt 2004; Schlundt et al. 2000). Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site 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). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa root mean square, 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 these studies were generally not designed to test avoidance behavior and animals were commonly reinforced with food, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Studies with captive harbor porpoises showed increased respiration rates upon introduction of 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) and emissions for underwater data transmission (Kastelein et al. 2005c). However, exposure of the same acoustic alarm 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.

6.1.2.5.1.3 Pinnipeds

Different responses displayed by captive and wild phocid seals to sound judged to be "unpleasant" have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2010). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Another study found that captive hooded seals reacted to 1–7 kHz sonar signals, in part with displacement to the areas of least sound pressure level, at levels between 160 and 170 dB re 1 μPa (Kvadsheim et al. 2010).

Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively unpleasant sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, as opposed to the more commonly studied factor of received sound level, can affect diving behavior (Götz and Janik 2010).

6.1.2.5.2 Behavioral Reactions to Impulsive Sound Sources

6.1.2.5.2.1 Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Gordon et al. 2003; Richardson et al. 1995; Southall et al. 2007). 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 rms. Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa.

Gray whales migrating along the U.S. west coast showed avoidance responses to seismic vessels by 10 percent of animals at 164 dB re 1 µPa, and by 90 percent of animals at 190 dB re 1 µPa, with similar results for whales in the Bering Sea (Malme et al. 1988; Malme et al. 1986). In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates while resting or diving in western gray whales off the coast of Russia (Gailey et al. 2007; Yazvenko et al. 2007).

Humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and controlled exposure experiments in western Australia (McCauley et al. 1998). 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 and a shift to a higher incidence of net entanglement closer to the noise source.

Seismic pulses at average received levels of 131 dB re 1 µPa^2s caused blue whales to increase call production (Di Iorio and Clark 2010). In contrast, 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). These studies demonstrate that even low levels of noise received far from the noise source can induce behavioral responses.

6.1.2.5.2.2 Odontocetes

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 nm away from the whales, and based on multipath propagation, received levels were as high as 162 dB sound pressure level re 1 µPa with energy content greatest between 0.3 to 3.0 kHz (Madsen et al. 2006). The whales showed no horizontal avoidance, although the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing (Miller et al. 2009). The remaining whales continued to execute foraging dives throughout exposure, however swimming movements during foraging dives were 6 percent lower during exposure than control periods, suggesting subtle effects of noise on foraging behavior (Miller et al. 2009). Captive bottlenose dolphins sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al. 2002).

6.1.2.5.2.3 Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in (Richardson et al. 1995; 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 impulsive source at levels of 165-170 dB re 1 µPa (Finneran et al. 2003c).

Experimentally, Götz and Janik (Götz and 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 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.

6.1.2.6 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat.

Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors speculated that repeated interruptions of the dolphins' foraging behaviors could lead to long-term implications for the population. Bejder et al. (Bejder et al. 2006a) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or simply tolerate the disturbance. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat. Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (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. Whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984). Over a shorter time scale, 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, and that individuals may move off of the range for several days during and following a sonar event. However animals are thought to continue feeding at short distances (a few kilometers) from the range out of the louder sound fields (less than 157 dB re 1 µPa) (McCarthy et al. 2011; Tyack et al. 2011). 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. Nevertheless, the long-term consequences of these habitat utilization changes are unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

6.1.2.7 Stranding

When a live or dead marine mammal swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a stranding (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). Animals outside of their "normal" habitat are also sometimes considered stranded even though they may not have beached themselves. The legal definition for a stranding within the United States is that: (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 apparently 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 USC § 1421(h)).

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 and Lounsbury 2005). Even for the fractions of more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for the majority of strandings remain undetermined. Natural factors related to strandings include, for example, the availability of food, predation, disease, parasitism, climatic influences, and aging (Bradshaw et al. 2006; Culik 2002; Geraci et al. 1999; Geraci and Lounsbury 2005; Hoelzel 2003; National Research Council 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors include, for example, pollution (Hall et al. 2006; Jepson et al. 2005), vessel strike (Geraci and Lounsbury 2005; Laist et al. 2001), fisheries interactions (Read et al. 2006), entanglement, and noise.

Along the coasts of the continental United States and Alaska between 2001-2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total) per year (National Marine Fisheries Service 2011). Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single cow-calf pair) that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in the Navy's Cetacean Stranding Technical Report on Marine Mammal Strandings Associated with U.S. Navy Sonar Activities (U.S. Department of the Navy 2012c).

Sonar use during exercises involving U.S. Navy (most often in association with other nations' defense forces) 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 (Marine Mammal Commission 2006b). These five mass strandings have resulted in about 40 known, scientifically verifiable sonar-related deaths among cetaceans consisting mostly of beaked whales (International Council for the Exploration of the Sea 2005).

In these circumstances, exposure to non-impulsive acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). One hypothesis is that strandings may result from tissue damage caused by "gas and fat embolic syndrome" (Fernández et al. 2005; Jepson et al. 2003; Jepson et al. 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding versus exposure to sonar (Cox et al. 2006).

As the International Council for the Exploration of the Sea (International Council for the Exploration of the Sea 2005) noted, taken in context of marine mammal populations in general, sonar is not a major threat or a significant portion of the overall ocean noise budget. This has also been demonstrated by monitoring in areas where the Navy operates (Bassett et al. 2010; Baumann-Pickering et al. 2010; McDonald et al. 2006; Tyack et al. 2011). Regardless of the direct cause, the Navy considers potential sonar related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings.

During a Navy training event on 4 March 2011 at the Silver Strand Training Complex in San Diego, California, three or possibly four dolphins were killed in an explosion. During an underwater detonation training event, a pod of 100–150 long-beaked common dolphins were observed moving towards the 700-yard exclusion zone around the explosive charge, monitored by personnel in a safety boat and participants in a dive boat. Approximately 5 minutes remained on a time-delay fuse connected to a single 8.76 lb. explosive charge (C-4 and detonation cord). 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 and three long-beaked common dolphins near the explosion died. In addition to the three dolphins found dead on 4 March 2011 at the event site, the remains of a fourth dolphin were discovered on 7 March 2011 near Ocean Beach, California (3 days later and approximately 11.8 mi. [19 km] from Silver Strand where the training event occurred), which might also have been related to this event. Association of the fourth stranding with the training event is uncertain because dolphins strand on a regular basis in the San Diego area. Details such as the dolphins' depth and distance from the explosive at the time of the detonation could not be estimated from the 250 yard (228.6 m) standoff point of the observers in the dive boat or the safety boat.

These dolphin mortalities are the only known occurrence of a U.S. Navy training or testing event involving impulse energy (underwater detonation) that caused mortality or injury to a marine mammal. Despite this being a rare occurrence, Navy has reviewed training requirements, safety procedures, and possible mitigation measures and implemented changes to reduce the potential for this to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), which details all mitigations.

In comparison to potential strandings or injury resulting from events associated with Navy activities, marine mammal strandings and injury from commercial vessel ship strike, impacts from urban pollution, and annual fishery-related bycatch have been estimated to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals) (Culik 2002; International Council for the Exploration of the Sea 2005; Read et al. 2006). This does not negate the potential influence of mortality or additional stressors to small, regionalized sub-populations that may be at greater risk from human related impacts (fishing, vessel strike, and sound) than populations with larger distributions.

6.1.2.8 Long-Term Consequences for the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), hearing loss (which depending on severity could impact navigation, foraging, predator avoidance, or communication), chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement) (Section 6.1.1.1, Flowchart). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a measurable cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could produce a cost of a lost reproductive opportunity, but these events may be “made up” during the life of a normal healthy individual. The same holds true for exposure to human-generated sound sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. All too often, the long-term consequence of relatively trivial events like short-term masking of a conspecific’s social sounds, or a single lost feeding opportunity, is exaggerated beyond its actual importance by focus on the single event and not the important variable, which is the individual and its lifetime parameters of growth, reproduction and survival.

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual’s vital rates (growth, survival and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council (2005). The Population Consequences of Acoustic Disturbance model (National Research Council 2005) proposes a quantitative methodology 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. 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. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time period or stage to the next. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known.

The best assessment of long-term consequences from training and testing activities will be to monitor the populations over time within the Study Area. A recent 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 monitoring plans for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy’s current mitigation practices. Results from 2 years (2009–2010) of intensive monitoring by independent scientists and Navy observers in Southern California Range Complex and Hawaii Range Complex have recorded an estimated

161,894 marine mammals with no evidence of distress or unusual behavior observed during Navy activities. Continued monitoring efforts over time will be necessary to begin to evaluate the long-term consequences of exposure to noise sources.

6.1.3 Summary of Monitoring Observations During Previous Navy Activities

The Navy, non-navy marine mammal scientists, and research institutions have, since 2006, conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where Navy has been and proposes to continue training and testing. Data collected from Navy monitoring, scientific research findings, and annual reports provided to NMFS (as available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications) may be informative to the analysis of impacts to marine mammals for a variety of reasons, including species distribution, habitat use, and evaluating potential responses to Navy activities. Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas, and (2) collecting data during individual training or testing activities. Monitoring efforts during anti-submarine warfare and explosive events are focused on observing individual animals in the vicinity of the event and documenting behavior and any observable responses. Although these monitoring events are very localized and short-term, over time they will provide valuable information to support the impact analysis.

The majority of the training and testing activities Navy is proposing for the next five years, are similar if not identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency ASW sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as was first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities.

6.1.3.1 Observations in Association with Activities Involving the Use of Active Acoustic Sources

Monitoring efforts were conducted during training events from January 2009 - December 2011, as part of the AFAST letter of authorization. A total of five anti-submarine warfare events were monitored with third party aerial, vessel, and passive acoustic surveys by trained marine mammal observers. A total of 77.5 hours of aerial, 25.1 hours of vessel, and 26.5 hours of towed hydrophone array passive acoustic effort was spent to collect data before, during, and after the exercises. A total of 1,068 marine mammals were observed during these events and no observable behavioral disturbance was noted.

In addition, the Navy has recorded a total of approximately 19,500 hours of passive acoustic monitoring data during anti-submarine training events. These data were collected during one event in the Onslow Bay, North Carolina location and three events in the JAX Undersea Warfare Training Range location using an array of Cornell's Marine Acoustic Recording Units and JASCO's Advanced Multi-channel Acoustic Recorders. The goal of these recordings was to test the feasibility of using passive acoustic monitoring during Navy training and testing events to assess any behavioral acoustic response to the activities. The data are currently being analyzed for the occurrence of marine mammal vocalizations during sonar activity.

Monitoring efforts were conducted during testing events from March 2009 – August 2012 within the AFTT Study Area. A total of twelve anti-submarine warfare events were monitored with aerial, vessel, and passive acoustic surveys by trained marine mammal observers. A total of 243 hours of aerial and 317 hours of vessel effort were spent to collect data before, during, and after the exercises. Dolphins, large whales, manatees, and sea turtles were observed. Due to differences in reporting requirements, the total numbers of animals observed is unavailable. For example, the number of individual dolphins within a pod is not recorded; the after action reports only identify a single dolphin pod. Where numbers of animals were recorded, a range of 155-214 marine mammals (based on minimum and maximum group size) were observed during these events, with no behavioral disturbance noted as a result of the events.

Sightings data within Narragansett Bay at the Naval Undersea Warfare Center Division Newport Testing Range have been recorded since 2009. These sightings, however, are not in response to specific testing activities; all sightings data are recorded regardless of whether a test event is being conducted or not. A total of 39-59 dolphins or porpoise and 62-67 seals have been observed (based on minimum and maximum group size estimates).

Between June 2011 – June 2012, three mine warfare events were monitored with vessel surveys by trained marine mammal observers. A total of 220.75 hours of vessel effort was spent to collect data before, during, and after the exercises. 45 marine mammals and sea turtles were observed during these events and no observable behavioral disturbance was noted.

Between August 2, 2010 – August 1, 2011, two sonar tests were monitored with aerial surveys by trained marine mammal observers. A total of 22.1 hours of aerial effort was spent to collect data before, during, and after the exercises. 38 marine mammals and 152 sea turtles were observed during these events and no observable behavioral disturbance was noted. In addition, trained marine mammal observers conducted a total of 22.1 hours of survey effort from the Navy vessels conducting the anti-submarine warfare tests. A total of 25 marine mammals and 5 sea turtles were observed before, during, or after these events and no observable behavioral disturbance, injury, or mortality was noted using the above mentioned survey methods.

6.1.3.2 Observations in Association with Activities Involving the Use of Explosives

Monitoring efforts were conducted during training events from June 2009 - June 2012, as part of the East Coast Range Complexes letters of authorization. A total of twelve events involving the use of explosives were monitored with aerial, vessel, and passive acoustic surveys. A total of 39 hours of third party aerial, 34.5 hours of vessel, and 53.8 hours of passive acoustic recording effort was spent to collect data before, during, and after the exercises. In addition, trained marine mammal observers conducted a total of 14 hours of survey effort from the firing Navy vessel during a firing exercise event. A total of 304 marine mammals and 161 sea turtles were observed before, during, or after these events and no observable behavioral disturbance, injury, or mortality was noted using the above mentioned survey methods. The passive acoustic data are currently being analyzed for the occurrence of marine mammal vocalizations during the explosive events.

Monitoring efforts were conducted during an Airborne Mine Neutralization System testing event in December 2011. A total of 25.8 hours of vessel surveys were conducted which resulted in 4 marine mammal and 7 sea turtle sightings before, during and after the event. In addition, a total of 1,773 hours of passive acoustic monitoring data was recorded. A total of 3 marine mammal acoustic detections were made on the pre-event survey, all associated with visual sightings. No acoustic detections were made on the during or after event surveys.

Monitoring of the shock trials of the USS WINSTON S. CHURCHILL (DDG 81) and USS MESA VERDE (LPD 19) involved pre- and post-detonation surveys by shipboard and aerial observers (U.S. Department of the Navy 2001, 2008). Post-detonation monitoring commenced immediately after each detonation and occurred for at least two hours, with additional surveys conducted on the following two days after each of the first two detonations, and for at least five days following the third detonation. A total of 92 marine mammals and sea turtle sightings were recorded during post-detonation monitoring of the USS WINSTON S. CHUCHILL (DDG 81) ship shock trial, and 64 marine mammal and sea turtles were observed during post-detonation monitoring of the USS MESA VERDE (LPD 19) ship shock trial. No marine mammal or sea turtle mortalities or injuries were observed during either event.

6.1.3.3 Relevant Data from HSTT Study Area

In the HRC portion of the HSTT Study Area between 2006 and 2011, there were 21 scientific marine mammal surveys conducted before, during, or after major exercises. In the SOCAL and HRC portions of HSTT from 2009 to 2011, Navy funded marine mammal monitoring research has completed over 4,000 hours of visual survey effort covering over 64,800 nautical miles, sighted over 256,000 individual marine mammals, taken over 45,500 digital photos and 32 hours of digital video, attached 70 satellite tracking tags to individual marine mammals, and collected over 25,000 hours of passive acoustic recordings. Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Island Fisheries Science Center and Southwest Fisheries Science Center. Finally, there were an additional 1,262 sightings of an estimated 12,875 marine mammals made and reported by Navy lookouts aboard Navy ships within the HSTT from 2009 to 2011. No observable behavioral disturbance, injury, or mortality was noted using the above mentioned survey methods.

6.1.4 Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals

If proposed Navy activities introduce sound or explosive energy into the marine environment, an analysis of potential impacts on marine mammals is conducted. To do this, information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed.

6.1.4.1 Mortality and Injury from Explosions

There is a considerable body of laboratory data on injuries from impulsive sound exposure, usually from explosive pulses, obtained from tests with a variety of lab animals (e.g., mice, rats, dogs, pigs, sheep, and other species). Onset mortality, onset slight lung injury, and onset slight gastrointestinal tract injury represent a series of effects with decreasing likelihood of serious injury or lethality. Primary impulse injuries from explosive blasts are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear) (Craig and Hearn 1998b; Craig Jr. 2001).

Criteria and thresholds for predicting mortality and injury to marine mammals from explosions were initially developed for the U.S. Navy shock trials of the Seawolf submarine (Craig and Hearn 1998b) and

Winston S. Churchill surface ship (Craig Jr. 2001). Similar criteria and thresholds also were used for the shock trial of the U.S. Navy amphibious transport dock ship Mesa Verde (U.S. Deparment of Navy 2008) and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the Mesa Verde shock trial (National Marine Fisheries Service 2008). Functional hearing ranges are not applied for lethal and injurious exposures. These criteria and their origins are explained in greater detail in the Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report (Finneran and Jenkins 2012).

6.1.4.1.1 Mortality and Slight Lung Injury

In air or submerged, the most commonly reported internal bodily injury was hemorrhaging in the fine structure of the lungs. Biological damage is governed by the impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton and Richmond 1981; Yelverton et al. 1973; Yelverton et al. 1975). Therefore, impulse was used as a metric upon which internal organ injury could be predicted.

Impulse thresholds for onset mortality and slight lung injury are indexed to 75 and 93 lb (34 and 42 kg) for mammals, respectively (Richmond et al. 1973). The regression curves based on these experiments were plotted so that a prediction of mortality to larger animals could be determined as a function of impulse and mass (Craig Jr. 2001). After correction for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass, as used in the Goertner injury model (Goertner 1982), the minimum impulse for predicting onset of extensive lung injury for “1 Percent Mortality” (defined as where most survivors had moderate blast injuries and should survive on their own) and slight lung injury for “0 Percent Mortality” (defined as no mortality, slight blast injuries) (Yelverton and Richmond 1981) were derived for each species. The Navy uses the minimum impulse level predictive of extensive lung injury, the exposure level likely to result in one percent mortality of animals in a population (99 percent would be expected to recover from the injury) as the onset of mortality. The scaling of lung volume to depth is conducted for all species, since data is from experiments with terrestrial animals held near the water's surface and marine mammals’ gaseous cavities compress with depth making them less vulnerable to impulse injury. The received impulse that is necessary for onset mortality or slight lung injury must be delivered over a time period that is the lesser of the positive pressure duration or 20% of the natural period of the assumed-spherical lung adjusted for the size and depth of the animal. Therefore, as depth increases or animal size decreases, the impulse delivery time to experience an effect decreases (Goertner 1982).

Species-specific calf masses are used for determining impulse-based thresholds because they most closely represent effects on individual species. The Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases, body masses were extrapolated from similar species rather than the listed species. Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of all newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects to animals near an explosion. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

The use of onset mortality and onset slight lung injury is a conservative method to estimate potential mortality and recoverable (non-mortal, non-PTS) injuries. When analyzing impulse-based effects, all animals within the range to these thresholds are assumed to experience the effect. The onset mortality and onset slight lung injury criteria identify the impulse at which these effects are predicted for one percent of animals, and the portion of animals affected would increase closer to the explosion. Therefore, these criteria conservatively over-estimate the number of animals that could be killed or injured.

6.1.4.1.2 Onset of Gastrointestinal Tract Injury

Evidence indicates that gas-containing internal organs, such as lungs and intestines, were the principal damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the peak pressure of the shock wave and would be independent of the animal’s size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak pressure was 237 dB re 1 µPa.

There are instances where injury to the gastrointestinal tract could occur at a greater distance from the source than slight lung injury, especially near the surface. Gastrointestinal tract injury from small test charges (described as “slight contusions”) was observed at peak pressure levels as low as 104 pounds per square inch (psi), equivalent to a sound pressure level of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by Navy and NMFS for ship shock trials (U.S. Department of the Navy 1998, 2001, 2008; National Marine Fisheries Service 2008c).

6.1.4.2 Frequency Weighting

Frequency-weighting functions, called "M-weighting" functions, were proposed by Southall et al. (2007) to account for the frequency bandwidth of hearing in marine mammals. Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. The weighting functions de-emphasize sound exposures at frequencies to which marine mammals are not particularly sensitive. This effectively makes the acoustic thresholds frequency-dependent, which means they are applicable over a wide range of frequencies and therefore applicable for a wide range of sound sources. The Southall et al. (2007) M-weighting functions are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a conservative approach to assessing the effects of noise (Figure 6-3). For the purposes of this analysis, the Navy will refer to these as Type I auditory weighting functions. These Type I functions are applied to the received sound level from sonar and other active acoustic sources before comparing the level to the Behavioral Response Function.

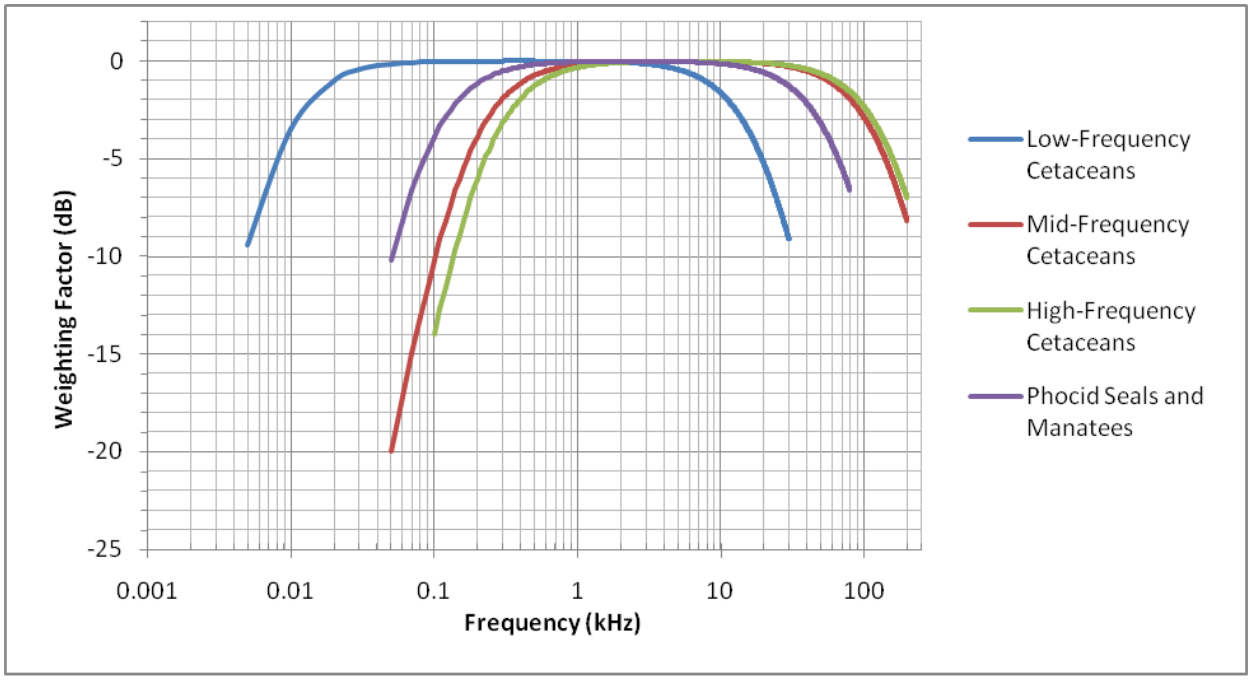


Figure 6-3. Type I Auditory Weighting Functions Modified from Southall et al. (2007) M-Weighting Functions

Frequency Weighting Example:

A common dolphin, a mid-frequency cetacean (see Table 4-1), receives a 10 kHz ping from a sonar with a sound exposure level (SEL) of 180 dB re 1µPa^2-s. To discern if this animal may suffer a TTS, the received level must first be adjusted using the appropriate Type II auditory weighting function for mid-frequency cetaceans (Figure 6-9). At 10 kHz, the weighting factor for mid-frequency cetaceans is -3 dB, which is then added to the received level (180 dB re 1µPa^2-s + (-3 dB) = 177 dB re 1µPa^2-s) to yield the weighted received level. This is compared to the non-impulsive mid-frequency cetacean TTS threshold (178 dB re 1µPa^2-s; Table 6-9). Since the adjusted received level is less than the threshold, TTS is not likely for this animal from this exposure.

Two experiments conducted since 2007 suggest that modification of the mid-frequency cetacean auditory weighting function is necessary. The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3–28 kHz (Finneran 2010). These data were used to derive onset-TTS values as a function of exposure frequency, and demonstrate that the use of a single numeric threshold for onset-TTS, regardless of frequency, is not correct. The second experiment examined how subjects perceived the loudness of sounds at different frequencies to derive equal loudness contours (Finneran and Schlundt 2011). These data are important because human auditory weighting functions are based on equal loudness contours. The dolphin equal loudness contours provide a means to generate auditory weighting functions in a manner directly analogous to the approach used to develop safe exposure guidelines for people working in noisy environments (National Institute for Occupational Safety and Health 1998). Taken together, the recent higher-frequency TTS data and equal loudness contours provide the underlying data necessary to develop new weighting functions, referred to as Type II auditory weighting functions, to improve accuracy and avoid underestimating the impacts on animals at higher frequencies (Figure 6-4). To generate the new Type II weighting functions, Finneran and Schlundt (2011) substituted lower- and upper-frequency values which differ from the values used by Southall et al. (2007). The new weighting curve predicts appreciably higher (almost 20 dB) susceptibility for frequencies above 3 kHz for bottlenose dolphins, a mid-frequency cetacean. Since data below 3 kHz are not available, the original weighting functions from Southall et al. (2007) were substituted below this frequency. Low- and high-frequency cetacean weighting functions were extrapolated from the dolphin data as well because of the suspected similarities of greatest susceptibility at best frequencies of hearing.

The Type II auditory weighting functions (Figure 6-4) are applied to the received sound level before comparing it to the appropriate sound exposure level thresholds for TTS or PTS, or the explosive behavioral response threshold. For some criteria, received levels are not weighted before being compared to the thresholds to predict effects. These include the peak pressure criteria for predicting TTS and PTS from underwater explosions; the acoustic impulse metrics used to predict onset-mortality and slight lung injury from underwater explosions; and the thresholds used to predict behavioral responses from harbor porpoises and beaked whales from sonar and other active acoustic sources. As mentioned above, the Type I auditory weighting functions (Figure 6-3) are applied to the received sound level from sonar and other active acoustic sources before comparing the adjusted sound level to the behavioral response function.

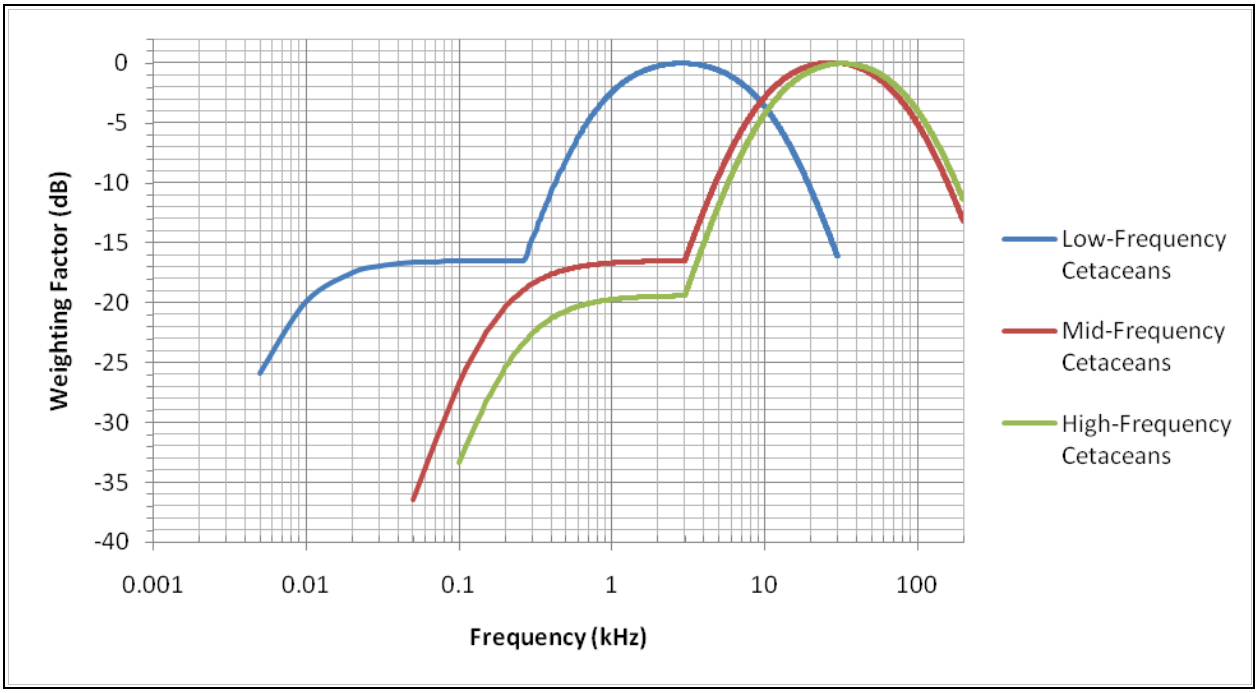


Figure 6-4. Type II Weighting Functions for Low-, Mid-, and High-Frequency Cetaceans

6.1.4.3 Summation of Energy from Multiple Sources

In most cases, an animal's received level will be the result of exposure to a single sound source. In some scenarios, however, multiple sources will be operating simultaneously, or nearly so, creating the potential for accumulation of energy from multiple sources. In such scenarios, energy will be summed for all exposures within a cumulative exposure band, with the cumulative exposure bands defined in four bands: 0-0.9 kHz (low-frequency sources); 1.0-10.0 kHz (mid-frequency sources); 10.1-100.0 kHz (high-frequency sources); and above 100.0 kHz (very-high frequency sources). Sources operated at frequencies above 200 kHz are considered to be inaudible to all groups of marine mammals and are not analyzed in the quantitative modeling of exposure levels.

6.1.4.4 Hearing Loss: Temporary and Permanent Threshold Shift

Criteria for physiological effects from sonar and other active acoustic sources are based on TTS and PTS with thresholds based on cumulative sound exposure levels (Table 6-1). The onset of TTS or PTS from exposure to underwater explosions sources is predicted using sound exposure level-based thresholds in conjunction with peak pressure thresholds. The horizontal ranges are then compared, with the threshold producing the longest range being the one used to predict effects. For multiple exposures within any 24-hour period, the received sound exposure level (SEL) for individual events are accumulated for each marine mammal.

Since no studies have been designed to intentionally induce PTS in marine mammals, onset-PTS levels for these animals must be estimated using empirical TTS data obtained in marine mammals and relationships between TTS and PTS established in terrestrial mammals.

TTS and PTS thresholds are based on TTS onset values for impulsive and non-impulsive sounds obtained from representative species of mid- and high-frequency cetaceans and pinnipeds. These data are then extended to the other marine mammals for which data are not available. The Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report (Finneran and Jenkins 2012) provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals. Tables 6-2 and 6-3 provide a summary of acoustic thresholds for TTS and PTS for marine mammals.

Table 6-1. Acoustic Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals from Sonar and Other Active Acoustic Sources

Group	Species	Physiological	
		Onset TTS	Onset PTS
Low-Frequency Cetaceans	All mysticetes	178 dB re 1µPa^2-s SEL (LF_{II})	198 dB re 1µPa^2-s SEL (LF_{II})
Mid-Frequency Cetaceans	Dolphins, beaked whales, and medium and large toothed whales	178 dB re 1µPa^2-s SEL (MF_{II})	198 dB re 1µPa^2-s SEL (MF_{II})
High-Frequency Cetaceans	Harbor Porpoise and *Kogia* species	152 dB re 1µPa^2-s SEL (HF_{II})	172 dB re 1µPa^2-s SEL (HF_{II})
Phocid Seals (In-Water)	Harbor, Bearded, Hooded Common, Spotted, Ringed, Harp, Ribbon, & Gray Seals	183 dB re 1µPa^2-s SEL (P_{WI})	197 dB re 1µPa^2-s SEL (P_{WI})

LF_{II}: Low-Frequency Cetacean Type II weighting function; MF_{II}: Mid-Frequency Cetacean Type II weighting function; HF_{II}: High-Frequency Cetacean Type II weighting function; P_{WI}: Phocid Type I weighting function

Table 6-2. Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals from Explosions

Group	Species	Onset TTS	Onset PTS	Onset Slight GI Tract Injury	Onset Slight Lung Injury	Onset Mortality
Low-Frequency Cetaceans	All mysticetes	172 dB re 1μPa²-s SEL (LF_{II}) or 224 dB re 1μPa Peak SPL (unweighted)	187 dB re 1μPa²-s SEL (LF_{II}) or 230 dB re 1μPa Peak SPL (unweighted)	237 dB re SPL (unweighted)	Equation 1	Equation 2
Mid-Frequency Cetaceans	Most dolphins, beaked whales, med and large toothed whales	172 dB re 1μPa²-s SEL (MF_{II}) or 224 dB re 1μPa Peak SPL (unweighted)	187 dB re 1μPa²-s SEL (MF_{II}) or 230 dB re 1μPa Peak SPL (unweighted)			
High-Frequency Cetaceans	Porpoises and *Kogia* species	146 dB re 1μPa²-s SEL (HF_{II}) or 195 dB re 1μPa Peak SPL (unweighted)	161 dB re 1μPa²-s SEL (HF_{II}) or 201 dB re 1μPa Peak SPL (unweighted)			
Phocid Seals (In-Water)	Harbor, Bearded, Hooded Common, Spotted, Ringed, Harp, Ribbon, and Gray Seals	177 dB re 1μPa²-s SEL (P_{WI}) or 212 dB re 1μPa Peak SPL (unweighted)	192 dB re 1μPa²-s SEL (P_{WI}) or 218 dB re 1μPa Peak SPL (unweighted)			

LF_{II}: Low-Frequency Cetacean Type II weighting function; MF_{II}: Mid-Frequency Cetacean Type II weighting function; HF_{II}: High-Frequency Cetacean Type II weighting function; P_{WI}: Phocid Type I weighting function

(1) $$= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$$

(2) $$= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\sec$$

M = mass of the animals in kg

D_{rm} = depth of the receiver (animal) in meters

SPL = sound pressure level

6.1.4.4.1 Temporary Threshold Shift for Sonar and Other Active Acoustic Sources

TTS values for mid-frequency cetaceans exposed to non-impulsive sound are derived from multiple studies (Finneran et al. 2010a; Finneran et al. 2005a; Mooney et al. 2009a; Schlundt et al. 2000) from two species, bottlenose dolphins and beluga whales. Especially notable are data for frequencies above 3 kHz, where bottlenose dolphins have exhibited lower TTS onset thresholds than at 3 kHz (Finneran and Schlundt 2010). This difference in TTS onset at higher frequencies is incorporated into the weighting functions.

There are no direct measurements of TTS from non-impulse sound in high-frequency cetaceans. Lucke et al. (2009) measured TTS in a harbor porpoise exposed to a small seismic airgun and those results are reflected in the impulse sound TTS thresholds described below. The beluga whale (the only species for which both impulsive and non-impulsive TTS data exist) has a (weighted) non-impulsive TTS onset value 6 dB above the (weighted) impulsive threshold (Finneran et al. 2002; Schlundt et al. 2000). Therefore, 6 dB was added to the harbor porpoise's impulsive TTS threshold demonstrated by Lucke et al. (2009) to derive the non-impulse TTS threshold.

There are no direct measurements of TTS or hearing abilities for low-frequency cetaceans. The Navy has used mid-frequency cetacean thresholds, since the mid-frequency cetaceans are the most similar to the low-frequency cetacean group.

Pinniped TTS criteria are based on data provided by Kastak et al. (2005) for representative species of both of the pinniped hearing groups: harbor seals (Phocidae) and California sea lions (Otariidae and Odobenidae). Kastak et al. (2005) used octave band noise centered at 2.5 kHz to extrapolate an onset TTS threshold.

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS.

6.1.4.4.2 Temporary Threshold Shift for Explosions

The TTS sound exposure level thresholds for cetaceans are consistent with the Mesa Verde ship shock trial that was approved by NMFS (National Marine Fisheries Service 2008c) and are more representative of TTS induced from impulses (Finneran et al. 2002) rather than pure tones (Schlundt et al. 2000). In most cases, a total weighted sound exposure level is more conservative than the greatest sound exposure level in any single 1/3-octave band, which was used prior to the Mesa Verde shock trial. There are no data on TTS obtained directly from low-frequency cetaceans, so mid-frequency cetacean impulse threshold criteria from Finneran et al. (2002a) have been used. High-frequency cetacean TTS thresholds are based on research by Lucke et al. (2009), who exposed harbor porpoises to pulses from a single airgun.

Pinniped thresholds were not included for prior ship shock trials, as pinnipeds were not expected to occur at the shock trial sites, and TTS thresholds for previous Navy EIS/OEISs also were not differentiated between cetaceans and pinnipeds (National Marine Fisheries Service 2008c). TTS values for impulse sound have not been obtained for pinnipeds, but there are TTS data for octave band sound from representative species of both major pinniped hearing groups (Kastak et al. 2005). Impulse sound TTS criteria for pinnipeds were estimated by applying the difference between mid-frequency cetacean TTS onset for impulse and non-impulse sounds to the pinniped non-impulse TTS data (Kastak et al. 2005), a methodology originally developed by Southall et al. (2007). Therefore, the TTS threshold for sounds from explosions for pinnipeds is 6 dB less than the non-impulsive onset-TTS threshold derived from Kastak et al. (2005).

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict TTS.

6.1.4.4.3 Permanent Threshold Shift for Sonar and Other Active Acoustic Sources

There are no direct measurements of PTS onset in marine mammals. Well-understood relationships between terrestrial mammalian TTS and PTS have been applied to marine mammals. Threshold shifts up to 40–50 dB have been induced in terrestrial mammals without resultant PTS (Miller et al. 1963; Ward et al. 1958; Ward et al. 1959b). These data would suggest that 40 dB of TTS would be a reasonable limit for approximating the beginning of PTS for marine mammals exposed to continuous sound. Data from terrestrial mammal testing (Ward et al. 1958; Ward et al. 1959b) show growth of TTS by 1.5 to 1.6 dB for every 1 dB increase in exposure level. The difference between measurable TTS onset (6 dB) and the selected 40 dB upper safe limit of TTS yields a difference in TTS of 34 dB which, when divided by a TTS growth function of 1.6 indicates that an increase in exposure of 21 dB would result in 40 dB of TTS. For simplicity and additional conservatism, the number was rounded down to 20 dB (Southall et al., 2007).

Therefore, exposures to sonar and other active acoustic sources with levels 20 dB above those producing TTS are assumed to produce PTS. For example, an onset-TTS threshold of 195 dB re 1 μPa^2-s would have a corresponding onset-PTS threshold of 215 dB re 1 μPa^2-s. This extrapolation process is identical to that recently proposed by Southall et al. (2007). The method predicts greater effects than have actually been observed in tests on a bottlenose dolphin (Schlundt et al. 2006) and is therefore protective.

Kastak et al. (2007) obtained different TTS growth rates for pinnipeds than Finneran and colleagues obtained for mid-frequency cetaceans. NMFS recommended reducing the estimated PTS criteria for both groups of pinnipeds, based on the difference in TTS growth rate reported by Kastak et al. (2007) (14 dB instead of 20 dB).

The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict PTS.

6.1.4.4.4 Permanent Threshold Shift for Explosions

Since marine mammal PTS data from impulsive exposures do not exist, onset-PTS levels for these animals are estimated by adding 15 dB to the sound exposure level-based TTS threshold and by adding 6 dB to the peak pressure-based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each species group is applied when using the sound exposure level-based thresholds to predict PTS.

6.1.4.5 Behavioral Responses

The behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response. In this analysis, animals may be behaviorally harassed in each modeled scenario (using the Navy Acoustic Effects Model) or within each 24-hour period, whichever is shorter. Therefore, the same animal could have a behavioral reaction multiple times over the course of a year.

6.1.4.5.1 Sonar and Other Active Acoustic Sources

Potential behavioral effects from in-water sound from sonar and other active acoustic sources were predicted using the behavioral response functions for most marine mammal species. The received sound level is weighted with the Type I auditory weighting functions (Figure 6-3) before the behavioral response function is applied. The harbor porpoise and beaked whales are the exception. They have unique criteria based on specific data that show these animals to be especially sensitive to sound.

Harbor porpoise and beaked whale non-impulsive behavioral criteria are used unweighted - without weighting the received level before comparing it to the threshold.

6.1.4.5.1.1 Behavioral Response Functions

This analysis assumes that the probability of eliciting a behavioral response to sonar and other active acoustic sources on individual animals would be a function of the received sound pressure level (dB re 1 µPa). The behavioral response function applied to mysticetes (Figure 6-6) differs from that used for odontocetes and pinnipeds (Figure 6-5) in having a shallower slope, which results in the inclusion of more behavioral impacts at lower received levels, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to sound pressure levels below a certain basement value.

The values used in this analysis are based on three sources of data: behavioral observations during TTS experiments conducted at the Navy Marine Mammal Program (Finneran et al. 2001, 2003b; Finneran et al. 2005a; Finneran and Schlundt 2004); reconstruction of sound fields produced by the USS Shoup associated with the behavioral responses of killer whales observed in Haro Strait (U.S. Department of the Navy 2003; Fromm 2009; National Marine Fisheries Service 2005); and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004).

In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995; Southall et al. 2007; Wartzok et al. 2003). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict. Therefore, the behavioral response functions represent a relationship that is deemed generally accurate, but may not be true in specific circumstances.

Specifically, the behavioral response function treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, many other variables such as the marine mammal's gender, age, and prior experience; the activity it is engaged in during a sound exposure; its distance from a sound source; the number of sound sources; and whether the sound sources are approaching or moving away from the animal can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al. 2007). Currently available data do not allow for incorporation of these other variables in the current behavioral response functions; however, the response function represents the best use of the data that are available. Furthermore, the behavioral response functions do not differentiate between different types of behavioral reactions (e.g., area avoidance, diving avoidance, or alteration of natural behavior) or provide information regarding the predicted consequences of the reaction.

The behavioral response function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training with mid-frequency active sonar) at a given received level of sound. For example, at 165 dB sound pressure level (dB re 1µPa root mean square), the risk (or probability) of harassment is defined according to this function as 50 percent. This means that 50 percent of the individuals exposed at that received level would be predicted to exhibit a significant behavioral response.

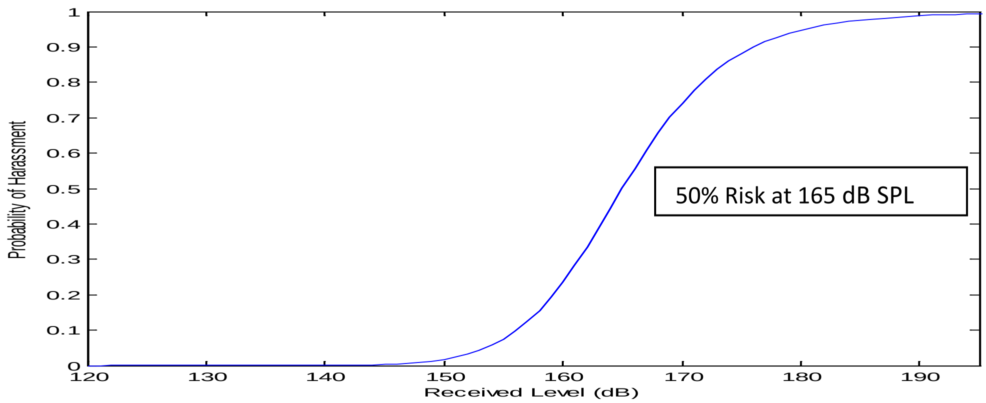


Figure 6-5. Behavioral Response Function Applied to Odontocetes and Pinnipeds (BRF_2) (Excluding Beaked Whales and Harbor Porpoises)

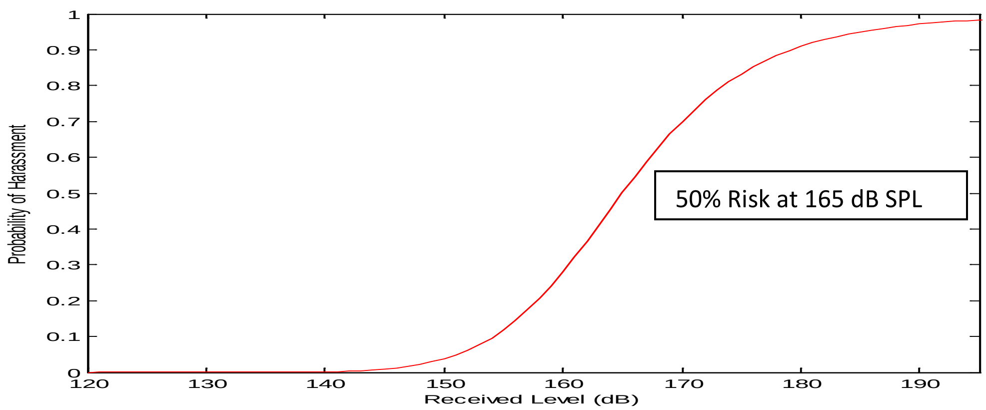


Figure 6-6. Behavioral Response Function Applied to Mysticetes (BRF_1)

6.1.4.5.1.2 Harbor Porpoises

The information currently available regarding this species 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. 2005c) 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, a sound pressure level of 120 dB re 1 µPa is used in this analysis as a threshold for predicting behavioral responses in harbor porpoises (Table 6-3).

6.1.4.5.1.3 Beaked Whales

The inclusion of a special behavioral response criterion for beaked whales of the family Ziphiidae is new to these Phase II criteria. It has been speculated for some time that beaked whales might have unusual sensitivities to sound due to a few strandings in conjunction with mid-frequency sonar use, even in areas where other species were more abundant (D'Amico et al. 2009), but there were not sufficient data to support a separate treatment for beaked whales until recently. With the recent publication of results from Blainville's beaked whale monitoring and experimental exposure studies on the instrumented Atlantic Undersea Test and Evaluation Center range in the Bahamas (McCarthy et al. 2011; Tyack et al. 2011), there are now statistically strong data suggesting that beaked whales tend to avoid both actual naval mid-frequency sonar in real anti-submarine training scenarios as well as sonar-like signals and other signals used during controlled sound exposure studies in the same area. The Navy has therefore adopted a 140 dB re 1 µPa sound pressure level threshold for significant behavioral effects for all beaked whales (family: Ziphiidae) (Table 6-3).

Table 6-3. Summary of Behavioral Thresholds for Marine Mammals

Group	Behavioral Thresholds for Sonar and Other Active Acoustic Sources	Behavioral Thresholds for Explosions
Low-Frequency Cetaceans	(LF_I) SPL: BRF_1	(LF_{II}) SEL: 167 dB re 1 µPa^2·s
Mid-Frequency Cetaceans	(MF_I) SPL: BRF_2	(MF_{II}) SEL: 167 dB re 1 µPa^2·s
High-Frequency Cetaceans	(HF_I) SPL: BRF_2	(HF_{II}) SEL: 141 dB re 1 µPa^2·s
Phocid Seals (In-Water)	(P_{WI}) SPL: BRF_2	(P_{WI}) SEL: 172 dB re 1 µPa^2·s
Beaked Whales	(unweighted) SPL: 140 dB re 1 µPa	(MF_{II}) SEL: 167 dB re 1 µPa^2·s
Harbor Porpoises	(unweighted) SPL: 120 dB re 1 µPa	(HF_{II}) SEL: 141 dB re 1 µPa^2·s

$LF_{I/II}$: Low-Frequency Cetacean Type I/II weighting function; $MF_{I/II}$: Mid-Frequency Cetacean Type I/II weighting function; $HF_{I/II}$: High-Frequency Cetacean Type I/II weighting function; P_{WI}: Phocid Type I weighting function; BRF: Behavioral Response Function

6.1.4.5.2 Explosions

If more than one explosive event occurs within any given 24-hour period within a training or testing activity, criteria are applied to predict the number of animals that may have a behavioral reaction. For events with multiple explosions the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in sound exposure level) (Table 6-3). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulse TTS testing (Schlundt et al. 2000).

Some multiple explosion events, 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 and is extended to the criteria used in this analysis.

Since impulse events can be quite short, it may be possible to accumulate multiple received impulses at sound pressure levels considerably above the energy-based criterion and still not be considered a behavioral take. The Navy treats all individual received impulses as if they were one second long for the purposes of calculating cumulative sound exposure level for multiple impulse events. For example, five air gun impulses, each 0.1 second long, received at 178 dB sound pressure level would equal a 175 dB sound exposure level, and would not be predicted as leading to a significant behavioral response. However, if the five 0.1 second pulses are treated as a 5 second exposure, it would yield an adjusted value of approximately 180 dB, exceeding the threshold. For impulses associated with explosions that have durations of a few microseconds, this assumption greatly overestimates effects based on sound exposure level metrics such as TTS and PTS and behavioral responses.

Appropriate weighting values will be applied to the received impulse in one-third octave bands and the energy summed to produce a total weighted sound exposure level value. For impulsive behavioral criteria, the new weighting functions (Figure 6-4) are applied to the received sound level before being compared to the threshold.

6.1.4.5.3 Pile Driving and Airgun Criteria and Thresholds

Existing NMFS risk criteria are applied to the unique impulsive sounds generated by pile driving and airguns (Table 6-4).

Table 6-4. Pile Driving and Airgun Thresholds Used in this Analysis to Predict Effects on Marine Mammals

Species Groups	Underwater Vibratory Pile Driving Criteria (sound pressure level, dB re 1 µPa)		Underwater Impact Pile Driving and Airgun Criteria (sound pressure level, dB re 1 µPa)	
	Level A Injury Threshold	Level B Disturbance Threshold	Level A Injury Threshold	Level B Disturbance Threshold
Cetaceans (whales, dolphins, porpoises)	180 dB rms	120 dB rms	180 dB rms	160 dB rms
Pinnipeds (seals)	190 dB rms	120 dB rms	190 dB rms	160 dB rms

rms – root mean square
Note: Root mean square calculation is based on the duration defined by 90 percent of the cumulative energy in the impulse.

6.1.5 Quantitative Analysis

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be affected by acoustic sources or explosives used during Navy training and testing activities. Inputs to the quantitative analysis included marine mammal density estimates; marine mammal depth occurrence distributions; oceanographic and environmental data; marine mammal hearing data; and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential mortalities and harassments. The model calculates sound energy propagation from sonars, other active acoustic sources, and explosives during naval activities; the sound or impulse received by animat dosimeters representing marine mammals distributed in the area around the modeled activity; and whether the sound or impulse received by a marine mammal exceeds the thresholds for effects. The model estimates are then further analyzed to consider animal avoidance and implementation of mitigation measures, resulting in final estimates of effects due to Navy training and testing.

Various computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g., sonar or underwater detonation) to a receiver (e.g., dolphin). Basic underwater sound models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can influence the result. Assumptions in previous and current Navy models have intentionally erred on the side of overestimation when there are unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is often limited to a synthesis of data gathered over wide areas and requiring many years of research, known information tends to be an average of a seasonal or annual variation. El Niño Southern Oscillation events of the ocean-atmosphere system are an example of dynamic change where unusually warm or cold ocean temperatures are likely to redistribute marine life and alter the propagation of underwater sound energy. Previous Navy modeling therefore made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor). More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as bathymetry and an animal's likely presence at various depths.

The Navy has developed a set of data and new software tools for quantification of estimated marine mammal impacts from Navy activities. This new approach is the resulting evolution of the basic model previously used by Navy and reflects a more complex modeling approach as described below. Although this more complex computer modeling approach accounts for various environmental factors affecting acoustic propagation, the current software tools do not consider the likelihood that a marine mammal would attempt to avoid repeated exposures to a sound or avoid an area of intense activity where a training or testing event may be focused. Additionally, the software tools do not consider the implementation of mitigation (*e.g.*, stopping sonar transmissions when a marine mammal is within a certain distance of a ship or mitigation zone clearance prior to detonations). In both of these situations, naval activities are modeled as though an activity would occur regardless of proximity to marine mammals and without any horizontal movement by the animal away from the sound source or human activities. Therefore, the final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation and the possibility that marine mammals would avoid continued or repeated sound exposures.

The quantified results of the marine mammal acoustic effect analysis presented in this Request for Letters of Authorization differ from the quantified results presented in the AFTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). Presentation of the results in this new manner for MMPA, ESA, and other regulatory analyses is well within the framework of the previous NEPA analyses presented in the DEIS. These differences are due to two factors: (1) refinement of training and testing model inputs and (2) additional post-model analysis of acoustic effects to include animal avoidance of repeated sound exposures, avoidance of areas of activity before use of a sound source or explosive by sensitive species, and implementation of mitigation. This additional post-model analysis of acoustic effects was performed to clarify potential misunderstanding of the numbers presented as modeling results in the AFTT DEIS/OEIS. Some comments indicated that the readers believed the acoustic effects to marine mammals presented in the AFTT DEIS/OEIS were representative of the actual expected effects, although the AFTT DEIS/OEIS did not account for animal avoidance of an area prior to commencing sound-producing activities, animal avoidance of repeated explosive noise exposures, and the protections due to standard Navy mitigations. Therefore, the numbers presented in this Request for Letters of Authorization and to be reflected in the AFTT Final EIS/OEIS have been refined to better quantify the expected effects by fully accounting for animal avoidance and implementation of standard Navy mitigations.

The quantified acoustic impact analysis in the AFTT DEIS/OEIS considered the potential for marine mammals to avoid repeated exposures to sonar and other active acoustic sources. The acoustic analysis results presented in the following sections improve the post-model analysis shown in the AFTT DEIS/OEIS by considering pre-activity avoidance by sensitive species, avoidance of multiple explosive exposures, and implementation of mitigation measures.

The revised model estimates (without consideration of avoidance or mitigation) are presented in a revised technical report (Marine Species Modeling Team 2012).

The sections below describe the steps of the quantitative analysis of acoustic effects.

6.1.5.1 Marine Mammal Density

A quantitative analysis of impacts on a species requires data on the abundance and distribution of the species population in the potentially impacted area. The most appropriate metric for this type of analysis is density, which is the number of animals present per unit area.

There is no single source of density data for every area of the world, species, and season because of the fiscal costs, resources, and effort involved in providing survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the Study Area, the Navy compiled data from several sources. To compile and structure the most appropriate database of marine species density data, the Navy developed a protocol to select the best available data sources based on species, area, and time (season). The resulting Geographic Information System database called the Navy Marine Species Density Database includes seasonal density values for every marine mammal species present within the Study Area (U.S. Department of the Navy 2012b).

The Navy Marine Species Density Database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Exclusive Economic Zone. In this analysis, marine mammal density data were used as an input in the Navy Acoustic Effects Model in their original temporal (seasonal) and spatial resolution. Seasons are defined as winter (December–February), spring (March–May), summer (June–August), and fall (September– November).The density grid cell spatial resolution varied, depending on the original data source used, from 10 km^2 to 0.5 $degrees^2$ (latitude/longitude). Where data sources overlap, there might be a sudden increase or decrease in density due to different derivation methods or survey data utilized. This is an artifact of attempting to use the best available data for each geographic region. The density data were used as-is in order to preserve the original values. Any attempt to smooth the data sets would either increase or decrease adjacent values and would inflate the error of those values by an unknown amount.

The Navy modeled acoustic effects within representative locations where training and testing has historically occurred in the past and is expected to occur in the future. Within the Study Area, the expected geographic extent of some species did not overlap with any area where potential acoustic impacts were modeled. Therefore, since there were no expected impacts from the modeled sources, the following species were excluded from quantitative analysis:

- Bowhead whale
- Beluga whale
- Narwhal

These species are included for further qualitative assessment of impacts from other nonmodeled sources such as vessel noise, aircraft overflight noise, weapons firing, launch and non-explosive impact noise.

All species density distributions matched the expected distributions from published literature and the NMFS stock assessments, with the exception of long-beaked common dolphin and harbor porpoise. The NMFS stock assessment does not consider long-beaked common dolphin to occur within the U.S. Exclusive Economic Zone. However, the Navy Marine Species Density Database predicts a possible low-occurrence within the Study Area, extending into the U.S. Atlantic Exclusive Economic Zone. Since long-beaked common dolphin is a rare or uncommon species in the western Atlantic and the Study Area extends beyond the NMFS survey coverage area, the Navy decided to include this species in the acoustic analysis for completeness since there may be a possible low probability of occurrence within the Study Area.

The harbor porpoise density distribution comprised multiple data sources. The Sea Mammal Research Unit Limited density data source did not match the expected distribution within the NMFS stock assessment survey coverage area. This was a function of the parameters defined for the harbor porpoise habitat model used in the density estimate. The parameters were defined to encompass several distinct harbor porpoise populations across the northern Atlantic and adjacent waters and may not accurately represent the population occurring within the Study Area. Therefore, using the best available definition of the harbor porpoise distribution extent, the Navy corrected and defined the extent to match the distribution published in the NMFS Stock Assessment Report. See U.S. Department of the Navy (2012) for further details on this correction.

6.1.5.2 Upper and Lower Frequency Limits

The Navy has adopted a single frequency cutoff at each end of a functional hearing group's frequency range based on the most liberal interpretations of their composite hearing abilities. These are not the same as the values used to calculate weighting curves but exceed the demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 6-5 provides the lower and upper frequency limits for each species group. Sounds with frequencies below the lower frequency limit, or above the upper frequency limit, are not analyzed with respect to auditory effects for a particular group.

Table 6-5. Lower and Upper Cutoff Frequencies for Marine Mammal Functional Hearing Groups Used in this Acoustic Analysis.

Functional Hearing Group	Limit (Hz)	
	Lower	Upper
Low-Frequency Cetaceans	5	30,000
Mid-Frequency Cetaceans	50	200,000
High-Frequency Cetaceans	100	200,000
Phocid seals (in water) and Sirenians	50	80,000

6.1.5.3 Navy Acoustic Effects Model

The Navy developed a set of software tools and compiled data for estimating acoustic impacts on marine mammals, without consideration of mitigation or behavioral avoidance. These databases and tools collectively form the Navy Acoustic Effects Model (NAEMO). Details of this model's processes and the description and derivation of the inputs are presented in Marine Species Modeling Team (2012)

The Navy Acoustic Effects Model improves upon previous modeling efforts in several ways. First, unlike earlier methods that modeled sources individually, the Navy Acoustic Effects Model has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes; in the Navy Acoustic Effects Model, animats (virtual animals) are distributed nonuniformly based on higher resolution species-specific density, depth distribution, and group size information, and animats serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animat exposure in the Navy Acoustic Effects Model, rather than a two-dimensional environment where the worse case sound pressure level across the water column is always encountered. Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling (Marine Species Modeling Team 2012). The following paragraphs provide an overview of the Navy Acoustic Effects Model process and its more critical data inputs.

Using the best available information on the predicted density of marine mammals in the area being modeled, the Navy Acoustic Effects Model derives an abundance (total number of individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). For example, for non-impulsive sources, all animats that are predicted to occur within a range that could receive sound pressure levels greater than or equal to 120 dB sound pressure level are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles) (the (Marine Species Modeling Team 2012)] discusses animal dive profiles in detail). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus (horizontal movement), or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the Navy Acoustic Effects Model in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animats remain static at that position throughout the entire simulation. In the Navy Acoustic Effects Model, animats are placed horizontally dependent on nonuniform density information, and then move up and down over time within the water column by integrating species-typical depth distribution information. Second, for the static method they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the Navy Acoustic Effects Model. Third, Schecklman et al. (2011) ran 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density), only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the Navy Acoustic Effects Model overpopulates the animats over a nonuniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were compared during development of the Navy Acoustic Effects Model. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures were similar between the Navy Acoustic Effects Model and the fully moving distribution; however, computational time was much longer for the fully moving distribution.

The Navy Acoustic Effects Model calculates the likely propagation for various levels of energy (sound or pressure) resulting from each non-impulse or impulse source used during a training or testing event. This is done by taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event's location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include as much environmental variation within the Study Area as is reasonably available and can be incorporated into the model.

The Navy Acoustic Effects Model then records the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects on the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., PTS over TTS) predicted for a given animat is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine animal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the Study Area are counted as if they occurred within the Study Area boundary. The Navy Acoustic Effects Model provides the initial estimated effects on marine species with a static horizontal distribution. These model-estimated results are then further analyzed to account for pre-activity avoidance by sensitive species, mitigation (considering sound source and platform), and avoidance of repeated sound exposures by marine mammals, producing the final predictions of effects used in this request for LOAs.

6.1.5.4 Model Assumptions and Limitations

There are limitations to the data used in the Navy Acoustic Effects Model, and the results must be interpreted with consideration for these known limitations. Output from the Navy Acoustic Effects Model relies heavily on the quality of both the input parameters and impact thresholds and criteria. When there was a lack of definitive data to support an aspect of the modeling (such as lack of well described diving behavior for all marine species), conservative assumptions believed to overestimate the number of exposures were chosen:

- Animats are modeled as being underwater and facing the source and therefore always predicted to receive the maximum sound level at their position within the water column (e.g. the model does not account for conditions such as body shading, porpoising out of the water, or an animal raising its head above water). Some odontocetes have been shown to have directional hearing, with best hearing sensitivity facing a sound source and higher hearing thresholds for sounds propagating towards the rear or side of an animal (Kastelein et al. 2005a; Mooney et al. 2008; Popov and Supin 2009).
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.

- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in PTS.
- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at farther distances and increased depths.
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures.
- Mitigation measures that are implemented during many training and testing activities were not considered in the model (see Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected within the mitigation zones around sound sources.

Because of these inherent model limitations and simplifications, model-estimated results must be further analyzed, considering such factors as the range to specific effects, avoidance, and the likelihood of successfully implementing mitigation measures. This analysis uses a number of factors in addition to the acoustic model results to predict acoustic effects on marine mammals.

6.1.5.5 Marine Mammal Avoidance of Sound Exposures

Marine mammals may avoid sound exposures by either avoiding areas with high levels of anthropogenic activity or moving away from a sound source. Because the Navy Acoustic Effects Model does not consider horizontal movement of animats, including avoidance of human activity or sounds, it over-estimates the number of marine mammals that would be exposed to sound sources that could cause injury. Therefore, the potential for avoidance is considered in the post-model analysis. The consideration of avoidance during use of sonar and other active acoustic sources and during use of explosives is described below and discussed in more detail in Sections 6.1.6 (Impacts from Sonar and Other Active Acoustic Sources) and in Section 6.1.7 (Impacts from Explosions).

6.1.5.5.1 Avoidance of Human Activity

Cues preceding the commencement of an event (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Harbor porpoises and beaked whales have been observed to be especially sensitive to human activity, which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonars and other active acoustic sources. Both finless porpoises (Li et al. 2008) and harbor porpoises (Barlow 1988; Evans et al. 1994; Palka and Hammond 2001; Polacheck and Thorpe 1990) routinely avoid and swim away from large motorized vessels. The vaquita, which is closely related to the harbor porpoise, appears to avoid large vessels at about 2,995 ft. (913 m) (Jaramillo-Legorreta et al. 1999). The assumption is that the harbor porpoise would respond similarly to large Navy vessels. Beaked whales have also been documented to exhibit avoidance of human activity (Pirotta et al. 2012).

Therefore, for certain naval activities preceded by high levels of vessel activity (multiple vessels) or hovering aircraft, harbor porpoises and beaked whales are assumed to avoid the activity area prior to the start of a sound-producing activity. Model-estimated effects during these types of activities are adjusted so that high level sound impacts to harbor porpoises and beaked whales (those causing PTS during use of sonar and other active acoustic sources and those causing mortality due to explosives) are considered to be TTS and injury, respectively, due to animals moving away from the activity and into a lower effect range.

6.1.5.5.2 Avoidance of Repeated Exposures

Marine mammals would likely avoid repeated high level exposures to a sound source that could result in injuries (i.e., PTS). Therefore, the model-estimated effects are adjusted to account for marine mammals swimming away from a sonar or other active source and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 6.1.6.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources) and avoidance of repeated explosive exposures is discussed further in Section 6.1.7.2 (Avoidance Behavior and Mitigation Measures as Applied to Explosives).

6.1.5.6 Implementing Mitigation to Reduce Sound Exposures

The Navy implements mitigation measures (described in Chapter 11) during sound-producing activities, including halting or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone; sound-producing activities would not begin or resume until the mitigation zone is observed to be free of marine mammals. The Navy Acoustic Effects Model estimates acoustic effects without any shutdown or delay of the activity in the presence of marine mammals; therefore, the model over-estimates impacts to marine mammals within mitigation zones. The post-model analysis considers the potential for highly effective mitigation to prevent Level A harassments due to exposure to sonar and other active acoustic sources and Level A harassments and mortalities due to explosives.

The effectiveness of mitigation depends on two factors: (1) the extent to which the type of mitigation proposed for a type of activity allows for observation of the mitigation zone prior to and during the sound-producing activity (probability of detection) and (2) the sightability of each species that may be present in the mitigation zone (availability bias). The mitigation zones proposed in Chapter 11 encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source.

Mitigation is considered in the acoustic effects analysis when the mitigation zone can be fully or mostly observed up to and during a sound-producing activity. Mitigation for each activity is considered in its entirety, taking into account the different scenarios that may take place as part of that activity (some scenarios involve different mitigation zones, platforms, or number of Lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) for each activity was estimated for each activity. Mitigation was considered in the acoustic analysis as follows:

- If the entire mitigation zone can be continuously visually observed based on the surveillance platform(s), number of Lookouts, and size of the range to effects zone, the mitigation is considered fully effective (Effectiveness = 1).
- If over half of the mitigation zone can be continuously visually observed or if there is one or more of the scenarios within the activity for which the mitigation zone cannot be continuously visually observed (but the majority of the scenarios can continuously visually observe the range to effects zone), the mitigation is considered mostly effective (Effectiveness = 0.5).

- If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, the mitigation is not considered in the acoustic effects analysis.

The mitigation effectiveness scores are multiplied by the estimated sightability of each species to estimate the percent of each species model-estimated to experience mortality (explosives only) or injury (all sound-producing activities) that would, in reality, be observed by Lookouts prior to or during a sound-producing activity. Observation of marine mammals prior to or during a sound-producing event would be followed by stop or delay of the sound-producing activity, which would reduce actual marine mammal sound exposures.

For purposes of this analysis, the sightability is based on availability bias g(0) for vessel and aerial platforms based on recent peer-reviewed literature. While g(0) is based on trained marine mammal observers' ability to identify specific species along a single line transect of a limited width and the animals being available for detection at the surface along that trackline, Lookouts aboard Navy platforms would observe the full mitigation zone prior to and during a sound-producing activity and sound-producing activities would be halted when any marine mammal is observed, regardless of species. Because Lookouts would report any marine mammal observation within the mitigation zone over a period of time preceding and during an activity, g(0) is considered to be a reasonable representation of the sightability of a marine mammal for this analysis.

The g(0) value used in the mitigation analysis is based on the platform(s) with Lookouts utilized in the activity. In the case of multiple platforms, the higher g(0) value for either the aerial or vessel platform is selected. For species for which there is only a single published value for each platform, that individual value is used. For species for which there is a range of published g(0) values, an average of the values, calculated separately for each platform, is used. A g(0) of zero is assigned to species for which there is no data available, unless a g(0) estimate can be extrapolated from similar species/guilds based on the published g(0) values. The g(0) values used in this analysis are provided in Table 6-6.

The post-model acoustic effect analysis process is summarized in Table 6-7. The consideration of mitigation during use of sonar and other active acoustic sources and during use of explosives is discussed in more detail in Section 6.1.6 (Impacts from Sonar and Other Active Acoustic Sources) and Section 6.1.7 (Impacts from Explosions). The final quantified results of the acoustic effects analysis are presented in Section 6.1.6.3 (Predicted Impacts).

Table 6-6: Sightability g(0) Values for Marine Mammal Species in AFTT Study Area

g(0)[1]	Location	Platform	Average g(0)[2]	Source
Threatened/Endangered Cetacean Species				
Right whale (*Eubalaena* species)				
0.29–1.00	United States Atlantic Coast	Shipboard	0.65	(Palka 2006)
0.11–0.71	United States Atlantic Coast	Aerial	0.41	(Hain et al. 1999)
0.19–0.29	United States Atlantic Coast	Aerial		(Palka 2005a)
Humpback whale (*Megaptera novaeangliae*)				
0.19–0.21	United States Atlantic Coast	Shipboard	0.2	(Palka 2005b)
0.95	United States West Coast	Aerial	0.61	(Forney et al. 1995)
0.26	Hawaii	Aerial		(Mobley et al. 2001)
Blue whale (*Balaenoptera musculus*)				
0.9–1.00	United States West Coast	Shipboard	0.95	(Barlow and Taylor 2001)
0.92	United States West Coast	Shipboard		(Barlow and Forney 2007; Forney 2007)
0.41	United States West Coast	Aerial	0.41	(Barlow et al. 1997; Carretta et al. 2000)
Sei whale (*Balaenoptera borealis*)				
0.92	United States West Coast	Shipboard	0.92	(Barlow and Forney 2007; Forney 2007)
		~~Aerial~~	~~0.24~~	~~Used lowest whale avg. g(0) value~~
Fin whale (*Balaenoptera physalus*)				
0.32–0.94	United States Atlantic Coast	Shipboard	0.63	(Blaylock et al. 1995; Palka 2006)
0.19–0.29	United States Atlantic Coast	Aerial	0.24	(Palka 2005a)
Sperm whale (*Physeter macrocephalus*)				
0.28–0.57	United States Atlantic Coast	Shipboard	0.43	(Palka 2005b, 2006)
0.19–0.29	United States Atlantic Coast	Aerial	0.24	(Palka 2005a)
Non-Threatened/Non-Endangered Cetacean Species				
Minke whale (*Balaenoptera acutorostrata*)				
0.31–0.70	United States Atlantic Coast	Shipboard	0.51	(Blaylock et al. 1995; Palka 2006)
0.19–0.29	United States Atlantic Coast	Aerial	0.24	(Palka 2005a)
Bryde's whale (*Balaenoptera edeni*)				
0.90–1.00	United States West Coast	Shipboard	0.95	(Barlow 1995; Barlow 2003a)
		~~Aerial~~	~~0.24~~	~~Used lowest whale avg. g(0) value~~
***Kogia* species**				
0.29–0.55	United States Atlantic Coast	Shipboard	0.42	(Palka 2006)
		~~Aerial~~	~~0.24~~	~~Used pilot whale avg. g(0) value~~
Ziphiidae (Beaked Whales)				
0.46–0.51	United States Atlantic Coast	Shipboard	0.49	(Palka 2005b, 2006)
0.19–0.21	United States Atlantic Coast	Aerial	0.2	(Palka 2005a)
Bottlenose dolphin (*Tursiops truncatus*)				
0.62–0.99	United States Atlantic Coast	Shipboard	0.81	(Palka 2005b, 2006)
0.58–0.77	United States Atlantic Coast	Aerial	0.68	(Palka 2005a)
Spinner dolphin (*Stenella longirostris*)				
0.61–0.76	United States Atlantic Coast	Shipboard	0.69	(Palka 2006)
		~~Aerial~~	~~0.68~~	~~Used lowest dolphin avg. g(0) value~~
Clymene dolphin (*Stenella clymene*)				
Not available				
Pantropical spotted dolphin (*Stenella attenuate*)				
0.37–0.94	United States Atlantic Coast	Shipboard	0.66	(Palka 2006)*
		~~Aerial~~	~~0.68~~	~~Used lowest dolphin avg. g(0) value~~

Table 6-6. Sightability g(0) Values for Marine Mammal Species in AFTT Study Area (Continued)

g(0)[1]	Location	Platform	Average g(0)[2]	Source
Atlantic spotted dolphin (*Stenella frontalis*)				
0.37–0.94	United States Atlantic Coast	Shipboard	0.66	(Palka 2006)
		Aerial	0.68	Used lowest dolphin avg. g(0) value
Striped dolphin (*Stenella coeruleoalba*)				
0.61–0.77	United States Atlantic Coast	Shipboard	0.69	(Palka 2005b, 2006)
		Aerial	0.68	Used lowest dolphin avg. g(0) value
Common dolphin (*Delphinus delphis*)				
0.52–0.95	United States Atlantic Coast	Shipboard	0.74	(Palka 2005b, 2006)
0.58–0.77	United States Atlantic Coast	Aerial	0.68	(Palka 2005a)
Rough-toothed dolphin (*Steno bredanensis*)				
0.74–1.00	United States West Coast	Shipboard	0.87	(Barlow 2003b)
0.74–1.00	Hawaii	Shipboard		(Barlow 2003a, 2006)
		Aerial	0.68	Used lowest dolphin avg. g(0) value
Fraser's dolphin (*Lagenodelphis hosei*)				
0.76–1.00	Hawaii	Shipboard	0.88	(Barlow 2003a, 2006)
White-sided dolphin (*Lagenorhynchus acutus and L. obliquidens*)				
0.27–0.38	United States Atlantic Coast	Shipboard	0.33	(Palka 2006)
0.58–0.77	United States Atlantic Coast	Aerial	0.68	(Palka 2005a)
White-beaked dolphin (*Lagenorhynchus albirostris*)				
Not available				
Risso's dolphin (*Grampus griseus*)				
0.51–0.84	United States Atlantic Coast	Shipboard	0.68	(Palka 2005b, 2006)
0.58–0.77	United States Atlantic Coast	Aerial	0.68	(Palka 2005a)
False killer whale (*Pseudorca crassidens*)				
0.74–1.00	Hawaii	Shipboard	0.87	(Barlow 2003a, 2006)
		Aerial	0.24	Used pilot whale avg. g(0) value
Pygmy killer whale (*Feresa attenuata*)				
0.74–1.00	Hawaii	Shipboard	0.87	(Barlow 2003a, 2006)
		Aerial	0.24	Used pilot whale avg. g(0) value
Killer whale (*Orcinus orca*)				
0.90	United States West Coast	Shipboard	0.9	(Barlow 2003b)
0.95–0.98	United States West Coast	Aerial	0.97	(Forney et al. 1995)
Melon-headed whale (*Peponocephala electra*)				
0.74–1.00	Hawaii	Shipboard	0.87	(Barlow 2003a, 2006)
		Aerial	0.24	Used pilot whale avg. g(0) value
Pilot whale (*Globicephala* species)				
0.48–0.67	United States Atlantic Coast	Shipboard	0.58	(Palka 2005b, 2006)
0.19–0.29	United States Atlantic Coast	Aerial	0.24	(Palka 2005a)
Harbor porpoise (*Phocoena phocoena*)				
0.35–0.73	United States Atlantic Coast	Shipboard	0.54	(Palka 1995a; Palka 1995b, 2006)
0.24–0.49	United States Atlantic Coast	Aerial	0.37	(Palka 2005a)
Non-Threatened/Non-Endangered Pinniped Species				
Harbor seal (*Phoca vitulina*)				
Not available				
0.28	United States West Coast	Aerial	0.28	(Barlow et al. 1997; Carretta et al. 2000)

* These numbers were either determined by the source or applied by the source for abundance/density estimation analyses in the particular geographic location.

[1] A g(0) value of 1.00 indicates that 100 percent of the animals are detected

[2] The average of the range of g(0) values was calculated for each source. When one or more source was available the average of each of the individual average for each source was calculated.

Table 6-7: Post-Model Acoustic Impact Analysis Process

Is the sound source sonar/other active acoustic source or explosives?	
Sonar and Other Active Acoustic Sources	**Explosives**
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter?	**E-1. Is the activity preceded by multiple vessel activity or hovering helicopter?**
Species sensitive to human activity (i.e., harbor porpoises and beaked whales) are assumed to avoid the activity area, putting them out of the range to Level A harassment. Model-estimated PTS to these species during these activities are unlikely to actually occur and, therefore, are considered to be behavioral disturbances (animal is assumed to move into the range of potential behavioral disturbance). The activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 6-12 in Section 6.1.6.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources)..	Species sensitive to human activity (i.e., harbor porpoises and beaked whales) are assumed to avoid the activity area, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential injury). The activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 6-23 in Section 6.1.7.2 (Avoidance Behavior and Mitigation as Applied to Explosives).
S-2. Is the range to effects for PTS very small?	
Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10 m) to experience PTS. These model-estimated PTS exposures of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of TTS).	
S-3. Can Lookouts observe the activity-specific mitigation zone (see Chapter 11) up to and during the sound-producing activity?	**E-2. Can Lookouts observe the activity-specific mitigation zone (see Chapter 11) up to and during the sound-producing activity?**
If lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation procedures in Chapter 11). Therefore, model-estimated PTS exposures are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 6-6. The Mitigation Effectiveness values are provided in Table 6-13 in Section 6.1.6.2 (Avoidance Behavior and Mitigation Measures as Applied to Sonar and Other Active Acoustic Sources).	If lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone (per the mitigation procedures in Chapter 11). Therefore, model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries are instead assumed to be injuries or behavioral disturbances, respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated Lookout(s). For activities with lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 6-6. The Mitigation Effectiveness values for explosive activities are provided in Table 6-24 in Section 6.1.7.2 (Avoidance Behavior and Mitigation as Applied to Explosives).

Table 6-7. Post-Model Acoustic Impact Analysis Process (Continued)

S-4. Does the activity cause repeated sound exposures which an animal would likely avoid?	E-3. Does the activity cause repeated sound exposures which an animal would likely avoid?
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS to high-frequency cetaceans, low frequency cetaceans, and phocids are expected to actually occur (after accounting for mitigation in step S-3). Model estimates of PTS beyond the initial pings are considered to actually be behavioral disturbances, as the animal is assumed to move out of the range to PTS and into the range of TTS.	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Table 6-25 in Section 6.1.7.2 (Avoidance Behavior and Mitigation as Applied to Explosives).

6.1.6 Impacts from Sonar and Other Active Acoustic Sources

Sonar and other active acoustic sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. Most systems operate within specific frequencies, meaning little sound is emitted outside of the operational frequency. Sonar use associated with anti-submarine warfare would emit the most non-impulsive sound underwater during training and testing activities. Sonar use associated with mine warfare would also contribute a notable portion of overall non-impulsive sound. Other sources of non-impulsive noise include acoustic communications, sonar used in navigation, and other sound sources used in testing. General categories of sonar systems are described in Section 1.5.5, Classification of Non-Impulsive and Impulsive Sources.

Underwater sound propagation is highly dependent upon environmental characteristics such as bathymetry, bottom type, water depth, temperature, and salinity. A very simple estimate of sonar transmission loss can be calculated using the spherical spreading law, $TL = 20 \log_{10} r$, where r is the distance from the sound source and TL is the transmission loss in decibels. The simplified estimate of spreading loss for a ping from a hull-mounted tactical sonar with a nominal source level of 235 dB re 1 µPa is shown in Figure 6-7. The figure shows that sound levels drop off significantly near the source, followed by a more steady reduction with distance. Most non-impulsive sound sources used during training and testing have sound source levels lower than this example.

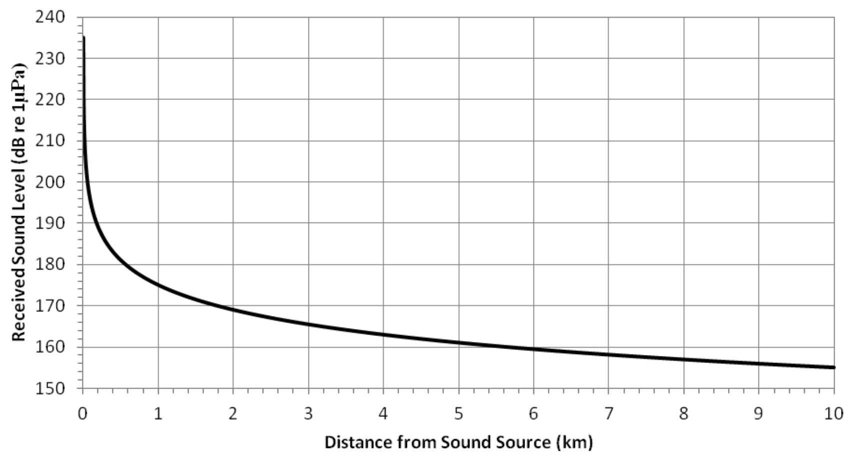


Figure 6-7. Estimate of Spreading Loss for a 235 dB re 1 µPa Sound Source Assuming Simple Spherical Spreading Loss

Sonars used in anti-submarine warfare are deployed on many platforms and are operated in various ways. Anti-submarine warfare active sonar is usually mid-frequency (1–10 kHz) because mid-frequency sound balances sufficient resolution to identify targets and distance within which threats can be identified. Ship tactical hull-mounted sonar contributes the largest portion of overall non-impulsive sound. Duty cycle, the ratio of active to non-active operation, can vary from about a ping per minute to continuously active. Sonar can be wide-ranging in a search mode or highly directional in a track mode. A submarine's mission revolves around its stealth; therefore, a submarine's mid-frequency sonar is used infrequently because its use would also reveal a submarine's location. Aircraft-deployed, mid-frequency, anti-submarine warfare systems include omnidirectional dipping sonar (deployed by helicopters) and omnidirectional sonobuoys (deployed from various aircraft), which have a typical duty cycle of several pings per minute. Acoustic decoys that continuously emulate broadband vessel sound or other vessel acoustic signatures may be deployed by ships and submarines. Torpedoes use directional high-frequency sonar when approaching and locking onto a target. Practice targets emulate the sound signatures of submarines or simulate sonar echoes bouncing off a submarine. Most anti-submarine warfare events occur more than 12 nm from shore and are concentrated in the VACAPES, Navy Cherry Point, and JAX Range Complexes.

Sonar used to locate mines and other objects is typically high-frequency, which provides higher resolution. Mine detection sonar is deployed at variable depths on moving platforms to sweep a suspect mined area (towed by ships, helicopters, or unmanned underwater vehicles). Mid-frequency hull-mounted sonar can also be used in an object detection mode known as "Kingfisher" mode. Mine detection sonar use would be concentrated in areas where practice mines are deployed, typically in water depths less than 200 ft. (61 m). These events are concentrated in the northeast GOMEX Range Complex and off-shore of Norfolk, Virginia, in the VACAPES Range Complex. Mine detection could also occur in deeper waters throughout the Study Area.

Active sound sources used for navigation and obtaining oceanographic information (e.g., depth, bathymetry, and speed) are typically directional, have high duty cycles, and cover a wide range of frequencies, from mid-frequency to very-high frequency. Sound sources used in communications are typically high-frequency or very-high frequency. Sound sources used in communication or navigation could be used throughout the Study Area.

While most non-impulsive sound sources are used beyond nearshore waters, some use would occur nearshore in inland waters such as bays, while pierside, or while in transit in and out of port. These activities include sonar maintenance, object detection/mine countermeasures, and navigation.

Most non-impulsive sound stressors associated with testing events, and about half of non-impulsive sound stressors associated with training events, involve a single unit or several units (ship, submarine, aircraft, or other platform) employing a single active sonar source in addition to sound sources used for communication, navigation, and measuring oceanographic conditions. Anti-submarine warfare activities may also use an acoustic target or an acoustic decoy. These events usually occur over a limited area and are completed in less than one day, often within a few hours. Most non-impulsive sound associated with these types of training events would occur in the VACAPES, Navy Cherry Point, and JAX Range Complexes. Most non-impulsive sound associated with testing events would occur in the Northeast and the GOMEX Range Complexes.

Multiday anti-submarine warfare events requiring coordination of movement and effort between multiple platforms with active sonar over a larger area occur less often, but constitute a large portion of overall non-impulsive underwater noise imparted by Navy activities. Approximately half of the non-impulsive sound stressors generated during training events occur during multiplatform anti-submarine warfare events. For example, the largest event, a composite training unit exercise, would have periods of concentrated, near-continuous anti-submarine warfare sonar use by several platforms during a several-week period, which could occur up to four times a year across the VACAPES, Navy Cherry Point, and JAX Range Complexes and once a year in the GOMEX Range Complex. Other events with multiple anti-submarine warfare sonar sources include joint task force exercise/sustainment exercise, integrated anti-submarine warfare course, group sail, Tactical Development Exercise, with periods of concentrated anti-submarine warfare sonar use within the overall event durations of one to ten days. These events would typically occur in the VACAPES, Navy Cherry Point, and JAX Range Complexes.

Exposure of marine mammals to non-impulsive sources such as active sonar is not likely to result in primary blast injuries or barotraumas. Sonar induced acoustic resonance and bubble formation phenomena are also unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 6.1.2.1 ,Direct Injury. Direct injury from sonar and other active acoustic sources would not occur under conditions present in the natural environment, and therefore, is not considered further in this analysis.

Research and observations of auditory masking in marine mammals is discussed in Section 6.1.2.3, Auditory Masking. Anti-submarine warfare sonar can produce intense underwater sounds in the Study Area associated with the Proposed Action. These sounds are likely within the audible range of most cetaceans, but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each but most are shorter than 1 second. The duty cycle is low with most tactical anti-submarine warfare sonar typically transmitting about once per minute. Furthermore, events are geographically and temporally dispersed and most events are limited to a few hours. Tactical sonars have a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood of sources causing significant auditory masking in marine mammals.

Some object-detecting sonars (i.e., mine warfare sonars) have a high duty cycle producing up to a few pings per second. These sonars typically employ high frequencies (above 10 kHz) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher-frequency mine warfare sonar systems are typically outside of the hearing and vocalization ranges of mysticetes (Section 4.2, Vocalization and Hearing of Marine Mammals), therefore, mysticetes are unlikely to be able to detect the higher frequency mine warfare sonars, and these systems would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many mine warfare sonars overlaps the hearing and vocalization abilities of some odontocetes; however, the frequency band of these sonars is narrow, limiting the likelihood of auditory masking. With any of these activities, the limited duration and dispersion of the activities in space and time reduce the potential for auditory masking effects from proposed activities on marine mammals.

The most probable effects from exposure to sonar and other active acoustic sources are PTS, TTS, and behavioral harassment (Section 6.1.2, Analysis Background and Framework, and Section 6.1.2.5, Behavioral Reactions).

Another concern is the number of times an individual marine mammal is exposed and potentially reacts to a sonar or other active acoustic source over the course of a year or within a specific geographic area. Animals that are resident during all or part of the year near Navy ports or on fixed Navy ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed in this analysis where applicable.

6.1.6.1 Range to Effects

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the acoustic criteria (Section 6.1.4, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals) and the acoustic propagation calculations from the Navy Acoustic Effects Model (Section 6.1.5.3). Although the Navy uses a number of sonar and active acoustic sources, the sonar bins provided below (i.e., MF1, MF4, and MF5) represent four of the most powerful sources. Section 1.5.1 (Classification of Non-Impulsive and Impulsive Sources) discusses sonar and other active acoustic source bins included in this analysis. These sonar bins are often the dominant source in the activity in which they are included, especially for smaller unit level training exercises and many testing activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

The ranges to specific effects are used to assess model results and determine adequate mitigation ranges to avoid higher level effects, especially physiological effects. Additionally, this data can be used to analyze the likelihood of an animal being able to avoid an oncoming sound source by simply moving a short distance (i.e., within a few hundred meters). Figure 6-8 shows a representation of effects with distance from a hypothetical sonar source; notice the proportion of animals that are likely have a behavioral response (yellow block; "risk-function") decreases with increasing distance from the source.

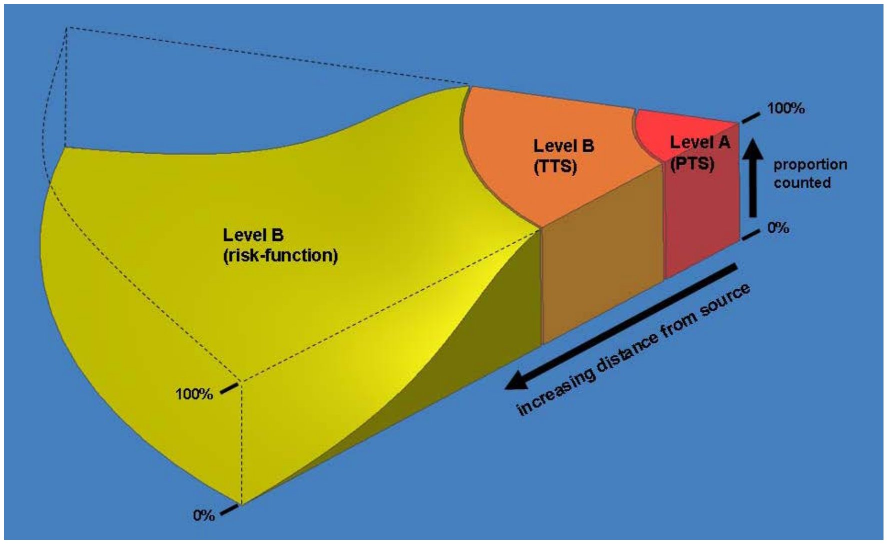


Figure 6-8. Hypothetical Range to Specified Effects for a Sonar Source

The ranges to the PTS threshold (i.e., range to the onset of PTS: the maximum distance to which PTS would be expected) are shown in Table 6-6 relative to the marine mammal's functional hearing group. For a SQS-53 sonar transmitting for 1 second at 3 kHz and a representative source level of 235 dB re 1 μPa^2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of 100 m (109 yd.). Since any hull-mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training would be moving at between 10–15 knots (5.1– 7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 257 m (281 yd.) during the time between those pings (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 functional hearing groups (low-frequency cetaceans, mid-frequency cetaceans, and phocid seals) single-ping PTS zones are within 100 m of the sound source. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship within the PTS zone; however, as indicated in Table 6-6, the distances required make PTS exposure less likely. For a Navy 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. For all sources except hull-mounted sonar (e.g., SQS-53 and BQQ-10) ranges to PTS are well within 50 m, even for multiple pings (up to five pings) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 6-9 illustrates the ranges to the onset of TTS (i.e., the maximum distances to which TTS would be expected) for one, five, and ten pings from four representative sonar source classes. 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.

The distances over which the sound pressure level from four representative sonar source classes is within the indicated 6-dB bins, and the percentage of animals that may exhibit a significant behavioral response under the mysticete and odontocete behavioral response function are shown in Table 6-10 and Table 6-11, respectively. See Section 6.1.4.5.1.1 (Behavioral Response Functions) for details on the derivation and use of the behavioral response function as well as the step function thresholds for harbor porpoises and beaked whales of 120 dB re 1 µPa and 140 dB re 1 µPa, respectively.

Range to 120 dB re 1 µPa varies by system but can approach 180 km (100 nm) for the most powerful hull-mounted sonars; however, only a very small percentage of animals would be predicted to react at received levels between 120 and 126 dB re 1 µPa, with the exception of harbor porpoises. All harbor porpoises that are predicted to receive 120 dB re 1 µPa or greater would be assumed to exhibit a behavioral response. Likewise, beaked whales would be predicted to have behavioral reactions at distances to approximately 80 km (43 nm).

Table 6-8. Range to PTS Criteria for Each Functional Hearing Group for a Single Ping from Four of the Most Powerful Sonar Systems within Representative Acoustic Environments Across the Study Area

Functional Hearing Group	Ranges to the Onset of PTS for One Ping (meters)[1]		
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull-mounted Sonar)	Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)	Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)
Low-Frequency Cetaceans	67	8	1
Mid-Frequency Cetaceans	10	2	1
High-Frequency Cetaceans	100	22	7
Phocid Seals	79	10	2

ASW: anti-submarine warfare; MIW: mine warfare; PTS: permanent threshold shift
[1] Ranges are based on spherical spreading (Transmission Loss = 20 log R, where R = range in meters).

Table 6-9. Range to the Onset of TTS for Four Representative Sonar Over a Representative Range of Environments within the Study Area

Functional Hearing Group	Approximate Ranges to the Onset of TTS (meters)[1]											
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull-mounted Sonar)			Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)			Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)		
	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings
Low-Frequency Cetaceans	557-2,277	1,226-6,249	1,616-8,861	217-237	494-1,913	754-2,702	109-122	238-305	336-1,555	100-161	150-727	150-821
Mid-Frequency Cetaceans	152-183	343-442	511-1,746	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
High-Frequency Cetaceans	2,166-7,567	4,054-15,351	5,431-19,597	90	183-188	255-953	< 50	< 50	< 50	< 50	< 50	< 50
Phocid Seals	72-1,721	239-3,568	346-4,850	< 50	100-102	145-147	< 50	< 50	< 50	< 50	< 50	< 50

ASW: anti-submarine warfare; MIW: mine warfare; TTS: temporary threshold shift
[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 receive TTS extends from onset-PTS to the distance indicated.

Table 6-10. Average Range to 6-dB Bins and Percentage of Behavioral Harassments in Each Bin for Low-Frequency Cetaceans under the Mysticete Behavioral Risk Function for Four Representative Sonar Systems

Received Level in 6-dB Bins	Sonar Bin MF1 (e.g., SQS-53; ASW Hull-mounted Sonar)		Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels
120 <= SPL < 126	179,213 – 147,800	0.00%	60,983 – 48,317	0.00%	19,750 – 15,275	0.00%	3,338 – 2,438	0.00%
126 <= SPL < 132	147,800 – 136,575	0.00%	48,317 – 18,300	0.09%	15,275 – 9,825	0.11%	2,438 – 1,463	0.04%
132 <= SPL < 138	136,575 – 115,575	0.12%	18,300 – 16,113	0.20%	9,825 – 5,925	2.81%	1,463 – 1,013	0.78%
138 <= SPL < 144	115,575 – 74,913	2.60%	16,113 – 11,617	4.95%	5,925 – 2,700	18.73%	1,013 - 788	4.16%
144 <= SPL < 150	74,913 – 66,475	2.94%	11,617 – 5,300	31.26%	2,700 – 1,375	26.76%	788 - 300	40.13%
150 <= SPL < 156	66,475 – 37,313	34.91%	5,300 – 2,575	29.33%	1,375 - 388	40.31%	300 - 150	23.87%
156 <= SPL < 162	37,313 – 13,325	43.82%	2,575 – 1,113	23.06%	388 - 100	10.15%	150 - 100	13.83%
162 <= SPL < 168	13,325 – 7,575	8.98%	1,113 - 200	10.60%	100 - <50	1.13%	100 - <50	17.18%
168 <= SPL < 174	7,575 – 3,925	4.59%	200 - 100	0.39%	<50	0.00%	<50	0.00%
174 <= SPL < 180	3,925 – 1,888	1.54%	100 - <50	0.12%	<50	0.00%	<50	0.00%
180 <= SPL < 186	1,888 - 400	0.48%	<50	0.00%	<50	0.00%	<50	0.00%
186 <= SPL < 192	400 - 200	0.02%	<50	0.00%	<50	0.00%	<50	0.00%
192 <= SPL < 198	200 - 100	0.00%	<50	0.00%	<50	0.00%	<50	0.00%

ASW: anti-submarine warfare; MIW: mine warfare; m: meter; SPL: sound pressure level

Table 6-11. Average Range to 6-dB Bins and Percentage of Behavioral Harassments in Each Bin for Mid-Frequency Cetaceans Under the Odontocete Behavioral Risk Function for Four Representative Sonar Systems (Odontocete Behavioral Risk Function is also used for High-Frequency Cetaceans and Phocid Seals)

Received Level in 6-dB Bins	Sonar Bin MF1 (e.g., SQS-53; ASW Hull-mounted Sonar)		Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance Over Which Levels Occur (m)	Percentage of Behavioral Harassments Occurring at Given Levels
120 <= SPL < 126	179,525 – 147,875	0.00%	61,433 – 48,325	0.00%	20,638 – 16,350	0.00%	4,388 – 4,050	0.00%
126 <= SPL < 132	147,875 – 136,625	0.00%	48,325 – 18,350	0.09%	16,350 – 10,883	0.07%	4,050 – 3,150	0.01%
132 <= SPL < 138	136,625 – 115,575	0.12%	18,350 – 16,338	0.18%	10,883 – 7,600	1.68%	3,150 – 2,163	0.38%
138 <= SPL < 144	115,575 – 74,938	2.58%	16,338 – 11,617	5.11%	7,600 – 3,683	18.02%	2,163 – 1,388	2.97%
144 <= SPL < 150	74,938 – 66,525	2.92%	11,617 – 5,425	30.08%	3,683 – 1,738	31.66%	1,388 – 1,013	7.15%
150 <= SPL < 156	66,525 – 37,325	34.71%	5,425 – 2,625	30.03%	1,738 - 425	39.81%	1,013 - 725	18.55%
156 <= SPL < 162	37,325 – 13,850	43.02%	2,625 – 1,125	23.44%	425 - 150	6.94%	725 - 250	53.79%
162 <= SPL < 168	13,850 – 7,750	9.77%	1,125 - 200	10.58%	150 - <50	1.82%	250 - 150	9.62%
168 <= SPL < 174	7,750 – 4,088	4.70%	200 - 100	0.38%	<50	0.00%	150 - 100	4.40%
174 <= SPL < 180	4,088 – 1,888	1.69%	100 - <50	0.11%	<50	0.00%	100 - <50	3.13%
180 <= SPL < 186	1,888 - 450	0.47%	<50	0.00%	<50	0.00%	<50	0.00%
186 <= SPL < 192	450 - 200	0.02%	<50	0.00%	<50	0.00%	<50	0.00%
192 <= SPL < 198	200 - 100	0.00%	<50	0.00%	<50	0.00%	<50	0.00%

ASW: anti-submarine warfare; MIW: mine warfare; m: meter; SPL: sound pressure level

6.1.6.2 Avoidance Behavior and Mitigation Measures as Applied to Sonar and Active Acoustic Sources

As discussed above (Section 6.1.5.4, Model Assumptions and Limitations), within the Navy Acoustic Effects Model, animats (virtual animals) do not move horizontally or react in any way to avoid sound at any level. In reality, various researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig et al. 1998). Section 6.1.2.5 (Behavioral Reactions) reviews research and observations of marine mammals' reactions to sound sources including sonar, ships, and aircraft. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around the sound source is the assumed behavioral response for most cases. Additionally, the Navy Acoustic Effects Model also does not account for the implementation of mitigation, which would prevent many of the model-estimated PTS effects. Therefore, the model-estimated PTS effects due to sonar and other active acoustic sources are further analyzed considering avoidance and implementation of mitigation measures in Section 6.1.5, Quantitative Analysis.

If sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, harbor porpoises and beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed in Section 6.1.5.5.1 (Avoidance of Human Activity). Table 6-8 shows the ranges to PTS for several sonar systems, including the most powerful system, the AN/SQS-53 in bin MF1. The range to PTS for all systems is generally much less than 50 m, with the exception of low-frequency cetaceans, high-frequency cetaceans, and phocids exposed to bin MF1 (range to PTS less than or equal to 100 m). Because the Navy Acoustic Effects Model does not include avoidance behavior, the model-estimated effects are based on unlikely behavior for these species- that they would tolerate staying in an area of high human activity. Harbor porpoises and beaked whales that were model-estimated to experience PTS due to sonar and other active acoustic sources are assumed to actually move into the range of TTS prior to the start of the sound-producing activity for the activities listed in Table 6-12.

Table 6-12: Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

ACTIVITY
Training
Airborne Mine Countermeasure - Mine Detection
Civilian Port Defense
COMPTUEX
Group Sail
IAC
JTFEX/SUSTAINEX
~~Kilo Dip~~
Mine Countermeasures Exercise (MCM) - Ship Sonar
Tactical Development Exercise
TRACKEX/TORPEX-Helo
Testing
Airborne Mine Hunting Test
ASW Mission Package Testing
ASW Tracking Test - Helo
Countermeasure Testing
Kilo Dip
MCM Mission Package Testing
Mine Countermeasure/Neutralization Testing
Mine Detection/Classification Testing
NSWC: Mine Detection and Classification Testing
NSWC: Stationary Source Testing
NSWC: UUV Demonstration
NSWC: UUV Testing
NUWC: Towed Equipment Testing
NUWC: UUV Demonstration
NUWC: UUV Testing
SFOMF: Surface Testing Activities
SFOMF: UUV Demonstration
Sonobuoy Lot Acceptance Testing
Torpedo (Explosive) Testing
Torpedo (Non-Explosive) Testing

The Navy Acoustic Effects Model does not consider mitigation, discussed in detail in Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures. As explained in Section 6.1.5.6, to account for the implementation of mitigation measures, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during use of the sound source, considering the mitigation effectiveness (see Table 6-13) and sightability of a species based on g(0) (see Table 6-6). The model-estimated PTS are reduced by the portion of animals that are likely to be seen (Mitigation Effectiveness x Sightability); these animals are instead assumed to be present within the range to TTS.

Table 6-13: Consideration of Mitigation in Acoustic Effects Analysis for Sonar and Other Active Acoustic Sources

Activity[1]	Mitigation Effectiveness Factor for Acoustic Analysis	Mitigation Platform
Training		
Airborne Mine Countermeasure - Mine Detection	1	Aircraft
Civilian Port Defense	1	Vessel
COMPTUEX	1	Vessel
IAC	1	Vessel
JTFEX/SUSTAINEX	1	Vessel
Group Sail	1	Vessel
~~Kilo Dip~~	~~1~~	~~Aircraft~~
Mine Countermeasures Exercise (MCM) - Ship Sonar	1	Vessel
Mine Neutralization - ROV	1	Vessel
Tactical Development Exercise	1	Vessel
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Object Detection	1	Vessel
Surface Ship Sonar Maintenance	1	Vessel
TRACKEX/TORPEX - MPA Sonobuoy	0.5	Aircraft
TRACKEX/TORPEX - Surface	0.5	Vessel
TRACKEX/TORPEX - Helo	0.5	Aircraft
Testing		
Airborne Mine Hunting Test	1	Aircraft
ASW Tracking Test – Helo	1	Aircraft
ASW Mission Package Testing	0.5	Aircraft
At-Sea Sonar Testing	0.5	Vessel
Combat System Ship Qualification Trials: In-Port	1	Vessel
Combat System Ship Qualification Trials: USW	0.5	Vessel
Countermeasure Testing	0.5	Vessel
Kilo Dip	1	Aircraft
Mine Countermeasure/Neutralization Testing	1	Vessel
Mine Detection/Classification Testing	1	Vessel
NSWC: Mine Detection and Classification Testing	1	Vessel
NSWC: Stationary Source Testing	1	Vessel
NUWC: Pierside Integrated Swimmer Defense	1	Vessel
NUWC: Semi-Stationary Equipment Testing	1	Vessel
NUWC: Towed Equipment Testing	1	Vessel
Pierside Integrated Swimmer Defense	1	Vessel
Pierside Sonar Testing	1	Vessel
SFOMF: Surface Testing Activities	1	Vessel
Sonobuoy Lot Acceptance Testing	1	Vessel
Submarine Sonar Testing/Maintenance	0.5	Vessel
Surface Combatant Sea Trials: ASW Testing	1	Vessel
Surface Combatant Sea Trials: Pierside Sonar Testing	1	Vessel
Surface Ship Sonar Testing/Maintenance	1	Vessel
Torpedo (Non-Explosive) Testing	0.5	Vessel

[1] If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, mitigation is not considered in the acoustic effects analysis of that activity and the activity is not listed in this table.

Animal avoidance of the area immediately around the sonar or other active acoustic system, coupled with mitigation measure designed to avoid exposing animals to high energy levels, would make the majority of model-estimated PTS exposures of mid-frequency cetaceans unlikely. The maximum ranges to the onset of PTS are discussed in Section 6.1.6.1 (Range to Effects) and shown in Table 6-6. The range to PTS for mid-frequency cetaceans (Table 6-8) does not exceed 50 m (55 yards) in any environment or for any sonar or other active acoustic source. In fact, the single ping range to PTS for mid-frequency cetaceans due to the AN/SQS-53 is 10 m, and the PTS range for five pings is about 20 m. The most powerful source, the AN/SQS-53, can span as much as 270 degrees, however, an animal would have to maintain a position within a 20 m radius in front of or along the bow of the ship for over 3 minutes (given the time between five pings) to experience PTS. Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Kastelein et al. 2005a; Mooney et al. 2008; Popov and Supin 2009).

An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. All model-estimated PTS exposures of mid-frequency cetaceans, therefore, are considered to actually be TTS due to the likelihood that an animal would be observed if it is present within the very short range to PTS effects.

Marine mammals in other functional hearing groups, if present but not observed by Lookouts, are assumed to leave the area near the sound source after the first 3 – 4 pings, thereby reducing sound exposure levels and the potential for PTS. As stated above, odontocetes, including high-frequency cetaceans, may also minimize sound exposure during avoidance due to directional hearing. During the first few pings of an event, or after a pause in sonar operations, if animals are caught unaware and mitigation measures are not yet implemented (e.g., animals are at depth and not visible at the surface) it is possible that they could receive enough acoustic energy to suffer PTS. Only these initial exposures resulting in model-estimated PTS exposures are expected to actually occur. The remaining model-estimated PTS exposures are considered to actually be TTS exposures due to avoidance.

6.1.6.3 Predicted Impacts

Table 6-14 through Table 6-17 present the predicted impacts on marine mammals separated between training and testing activities, and between annual and non-annual events. Non-annual events, those events that may only take place a few times over the 5-year period and do not reoccur every year, are considered separately because these impacts would not be assessed each year. These predicted effects are the result of the acoustic analysis, including acoustic effect modeling followed by consideration of animal avoidance of multiple exposures, avoidance of areas with high level of activity by sensitive species, and mitigation.

It is important to note that acoustic impacts presented in Table 6-14 through Table 6-17 are the total number of harassments and not necessarily the number of individuals harassed. As discussed in Section 6.1.5.3 (Navy Acoustic Effects Model), an animal could be predicted to receive more than one acoustic impact over the course of a year.

Table 6-14. Predicted Impacts per Year from Annually Recurring Sonar and Other Active Acoustic Training Activities

Species	Behavioral Reaction	TTS	PTS
Mysticetes			
Blue Whale*	50	97	0
Bryde's Whale	326	629	0
Minke Whale	19,497	40,866	10
Fin Whale*	1,608	2,880	1
Humpback Whale*	514	1,128	1
North Atlantic Right Whale*	51	60	0
Sei Whale*	3,582	6,604	1
Odontocetes – Delphinids			
Atlantic Spotted Dolphin	161,590	15,781	0
Atlantic White-Sided Dolphin	30,014	1,183	0
Bottlenose Dolphin	260,189	24,116	0
Clymene Dolphin	17,929	1,655	0
Common Dolphin	429,199	35,731	0
False Killer Whale	653	60	0
Fraser's Dolphin	2,044	161	0
Killer Whale	12,984	1,069	0
Melon-headed Whale	19,216	1,659	0
Pantropical Spotted Dolphin	64,668	6,291	0
Pilot Whale	94,552	6,672	0
Pygmy Killer Whale	1,364	123	0
Risso's Dolphin	220,716	17,779	0
Rough-toothed Dolphin	964	94	0
Spinner Dolphin	18,396	2,015	0
Striped Dolphin	206,688	17,593	0
White-Beaked Dolphin	1,547	44	0
Odontocetes – Sperm Whales			
Sperm Whale*	14,311	435	0
Odontocetes – Beaked Whales			
Blainville's Beaked Whale	27,991	187	0
Cuvier's Beaked Whale	34,698	196	0
Gervais' Beaked Whale	28,020	233	0
Northern Bottlenose Whale	18,320	36	0
Sowerby's Beaked Whale	9,907	56	0
True's Beaked Whale	16,637	73	0
Odontocetes – *Kogia* Species and Porpoises			
Dwarf and Pygmy Sperm Whales (*Kogia* species)	169	4,914	13
Harbor Porpoise	120,895	20,161	62
Phocid Seals			
Bearded Seal	0	0	0
Gray Seal	35	0	0
Harbor Seal	37	0	0
Harp Seal	0	0	0
Hooded Seal	5	0	0
Ringed Seal**	0	0	0

* ESA-Listed Species; ** ESA-proposed; PTS: permanent threshold shift; TTS: temporary threshold shift.

Table 6-15. Predicted Impacts per Year from Annually Recurring Sonar and Other Active Acoustic Testing Activities

Species	Behavioral Reaction	TTS	PTS
Mysticetes			
Blue Whale*	6	10	0
Bryde's Whale	21	39	0
Minke Whale	3,100	3,571	1
Fin Whale*	282	263	0
Humpback Whale*	100	94	0
North Atlantic Right Whale*	66	11	0
Sei Whale*	316	439	0
Odontocetes – Delphinids			
Atlantic Spotted Dolphin	12,562	7,447	0
Atlantic White-Sided Dolphin	7,776	2,164	0
Bottlenose Dolphin	16,488	11,760	0
Clymene Dolphin	1,302	695	0
Common Dolphin	28,764	16,913	0
False Killer Whale	60	37	0
Fraser's Dolphin	98	57	0
Killer Whale	921	486	0
Melon-headed Whale	767	590	0
Pantropical Spotted Dolphin	3,916	3,679	0
Pilot Whale	10,343	4,370	0
Pygmy Killer Whale	67	50	0
Risso's Dolphin	14,693	7,614	0
Rough-toothed Dolphin	70	50	0
Spinner Dolphin	1,799	786	0
Striped Dolphin	12,208	6,784	0
White-Beaked Dolphin	1,335	302	0
Odontocetes – Sperm Whales			
Sperm Whale*	1,101	584	0
Odontocetes – Beaked Whales			
Blainville's Beaked Whale	4,595	107	0
Cuvier's Beaked Whale	5,943	139	0
Gervais' Beaked Whale	4,526	130	0
Northern Bottlenose Whale	11,946	132	0
Sowerby's Beaked Whale	2,617	43	0
True's Beaked Whale	3,068	41	0
Odontocetes – *Kogia* Species and Porpoises			
Dwarf and Pygmy Sperm Whales (*Kogia* species)	29	1,061	5
Harbor Porpoise	1,964,774	78,250	99
Phocid Seals			
Bearded Seal	31	1	0
Gray Seal	1,874	828	7
Harbor Seal	1,703	5,833	62
Harp Seal	2,275	791	4
Hooded Seal	251	35	0
Ringed Seal**	355	4	0

* ESA-Listed Species; ** ESA-proposed; PTS: permanent threshold shift; TTS: temporary threshold shift.

Table 6-16. Predicted Impacts per Event for Sonar and Other Active Acoustic Sources Used in the Biennial Training Activity, Civilian Port Defense

Species	Behavioral Reaction	TTS	PTS
Mysticetes			
Blue Whale*	0	0	0
Bryde's Whale	0	0	0
Minke Whale	0	0	0
Fin Whale*	0	0	0
Humpback Whale*	0	0	0
North Atlantic Right Whale*	0	0	0
Sei Whale*	0	0	0
Odontocetes – Delphinids			
Atlantic Spotted Dolphin	149	1	0
Atlantic White-Sided Dolphin	20	0	0
Bottlenose Dolphin	345	6	0
Clymene Dolphin	1	0	0
Common Dolphin	24	0	0
False Killer Whale	0	0	0
Fraser's Dolphin	0	0	0
Killer Whale	1	0	0
Melon-headed Whale	0	0	0
Pantropical Spotted Dolphin	3	0	0
Pilot Whale	10	0	0
Pygmy Killer Whale	0	0	0
Risso's Dolphin	11	0	0
Rough-toothed Dolphin	1	0	0
Spinner Dolphin	1	0	0
Striped Dolphin	7	0	0
White-Beaked Dolphin	19	0	0
Odontocetes – Sperm Whale			
Sperm Whale*	1	0	0
Odontocetes – Beaked Whales			
Blainville's Beaked Whale	1	0	0
Cuvier's Beaked Whale	1	0	0
Gervais' Beaked Whale	2	0	0
Northern Bottlenose Whale	2	0	0
Sowerby's Beaked Whale	1	0	0
True's Beaked Whale	1	0	0
Odontocetes – *Kogia* Species and Porpoises			
Dwarf and Pygmy Sperm Whales (*Kogia* species)	0	1	0
Harbor Porpoise	725	432	0
Phocid Seals			
Gray Seal	47	0	0
Harbor Seal	43	0	0
Harp Seal	4	0	0
Hooded Seal	0	0	0

* ESA-Listed Species; ** ESA-proposed; PTS: permanent threshold shift; TTS: temporary threshold shift.

Table 6-17. Predicted Impacts for Nonannual Sonar and Other Active Acoustic Source Testing Activities Involving Unmanned Underwater Vehicle Demonstrations Occurring Once per 5-Year Period at Each Location: Naval Surface Warfare Center, Panama City Division Testing Range; South Florida Ocean Measurement Facility; and Naval Undersea Warfare Center Division, Newport Testing Range

Species	NSWC PCD			SFOMF			NUWCDIVNPT		
	Behavioral Reaction	TTS	PTS	Behavioral Reaction	TTS	PTS	Behavioral Reaction	TTS	PTS
Mysticetes									
Blue Whale*	0	1	0	0	1	0	0	0	0
Bryde's Whale	0	1	0	0	3	0	0	0	0
Minke Whale	23	469	1	3	342	0	6	191	1
Fin Whale*	2	30	0	0	2	0	0	14	0
Humpback Whale*	0	2	0	0	2	0	0	1	0
North Atlantic Right Whale*	0	0	0	0	0	0	0	10	0
Sei Whale*	1	14	0	0	18	0	0	1	0
Odontocetes – Delphinids									
Atlantic Spotted Dolphin	52	1,753	0	7	1,168	0	5	190	0
Atlantic White-Sided Dolphin	2	38	0	0	0	0	7	190	0
Bottlenose Dolphin	87	2,731	0	14	1,926	0	13	419	0
Clymene Dolphin	7	157	0	0	10	0	0	0	0
Common Dolphin	74	2,362	0	13	2,622	0	6	145	0
False Killer Whale	0	9	0	0	3	0	0	0	0
Fraser's Dolphin	0	6	0	0	9	0	0	0	0
Killer Whale	2	61	0	1	59	0	0	5	0
Melon-headed Whale	2	51	0	0	73	0	0	0	0
Pantropical Spotted Dolphin	21	261	0	1	55	0	0	0	0
Pilot Whale	12	351	0	3	385	0	6	120	0
Pygmy Killer Whale	0	4	0	0	11	0	0	0	0
Risso's Dolphin	36	1,111	0	6	723	0	2	77	0
Rough-toothed Dolphin	0	6	0	0	11	0	0	0	0
Spinner Dolphin	17	169	0	1	70	0	0	0	0
Striped Dolphin	20	443	0	4	604	0	1	22	0
White-Beaked Dolphin	0	0	0	0	0	0	9	171	0

Table 6-17. Predicted Impacts for Nonannual Sonar and Other Active Acoustic Source Testing Activities Involving Unmanned Underwater Vehicle Demonstrations Occurring Once per 5-Year Period at Each Location: Naval Surface Warfare Center, Panama City Division Testing Range; South Florida Ocean Measurement Facility; and Naval Undersea Warfare Center, Division Newport Testing Range (Continued)

Species	NSWC PCD			SFOMF			NUWCDIVNPT		
	Behavioral Reaction	TTS	PTS	Behavioral Reaction	TTS	PTS	Behavioral Reaction	TTS	PTS
Odontocetes – Sperm Whale									
Sperm Whale	1	27	0	0	52	0	0	3	0
Odontocetes – Beaked Whales									
Blainville's Beaked Whale	10	7	0	16	12	0	3	2	0
Cuvier's Beaked Whale	13	8	0	27	11	0	1	2	0
Gervais' Beaked Whale	29	18	0	36	22	0	1	1	0
Northern Bottlenose Whale	1	1	0	0	0	0	6	6	0
Sowerby's Beaked Whale	21	10	0	0	0	0	4	3	0
True's Beaked Whale	13	5	0	0	0	0	4	2	0
Odontocetes – *Kogia* Species and Porpoises									
Dwarf and Pygmy Sperm Whales (*Kogia* species)	0	48	1	0	17	1	0	0	0
Harbor Porpoise	0	0	0	0	0	0	121,689	17,326	0
Phocid Seals									
Bearded Seal	0	0	0	0	0	0	0	1	0
Gray Seal	0	0	0	0	0	0	22	557	6
Harbor Seal	0	0	0	0	0	0	37	1,083	15
Harp Seal	0	0	0	0	0	0	36	891	10
Hooded Seal	0	0	0	0	0	0	0	7	0
Ringed Seal	0	0	0	0	0	0	0	0	0

* ESA-Listed Species; ** ESA-proposed; PTS: permanent threshold shift; TTS: temporary threshold shift.

NSWC: Naval Surface Warfare Center, Panama City Division Testing Range; SFOMF: South Florida Ocean Measurement Facility; NUWCDIVNPT: Naval Undersea Warfare Center, Division Newport Testing Range.

6.1.6.4 Training Activities

As described in Chapter 1 (Introduction and Description of Activities), training activities that use sonar and other active acoustic sources could occur throughout the Study Area but would be concentrated in VACAPES, Navy Cherry Point, and JAX Range Complexes, with fewer numbers of events in the GOMEX and Northeast Range Complexes. These Navy range complexes are within the Northeast and Southeast U.S. Continental Shelf and Gulf of Mexico Large Marine Ecosystems and the Gulf Stream Open Ocean Area. Model predicted acoustic effects on marine mammals from exposure to sonar and other active acoustic sources for annually recurring training activities is shown in Table 6-14. See Table 6-16 for predicted marine mammal impacts from the mine warfare training activity civilian port defense. This event could take place biennially in any of the following locations: Earle, New Jersey; Groton, Connecticut; Hampton Roads, Virginia; Morehead City, North Carolina; Wilmington, North Carolina; Kings Bay, Georgia; Mayport, Florida; Beaumont, Texas; or Corpus Christi, Texas. Predicted impacts associated with sonar and other active acoustic sources used in these events are very low. This is due to the higher frequencies and lower power of mine detecting sonars (e.g., AN/AQS-20) used in these events. Significant behavioral reactions would be unlikely for most species during these events.

6.1.6.4.1 Mysticetes

As discussed in Section 6.1.6.1 (Range To Effects) for mysticetes (i.e., low-frequency cetaceans), predicted ranges to TTS for hull-mounted sonars (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of several kilometers, whereas some behavioral effects could take place at distances exceeding 100 km (54 nm), although behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

Acoustic effects on mysticetes from annually recurring training activities using sonar and other active acoustic sources are predicted within the JAX Range Complex (approximately 68 percent), followed by VACAPES (approximately 17 percent), Navy Cherry Point (approximately 6 percent), and the Northeast Range Complexes (approximately 3 percent), the GOMEX Range Complex (approximately 3 percent), and outside of OPAREAs and range complexes but within the Study Area (approximately 4 percent).

There are no predicted acoustic impacts on mysticetes from the biennial civilian port defense activities.

About 44 percent of predicted acoustic effects on mysticetes from sonar and other active acoustic sources are due to the major training exercises (composite training unit exercise, and joint task force /sustainment exercise). These major training exercises are multi-day events that transition across large areas and involve multiple anti-submarine warfare assets. These events take place in the VACAPES, Navy Cherry Point, and JAX Range Complexes, and one composite training unit exercise per year could take place within the GOMEX Range Complex. Within the JAX Range Complex, sonar activities could be concentrated on the Undersea Warfare Training Range after it is constructed. Potential acoustic impacts from major training exercises, especially behavioral impacts, could be more pronounced given the duration and scale of the events. Some animals may be exposed multiple times over the course of a few days. Many mysticetes may stop vocalizing, break off feeding dives, or ignore the acoustic stimulus, especially if it is located more than a few kilometers away (Section 6.1.3.5, Behavioral Reactions). Migrating mysticetes may divert around sound sources that are located within their path. More sensitive mysticetes may avoid a major training exercise as it moves through an area, although these activities do not use the same training locations day-after-day during multi-day activities.

Therefore, displaced animals could return quickly after the major training exercise moves away, allowing the animal to recover from any energy expenditure or missed resources.

Training activities involving the coordination of multiple assets include Group Sail, Tactical Development Exercise, southeastern anti-submarine warfare integrated training initiative, and integrated anti-submarine warfare course which are responsible for approximately 10 percent of the predicted impacts on mysticetes. Although smaller in scale and shorter in duration than major training exercises discussed above, these events can still last for a matter of days and transit across large areas of a range complex. The majority of these events take place within the JAX Range Complex, followed by the Navy Cherry Point and VACAPES Range Complexes; however, the integrated anti-submarine warfare course could also take place in the GOMEX Range Complex once per year. Repeated exposures to some individual whales are likely in these events; however, due to the shorter duration and smaller footprint as compared to major training exercises, impacts from these activities are likely to be less pronounced.

The anti-submarine warfare unit level training activities are responsible for approximately 35 percent of the total effects on mysticetes. These events could take place anywhere within the Study Area, but are concentrated with the VACAPES, Navy Cherry Point, and JAX Range Complexes, with fewer number of events taking place within the Northeast and GOMEX Range Complexes. These events often involve the use of a single aircraft or vessel, perhaps participating with an aircraft, but overall activity is limited and lasts for only a few hours over a small area of ocean. Submarine and surface ship sonar maintenance is responsible for about 9 percent of the total predicted acoustic impacts on mysticetes from sonar and other active acoustic sources; however, maintenance events always involve the use of a single system being used in a limited manner either pierside or in the open ocean. These training and maintenance activities are limited in scope and duration. Because of the overall low activity level and short duration of these events, significant behavioral reactions are not expected in most cases and model predicted results are likely an overestimate.

Less than 1 percent of the predicted acoustic effects would be due to surface ship object detection and submarine navigation exercises. All other activities including submarine under ice certification and mine hunting (mine countermeasures–ship sonar and airborne mine countermeasure–mine detection) use high-frequency systems that are not within mysticetes' ideal hearing range, and therefore, predicted numbers of impacts are very low. Section 4.2 (Vocalization and Hearing of Marine Mammals) discusses low-frequency cetaceans (i.e., mysticetes) hearing abilities, and therefore predicted numbers of impacts are very low. It is unlikely that any of the acoustic stressors within these events would cause a significant behavioral reaction to a mysticete.

North Atlantic right whales may be exposed to sonar or other active acoustic stressors associated with training activities throughout the year. Exposures could occur in feeding grounds off the New England coast, on migration routes along the east coast, and on calving grounds in the southeast off the coast of Florida and Georgia. Acoustic modeling predicts that North Atlantic right whales could be exposed to sound that may result in 60 TTS and 51 behavioral reactions per year from annually recurring training activities. The majority of these impacts are predicted within the JAX Range Complex where animals spend winter months calving. All predicted impacts would be to the Gulf of Maine stock because this is the only North Atlantic right whale stock present within the Study Area. In the southeast North Atlantic right whale mitigation area (as discussed in Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), no training activities using sonar or other active acoustic sources would occur with the exception of object detection/navigational sonar training and maintenance activities for surface ships and submarines while entering/exiting ports located in Kings Bay, Georgia (maintenance only), and Mayport, Florida. In addition, training activities involving helicopter dipping sonar would occur off of Mayport, Florida within the right whale mitigation area. The most concentrated densities of North Atlantic right whales are within the migratory corridor, which includes the southeastern North Atlantic right whale mitigation area (i.e., designated critical habitat) at its southern extent. However, the majority of active sonar activities would occur outside the southeast mitigation area. In the northeast North Atlantic right whale mitigation area, hull-mounted sonar would not be used. However, a limited number of torpedo exercises would be conducted in August and September when many North Atlantic right whales have migrated south out of the area. Of course, North Atlantic right whales can be found outside of designated mitigation areas and sound from nearby activities may be detectable within the mitigation areas. Acoustic modeling predictions consider these potential circumstances.

The acoustic analysis predicts that humpback whales could be exposed to sound that may result in 1 PTS, 1,129 TTS and 514 behavioral reactions per year. The majority of these impacts are predicted in the JAX, Navy Cherry Point, VACAPES, and Northeast Range Complexes. All predicted impacts would be to the Gulf of Maine stock because this is the only humpback whale stock present within the Study Area.

The acoustic analysis predicts that sei whales could be exposed to sound that may result in 1 PTS, 6,604 TTS, and 3,582 behavioral reactions per year from annually recurring training activities. The majority of these impacts are predicted in the VACAPES, Navy Cherry Point, and JAX Range Complexes, with a relatively small percent predicted in the GOMEX and Northeast Range Complexes and in areas outside of OPAREAS and range complexes. All predicted impacts would be to the Nova Scotia stock because this is the only sei whale stock present within the Study Area.

The acoustic analysis predicts that fin whales could be exposed to sound that may result in 1 PTS, 2,880 TTS and 1,608 behavioral reactions per year. The majority of these impacts are predicted in the VACAPES, Navy Cherry Point, and JAX Range Complexes, with a relatively small percent of impacts predicted in the GOMEX and Northeast Range Complexes. All predicted impacts would be to the Western North Atlantic stock because this is the only fin whale stock present within the Study Area.

The acoustic analysis predicts that blue whales could be exposed to sound that may result in 97 TTS and 50 behavioral reactions per year. The majority of these impacts are predicted in the VACAPES, Navy Cherry Point, and JAX Range Complexes, with a relatively small percent of impacts predicted in the GOMEX and Northeast Range Complexes. All predicted impacts would be to the Western North Atlantic stock because this is the only blue whale stock present within the Study Area.

The acoustic analysis predicts that Bryde's whales could be exposed to sound that may result in 629 TTS and 326 behavioral reactions. The majority of these impacts are predicted in the VACAPES, Navy Cherry Point, and JAX Range Complexes, with a relatively small percent of effects predicted in the Northeast Range Complex. All predicted effects on Bryde's whales would be to the Gulf of Mexico Oceanic stock because this is the only stock present within the Study Area.

The acoustic analysis predicts that minke whales could be exposed to sound that may result in 10 PTS, 40,866 TTS, and 19,497 behavioral reactions per year. The majority of these impacts are predicted in the VACAPES, Navy Cherry Point, and JAX Range Complexes, with a relatively small percent of effects predicted in the Northeast and GOMEX Range Complexes. All predicted effects on minke whales would be to the Canadian East Coast stock because this is the only stock present within the Study Area.

Research and observations show (Section 6.1.3.5, Behavioral Reactions) that if mysticetes are exposed to sonar or other active acoustic sources 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). Reactions may include alerting, breaking off feeding dives and surfacing, diving or swimming away, or no response at all. Additionally, migrating animals may ignore a sound source, or may divert around the source if it is in their path. In the ocean, the use of sonar and other active acoustic sources is transient and is unlikely to repeatedly expose the same population of animals over a short period. Around heavily trafficked Navy ports and on fixed ranges, the possibility is greater for animals that are resident during all or part of the year to be exposed multiple times to sonar and other active acoustic sources. A few behavioral reactions per year, even from a single individual, are unlikely to produce long-term consequences for that individual or the population.

Animals that do experience a hearing threshold shift may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts. Long-term consequences to populations would not be expected.

6.1.6.4.2 Odontocetes

As discussed in Section 6.1.6.1 (Range to Effects) for mid- and high-frequency cetaceans, ranges to TTS for hull-mounted sonars (e.g., sonar bin MF1; SQS-53 anti-submarine warfare hull-mounted sonar) can be on the order of a few hundred meters for mid-frequency odontocetes (cetaceans), however can stretch to distances of over 10 km for high-frequency cetaceans (i.e., harbor porpoises and dwarf and pygmy sperm whales). Some behavioral impacts could take place at distances exceeding 100 km, especially for more sensitive species such as harbor porpoises and beaked whales, although behavioral effects are much more likely at higher received levels within a few kilometers of the sound source.

The majority of acoustic impacts on odontocetes from annually recurring training activities using sonar and other active acoustic sources under the Proposed Action are predicted within the JAX Range Complex (approximately 59 percent), followed by VACAPES (approximately 21 percent), GOMEX (approximately 7 percent), the Navy Cherry Point Range Complexes (approximately 6 percent), and the Northeast Range Complexes (approximately 3 percent). The remaining impacts (approximately 4 percent) are predicted within areas outside of OPAREAS and range complexes but within the Study Area.

About 44 percent of predicted acoustic impacts on odontocetes from annually recurring sonar and other active acoustic sources are due to composite training unit exercise (up to five per year) and joint task force/sustainment exercise (up to four per year). These major training exercises are multi-day events that transition large areas and involve multiple anti-submarine warfare assets as described above under Mysticetes. More sensitive species of odontocetes such as beaked whales, harbor porpoises, and dwarf and pygmy sperm whales may avoid the area for the duration of the event (Section 6.1.2.5, Behavioral Reactions). Displaced animals would likely return after the major training exercise subsides within an area as seen in the Bahamas study with Blainville's beaked whales (Tyack et al. 2011).

Training activities involving the coordination of multiple assets include Group Sail, Tactical Development Exercise, southeastern anti-submarine warfare integrated training initiative, and integrated anti-submarine warfare course, which are responsible for approximately 10 percent of the predicted impacts on odontocetes from annually recurring activities. Although smaller in scale and shorter in duration than major training exercises discussed above, these events can still last for a matter of days and cover large parts of a range complex as described above for mysticetes. Repeated exposures to some individual animals are likely in these events; however, due to the shorter duration and smaller footprint as compared to major training exercises, impacts from these activities are likely to be less severe.

The anti-submarine warfare unit level training activities are responsible for approximately 29 percent of the total impacts on odontocetes from annually recurring activities. These events often involve the use of a single aircraft or vessel, perhaps participating with an aircraft, but overall activity is limited and lasts for only a few hours over a small area of ocean as described above for mysticetes. These training activities are very limited in scope and duration. Because of the overall low activity level and short duration of these events, significant behavioral reactions are not expected in most cases. Long-term consequences for individuals or populations would not be expected.

Approximately 8 percent of the predicted acoustic effects from annually recurring activities would be due to surface ship object detection and submarine navigation exercises. These events involve the use of a single surface ship or submarine in the ocean, and entering and leaving port as described above for mysticetes. Submarine and surface ship sonar maintenance is responsible for about 9 percent of the total predicted acoustic impacts on odontocetes from annually recurring sonar and other active acoustic sources; however, maintenance events always involve the use of a single system being used in a limited manner either pierside or in the open ocean as described above for mysticetes. Because of the very low activity level and short duration of these events and because many of these events are proposed in high-use ports, significant behavioral reactions are not expected in most cases. Long-term consequences for individuals or populations would not be expected.

All other annually recurring training activities including mine hunting (mine countermeasures-ship sonar and airborne mine countermeasure - mine detection) are responsible for less than 1 percent of the total predicted acoustic effects on odontocetes from the use of sonar and other active acoustic sources. It is unlikely that any of the acoustic stressors within these events would cause significant behavioral reactions in odontocetes because the few predicted impacts are dispersed in time and space. Long-term consequences for individuals or populations would not be expected.

Predicted acoustic impacts from the biennial training activity, civilian port defense, would be a maximum of 1,326 behavioral reactions and 440 TTS per event. Approximately half of the behavioral reactions and most of the TTS are predicted for harbor porpoises due to their lower thresholds for acoustic impacts, and the fact that they are numerous in some of the nearshore areas proposed for the civilian port defense activity.

The acoustic analysis predicts that sperm whales could be exposed to sound that may result in 435 TTS and 14,311 behavioral reactions annually from annually recurring training activities; and a maximum of one behavioral reactions from each biennial training activity civilian port defense. Research and observations (Section 6.1.3.5, Behavioral Reactions) show that if sperm whales are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sperm whales have shown resilience to acoustic and human disturbance, although they may react to sound sources and activities within a few kilometers. Sperm whales that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, avoid the area by swimming away or diving, or display aggressive behavior. Long-term consequences for individuals or populations would not be expected. Sperm whales within the Study Area belong to one of three stocks: North Atlantic; Gulf of Mexico Oceanic; or Puerto Rico and U.S. Virgin Islands. Predicted effects on sperm whales within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico Oceanic stock, whereas the majority of impacts predicted offshore of the east coast would impact the North Atlantic stock.

The acoustic analysis predicts that delphinids (17 species total) could be exposed to sound that may result in 132,026 TTS and 1,542,713 behavioral reactions annually from annually recurring training activities; and a maximum of 7 TTS and 592 behavioral reactions from each biennial training activity civilian port defense. Research and observations (Section 6.1.3.5, Behavioral Reactions) show that if delphinids are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Delphinids may not react at all until the sound source is approaching within a few hundred meters to within a few kilometers depending on the species. Delphinids that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, change their behaviors or vocalizations, avoid the sound source by swimming away or diving, or be attracted to the sound source. Long-term consequences to individual delphinids or populations are not likely due to exposure to sonar or other active acoustic sources. Most delphinid species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico. Predicted effects on delphinids within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks. Bottlenose dolphins are divided into one Oceanic and many Coastal stocks along the east coast. The majority of exposures to bottlenose dolphins are likely to the Oceanic stock with the exception of nearshore and in-port events that could expose animals in Coastal stocks.

The acoustic analysis predicts that beaked whales (six species total) could be exposed to sound that may result in 781 TTS and 135,573 behavioral reactions per year from annually recurring training activities; and a maximum of 8 behavioral reactions from each biennial training activity civilian port defense. Research and observations (Section 6.1.3.5, Behavioral Reactions) show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels of 157 dB re 1 µPa, or below (McCarthy et al. 2011). Furthermore, in research done at the Navy's fixed tracking range in the Bahamas, animals leave the immediate area of the anti-submarine warfare training exercise but return within a few days after the event ends. Populations of beaked whales and other odontocetes on the Bahamas, and other Navy fixed ranges that have been operating for tens of years, appear to be stable (Section 6.1.6.5, Marine Mammal Monitoring during Navy Training). 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) because this is one of the most sensitive marine mammal groups to anthropogenic sound of any species or group studied to date. Most beaked whale species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico. Predicted effects on beaked whales within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks.

Based on the best available science, the Navy believes that beaked whales that exhibit a significant behavioral reaction due to sonar and other active acoustic training 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.” Therefore, the Navy is requesting 10 serious injury or mortality takes for beaked whale species over the 5-year LOA period This approach overestimates the potential effects on marine mammals associated with Navy sonar training in the Study Area, as no mortality or serious injury of any species is anticipated. This request will be made even though almost 40 years of conducting similar exercises without observed incident in the operating environments represented in the Study Area indicate that injury, strandings, and mortality are not expected to occur as a result of Navy activities. Neither NMFS nor the Navy anticipates 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.

The acoustic analysis predicts that pygmy and dwarf sperm whales could be exposed to sound that may result in 13 PTS, 4,914 TTS, and 169 behavioral reactions from annually recurring training activities; and a maximum of 1 TTS from the biennial training activity civilian port defense. The majority of predicted impacts on these species are within the JAX and GOMEX Range Complexes. Research and observations (Section 6.1.3.5, Behavioral Reactions) on *Kogia* species are limited. However, these species tend to avoid human activity and presumably anthropogenic sounds. Pygmy and dwarf sperm whales may startle and leave the immediate area of the anti-submarine warfare training exercise. Significant behavioral reactions seem more likely than with most other odontocetes, however it is unlikely that animals would receive multiple exposures over a short time period allowing animals time to recover lost resources (e.g., food) or opportunities (e.g., mating). Therefore, long-term consequences for individual *Kogia* or their respective populations are not expected. Pygmy and dwarf sperm whales are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico Oceanic. Predicted effects within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks.

The acoustic analysis predicts that harbor porpoises could be exposed to sound that may result in 62 PTS, 20,161 TTS, and 120,895 behavioral reactions from annually recurring training activities; and a maximum of 432 TTS and 725 behavioral reactions from the biennial training activity civilian port defense. Predicted impacts on these species are within the VACAPES and Northeast Range Complexes primarily within inland waters and along the Northeast U.S. Continental Shelf Large Marine Ecosystem. Research and observations (Section 6.1.3.5, Behavioral Reactions) of harbor porpoises show that this small species is very wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. This level was determined by observing harbor porpoise reactions to acoustic deterrent and harassment devices used to drive away animals from around fishing nets and aquaculture facilities. Avoidance distances typically were about 1 kilometer or more, but it is unknown if animals would react similarly if the sound source were located at a great distance of tens or hundreds of kilometers. The behavioral response function is not used to estimate behavioral responses by harbor porpoises; rather, a single threshold is used. Because of this very low behavioral thhroshold (120 dB re 1 µPa) for harbor porpoises, animals at distances exceeding 200 km in some cases are predicted to have a behavioral reaction in this acoustic analysis. It is not known whether animals would actually react to sound sources at these ranges, regardless of the received sound level. Harbor porpoises may startle and leave the immediate area of the anti-submarine warfare training exercise, but return within a few days after the cessation of the event. Significant behavioral reactions seem more likely than with most other odontocetes. Since these species are typically found in nearshore and inshore habitats, animals that are resident during all or part of the year near Navy ports or fixed ranges could receive multiple exposures over a short period and throughout the year. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs reducing the likelihood of long-term consequences for the individual or population. All harbor porpoises within the Study Area belong to the Gulf of Maine/Bay of Fundy Stock and therefore all predicted impacts would be incurred to this stock.

Odontocetes that do experience a hearing threshold shift (i.e., PTS or TTS) may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts. Long-term consequences to populations would not be expected.

6.1.6.4.3 Phocid Seals

Predicted effects on pinnipeds from annual training activities under the Proposed Action from sonar and other active acoustic sources indicate that three species of phocid seals (i.e., gray, harbor, and hooded seals) could be exposed to sound that may result in ~~1 PTS and~~ 77 behavioral reactions per year from annually recurring training activities and a maximum of 94 behavioral reactions per event for the biennial training activity, civilian port defense. These predicted impacts would happen almost entirely within the Northeast Range Complexes.

Predicted effects on phocid seals are primarily from submarine sonar maintenance (approximately 60 percent) occurring within the Northeast Range Complexes. Approximately 37 percent of predicted impacts on phocid seals are due to tracking and torpedo exercises involving anti-submarine warfare hull-mounted sonar occurring within the Northeast Range Complexes. Approximately 2 percent of predicted impacts on phocid seals are due to submarine navigational exercises transiting in an out of port in Norfolk, Virginia. As discussed in Section 6.1.6.1 (Range to Effects), ranges to TTS for hull-mounted sonars (e.g., sonar bin MF1; SQS-53) can be on the order of a several kilometers for phocid seals. Some behavioral effects could hypothetically take place at distances exceeding 100 km, although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Bearded and ringed seals are rare in the Study Area and would generally not occur in areas proposed for training activities that use sonar and other active acoustic sources. The acoustic model predicted no exposures to these two species.

Effects within these complexes are predicted to occur mostly within the Northeast U.S. Continental Shelf Large Marine Ecosystem, with some effects predicted for the Gulf Stream Open Ocean Area. The hooded, gray, and harbor seals are all part of their species' respective Western North Atlantic stocks. Therefore, all predicted exposures to pinnipeds are associated with the species' single stock represented within the Study Area.

Research and observations (Section 6.1.3.5, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources, 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. Seals 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 seals or populations are unlikely.

Animals that do experience a hearing threshold shift may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts. Long-term consequences to populations would not be expected.

6.1.6.4.4 Conclusion

Training activities under the Proposed Action include the use of sonar and other active acoustic sources as described in Chapter 1, Introduction and Description of Activities. These activities do not overlap bowhead whale, beluga whale, or narwhal habitat. Therefore, it is very unlikely that these marine mammal species would be exposed to noise associated with these stressors.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for training activities

- *may expose marine mammals 2,049,947 times annually and 10,249,735 times over a 5-year period to sound levels that would be considered Level B harassment.*
- *may expose marine mammals 88 times annually and 440 times over a 5-year period to sound levels that would be considered Level A harassment.*

- *may expose marine mammals up to 1,860 times during each biennial civilian port defense activity and 5,580 times over a 5-year period due to civilian port defense activities to sound levels that would be considered Level B harassment.*
- *would not expose marine mammals during civilian port defense activities to sound levels that would be considered Level A harassment .*
- *may expose up to 10 beaked whales per year and no more than 10 beaked whales in a 5-year period to sound levels that may elicit stranding and subsequent serious injury or mortality.*

6.1.6.5 Testing Activities

As described in Chapter 1 (Introduction and Description of Activities), testing activities under the Proposed Action include activities that use sonar and other active acoustic sources which produce underwater sound. These activities would be concentrated in the Northeast Range Complexes, Rhode Island inland waters, the GOMEX Range Complex, and the Naval Surface Warfare Center, Panama City Division Testing Range. VACAPES, JAX, and Key West Range Complexes also host a significant number of testing activities. Within these range complexes, activities involving the use of sonar and other active acoustic sources are concentrated on the Northeast U.S. Continental Shelf and Gulf of Mexico Large Marine Ecosystems and the Gulf Stream Open Ocean Area.

Predicted acoustic effects on marine mammals from exposure to sonar and other active acoustic sources for annually recurring testing activities under the Proposed Action are shown in Table 6-15. Unmanned underwater vehicle demonstrations would be conducted under the Proposed Action no more than once per 5-year period at each location: Naval Surface Warfare Center, Panama City Division Testing Range; Naval Undersea Warfare Center Division, Newport Testing Range; and the South Florida Ocean Measurement Facility near Fort Lauderdale. Model predicted impacts for these nonrecurring activities (i.e., do not happen annually, but once over the 5-year period) are shown in Table 6-17.

6.1.6.5.1 Mysticetes

Predicted impacts on mysticetes from annual testing activities under the Proposed Action from sonar and other active acoustic sources in the Northeast Range Complexes and testing ranges (about 40 percent) are primarily from submarine sonar maintenance, countermeasures testing, torpedo (non-explosive) testing, anti-submarine warfare sonar, and unmanned underwater vehicle testing. Testing activities at Naval Surface Warfare Center, Panama City Division Testing Range and the GOMEX Range Complex are responsible for approximately 12 percent of predicted impacts on mysticetes, with most impacts due to unmanned underwater vehicle testing, anti-submarine sonar testing, mine warfare testing, and torpedo (non-explosive) testing. Testing activities in the VACAPES, Navy Cherry Point, and JAX Range Complexes are responsible for about 42 percent of the predicted impacts on mysticetes, with most impacts due to submarine sonar testing and maintenance, anti-submarine warfare sonar testing, countermeasure testing, ship qualification trials, and torpedo (non-explosive) testing. Remaining predicted effects from sonar and other active acoustic sources to mysticetes (approximately 6 percent) are due to pierside integrated swimmer defense in inland waters at Joint Expeditionary Base Little Creek-Fort Story; unmanned underwater vehicle testing within inland waters near Naval Undersea Warfare Center Division, Newport Testing Range; surface testing at South Florida Ocean Measurement Facility; and sonobuoy lot acceptance testing and special warfare testing in Key

West Range Complex. All other testing activities under the Proposed Action do not have model predicted effects on mysticetes from sonar or other active acoustic sources.

North Atlantic right whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year especially in feeding grounds off the New England coast. The acoustic analysis predicts that North Atlantic right whales could be exposed to sound that may result in 11 TTS and 66 behavioral reactions per year as a result of annually recurring testing activities. These impacts are predicted in Rhode Island inland waters and within the Northeast Range Complexes. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 10 TTS in the Northeast Range Complexes once over the 5-year period. All predicted effects would be to the Western North Atlantic stock because this is the only North Atlantic right whale stock present within the Study Area.

The acoustic analysis predicts that humpback whales could be exposed to sound that may result in 94 TTS and 100 behavioral reactions per year as a result of annually recurring testing activities. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 5 TTS once over the 5-year period, primarily at Naval Surface Warfare Center, Panama City Division Testing Range. All predicted impacts would be to the Gulf of Maine stock because this is the only humpback whale stock present within the Study Area.

The acoustic analysis predicts that sei whales could be exposed to sound that may result in 439 TTS and 316 behavioral reactions per year as a result of annually recurring testing activities. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 33 TTS and 1 behavioral reaction over the 5-year period for, primarily at Naval Surface Warfare Center, Panama City Division Testing Range. All predicted impacts would be to the Nova Scotia stock because this is the only sei whale stock present within the Study Area.

The acoustic analysis predicts that fin whales could be exposed to sound that may result in 263 TTS and 282 behavioral reactions per year as a result of annually recurring testing activities. The majority of these impacts are predicted within the Northeast Range Complexes with lesser impacts in the VACAPES, Navy Cherry Point, JAX, and GOMEX Range Complexes. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 46 TTS and 2 behavioral reactions over the 5-year period, primarily at Naval Surface Warfare Center, Panama City Division Testing Range. All predicted impacts would be to the Western North Atlantic stock because this is the only fin whale stock present within the Study Area.

Blue whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The acoustic analysis predicts that 10 TTS and 6 behavioral reactions may result from annual testing activities that use sonar and other active acoustic sources per year as a result of annually recurring testing activities. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 2 TTS over the 5-year period. All predicted impacts would be to the Western North Atlantic stock because this is the only blue whale stock present within the Study Area.

The acoustic analysis predicts that Bryde's whale could be exposed to sound that may result in 39 TTS and 21 behavioral reactions per year as a result of annually recurring testing activities. Nonrecurring unmanned underwater vehicle demonstrations could expose Bryde’s whales to 4 TTS over the 5-year period. All predicted effects on Bryde's whales would be to the Gulf of Mexico Oceanic stock because this is the only stock present within the Study Area.

The acoustic analysis predicts that minke whales could be exposed to sound that may result in 1 PTS, 3,571 TTS, and 3,100 behavioral reactions per year as a result of annually recurring testing activities. Nonrecurring unmanned underwater vehicle demonstrations could expose minke to sound that may result in 2 PTS, 1,002 TTS and 32 behavioral reactions over the 5-year period. All predicted effects on minke whales would be to the Canadian East Coast stock because this is the only stock present within the Study Area.

Research and observations show that if mysticetes are exposed to sonar or other active acoustic sources 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). Reactions may include alerting, breaking off feeding dives and surfacing, diving or swimming away, or no response at all. Additionally, migrating animals may ignore a sound source, or divert around the source if it is in their path. In the ocean, the use of sonar and other active acoustic sources is transient and is unlikely to repeatedly expose the same population of animals over a short period. Around heavily trafficked Navy ports and on fixed ranges, the possibility is greater for animals that are resident during all or part of the year to be exposed multiple times to sonar and other active acoustic sources. A few behavioral reactions per year, even from a single individual, are unlikely to produce long-term consequences for that individual or the population. Furthermore, mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts.

Animals that do experience a hearing threshold shift may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations until their hearing recovers. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts. Long-term consequences to populations would not be expected.

6.1.6.5.2 Odontocetes

Predicted effects on odontocetes from annual testing activities using sonar and other active acoustic sources are primarily (approximately 91 percent) to harbor porpoises within the Northeast and VACAPES Range Complexes within the Northeast U.S. Continental Shelf Large Marine Ecosystem.

Many testing events involve the use of a single sound source and have low levels of activity overall. More sensitive odontocetes (e.g., harbor porpoise, beaked whales, and pygmy and dwarf sperm whales) may avoid the area for the duration of the testing event. Because of the limited scope and duration of most testing events, significant behavioral reactions are not expected in most cases and model predicted results are likely an overestimate.

Sperm whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The acoustic analysis predicts that sperm whales could be exposed to sound that may result in 584 TTS and 1,101 behavioral reactions per year from annually recurring activities. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 82 TTS and one behavioral reaction over the 5-year period. Research and observations (Section 6.1.3.5, Behavioral Reactions) show that if sperm whales are exposed to sonar or other active acoustic sources they may react in a variety of ways, depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Sperm whales have shown resilience to acoustic and human disturbance, although they may react to sound sources and activities within a few kilometers. Sperm whales that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, avoid the area by swimming away or diving, or display aggressive behavior. Long-term consequences to the individual or population are not expected. Sperm whales within the Study Area belong to one of three stocks: North Atlantic; Gulf of Mexico Oceanic; or Puerto Rico and U.S. Virgin Islands. Predicted impacts on sperm whales within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico Oceanic stock, whereas the majority of impacts predicted offshore of the east coast would impact the North Atlantic stock.

Delphinids (dolphins and small whales) may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The acoustic analysis predicts that delphinids (17 species total) could be exposed to sound that may result in 63,784 TTS and 113,169 behavioral reactions per year from annually recurring activities. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 18,581 TTS and 431 behavioral reactions over the 5-year period. Research and observations (Section 6.1.3.5, Behavioral Reactions) show that if delphinids are exposed to sonar or other active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Delphinids may not react at all until the sound source is approaching within a few hundred meters to within a few kilometers depending on the species. Delphinids that are exposed to activities that involve the use of sonar and other active acoustic sources may alert, ignore the stimulus, change their behaviors or vocalizations, avoid the area by swimming away or diving, or be attracted to the sound source. Long-term consequences on individual delphinids or populations are not likely due to exposure to sonar or other active acoustic sources. Most delphinid species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico. Predicted effects on delphinids within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks. Bottlenose dolphins are divided into multiple coastal and one oceanic stock along the east coast. The majority of exposures to bottlenose dolphins are likely to the oceanic stock with the exception of nearshore and in-port events that could expose coastal animals.

Beaked whales may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The acoustic analysis predicts that beaked whales (six species total) could be exposed to sound that may result in 592 TTS and 32,695 behavioral reactions per year from annually recurring activities. The majority of these impacts happen within the Northeast Range Complexes, with lesser effects in the VACAPES, Navy Cherry Point, JAX, Key West and GOMEX Range Complexes. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 110 TTS and 185 behavioral reactions over the 5-year period. Research and observations (Section 6.1.3.5, Behavioral Reactions) show that if beaked whales are exposed to sonar or other active acoustic sources they may startle, break off feeding dives, and avoid the area of the sound source to levels below 157 dB re 1 µPa (McCarthy et al. 2011). Significant behavioral reactions seem likely in most cases if beaked whales are exposed to sonars within a few tens of kilometers, especially for prolonged periods (a few hours or more) because this is one of the most sensitive marine mammal groups to anthropogenic sound of any species or group studied to date. Most beaked whale species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico. Predicted effects on beaked whales within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks.

Pygmy and dwarf sperm whales (genus *Kogia*) may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year. The acoustic analysis predicts that pygmy and dwarf sperm whales could be exposed to sound that may result in 5 PTS, 1,061 TTS and 29 behavioral reactions per year from annually recurring activities. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 2 PTS and 65 TTS over the 5-year period. Research and observations (Section 6.1.3.5, Behavioral Reactions) on *Kogia* species are limited, however these species tends to avoid human activity and presumably anthropogenic sounds. Pygmy and dwarf sperm whales may startle and leave the immediate area of the testing exercise, but return within a few days after the end of the event. Significant behavioral reactions seem more likely than with most other odontocetes, however it is unlikely that animals would receive multiple exposures over a short time period. Those that do exhibit a significant behavioral reaction may recover from any incurred costs, reducing the likelihood of long-term consequences for the individual or population. *Kogia* species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico Oceanic. Predicted effects on pygmy and dwarf sperm whales within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks.

Harbor porpoises may be exposed to sonar or other active acoustic stressors associated with testing activities throughout the year under the Proposed Action. The acoustic analysis indicates that harbor porpoises could be exposed in annual testing activities to level of sonar and other active acoustic source sound resulting in 99 PTS, 78,250 TTS, and 1,964,774 behavioral responses per year from annually recurring activities. Almost all effects on harbor porpoises due to sonar and other active acoustic stressors proposed for use in testing activities would occur within the Northeast Range Complexes with lesser exposures within the VACAPES Range Complex. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 17,326 TTS and 121,689 behavioral reactions over the 5-year period. Research and observations (Section 6.1.3.5, Behavioral Reactions) of harbor porpoises show that this small species is very wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. This level was determined by observing harbor porpoise reactions to acoustic deterrent and harassment devices used to drive away animals from around fishing nets and aquaculture facilities. Avoidance distances typically were on the order of a kilometer or more, but it is unknown if an animals would react similarly if the sound source was located at a great distance of tens or hundreds of kilometers. The behavioral response function is not used to estimate behavioral responses by harbor porpoises; rather, a single threshold is used. Because of this very low behavioral response threshold (120 dB re 1 µPa) for harbor porpoises, in some cases animals at distances exceeding 200 km are predicted to have a behavioral reaction in this acoustic analysis. Since a large proportion of testing activities happen within harbor porpoise habitat in the northeast, predicted effects on this species are relatively greater than predicted effects for other marine mammals. Nevertheless, it is not known whether or not animals would actually react to sound sources at these ranges, regardless of the received sound level. Harbor porpoises may startle and leave the immediate area of the testing event, but may return after the end of the event. Significant behavioral reactions seem more likely than with most other odontocetes, especially at closer ranges (within a few kilometers). Since these species are typically found in nearshore and inshore habitats, animals that are resident during all or part of the year near Navy ports or fixed ranges in the northeast could receive multiple exposures over a short time period and throughout the year. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs reducing the likelihood of long-term consequences for the individual or population. All harbor porpoises within the Study Area belong to the Gulf of Maine/Bay of Fundy Stock and therefore all predicted impacts would be incurred to this stock.

Odontocetes that do experience hearing loss (PTS or TTS) may have reduced ability to detect relevant sounds such as predators, prey, or social vocalizations. Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts. Long-term consequences for the population would not be expected.

6.1.6.5.3 Phocid Seals

Predicted effects for annual testing activities from sonar and other active acoustic sources indicate that phocid seals could be exposed to sound that may result in 73 PTS, 7,492 TTS, and 6,489 behavioral reactions per year; these impacts happen almost entirely within the Northeast Range Complexes and adjacent testing ranges. Nonrecurring unmanned underwater vehicle demonstrations could expose animals to sound that may result in 31 PTS, 2,539 TTS, and 95 behavioral reactions over the 5-year period at Naval Undersea Warfare Center Division, Newport Testing Range.

Research and observations (Section 6.1.3.5, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If seals are exposed to sonar or other active acoustic sources they 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 seals or populations are unlikely.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11

(Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts.

6.1.6.5.4 Conclusion

Testing activities under the Proposed Action include the use of sonar and other active acoustic sources as described in Chapter 1, Introduction and Description of Activities. These activities do not overlap bowhead whale, beluga whale, or narwhal habitat. Therefore, it is very unlikely that these marine mammal species would be exposed to sound associated with these stressors.

Pursuant to the MMPA, the use of sonar and other active acoustic sources for testing activities

- *may expose marine mammals up to 2,278,338 times annually and 11,391,690 times over a 5-year period to sound levels that would be considered Level B harassment.*
- *may expose marine mammals up to 178 times annually and 890 times over a 5-year period to sound levels that would be considered Level A harassment.*
- *may expose marine mammals up to 162,241 times over a 5-year period associated with unmanned underwater vehicle demonstrations to sound levels that would be considered Level B harassment.*
- *may expose marine mammals up to 35 times over a 5-year period associated with unmanned underwater vehicle demonstrations to sound levels that would be considered Level A harassment.*

6.1.7 IMPACTS FROM EXPLOSIONS

Explosive detonations during training and testing activities are associated with high-explosive ordnance (including bombs, missiles, torpedoes, and naval gun shells), mines, demolition charges, explosive sonobuoys, and ship shock trial charges. Most explosive detonations during training and testing would be in the air or near the water surface, although there are exceptions, such as charges associated with mine neutralization near the ocean bottom and charges associated with torpedoes or ship shock trials in the water column. Most detonations would occur in waters greater than 200 ft. (61 m) in depth and greater than 3 nm from shore, although mine warfare, demolition, and some testing detonations could occur closer to shore. Detonations associated with Anti-Submarine Warfare would typically occur in waters greater than 600 ft. (180 m) depth. The numbers of explosions in each explosive source class proposed under each alternative are shown in Table 1-4 through Table 1-6.

Explosives introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: (1) the weight of the explosive warhead, (2) the type of explosive material, and (3) the detonation depth. The net explosive weight, the explosive power of a charge expressed as the equivalent weight of TNT, accounts for the first two parameters. In general, explosive events would consist of a single explosion or multiple explosions over a short period. During training, all large, high-explosive bombs would be detonated near the surface over deep water. Bombs with high-explosive ordnance would be fused to detonate on contact with the water. Other detonations would occur near but above the surface upon impact with a target; these detonations are conservatively assumed to occur at a depth of 3 ft. (1 m) for purposes of analysis. Table 6-18 shows the depths at which representative explosive source classes are assumed to detonate underwater for purposes of analysis.

Table 6-18. Representative Ordnance, Net Explosive Weights, and Underwater Detonation Depths

Representative Ordnance	Explosive Source Class (Net Explosive Weight)	Representative Detonation Depth[1]
Small caliber projectiles	E1 (0.1-0.25 lb.)	1 m (3 ft.)
Medium-caliber projectiles	E2 (0.26-0.5 lb.)	1 m (3 ft.)
Improved extended echo ranging sonobuoy	E4 (2.6-5 lb.)	10 m (33 ft.), 20 m (66 ft.)
5 in. projectiles	E5 (6-10 lb.)	1 m (3 ft.)
Demo block/ shaped charge	E7 (21-60 lb.)	15 m (50 ft.)
Explosive torpedo	E8 (61-100 lb.)	6 m (20 ft.)
500 lb. bomb	E9 (101-250 lb.)	1 m (3 ft.)
650 lb. mine	E11 (501-650 lb.)	6 m (20 ft.), 10 m (33 ft.)
2,000 lb. bomb	E12 (651-1,000 lb.)	1 m (3 ft.)
Ship shock charge	E16 (7,251-14,500 lb.)	61 m (200 ft.)
	E17 (14,501-58,000 lb.)	

An explosive detonation generates a high-speed shock wave that rises almost instantaneously to a maximum pressure, then rapidly decays. At the instant of explosion, gas is instantaneously generated at high pressure and temperature, creating a bubble. In addition, the heat causes a certain amount of water to vaporize, adding to the volume of the bubble. This action immediately begins to force the water in contact with the blast front in an outward direction creating an intense pressure wave. This shock wave passes into the surrounding medium and travels faster than the speed of sound. The near-instantaneous rise from ambient to high pressures is what makes the shock wave potentially damaging. As the high pressure wave travels away from the source, it begins to slow and act like an acoustic wave similar to other impulsive sources that lack the strong shock wave (e.g., airguns). Noise associated with the blast is also transmitted into the surrounding medium as acoustic waves.

The peak pressure experienced by a receptor (i.e., an animal) is a function of the explosive material, the net explosive weight (the equivalent explosive energy expressed in weight of TNT), and the distance from the charge. The peak pressure is higher for larger charge weights at a given distance and decreases for increasing distances from a given charge. In general, shock wave effects near an explosive charge increase in proportion to the cube root of the explosive weight (Young 1991). For example, shock wave impacts will double when the explosive charge weight is increased by a factor of eight (i.e., cube root of eight equals two).

If the detonation occurs underwater and is not near the surface, gases released during the explosive chemical reaction form a bubble that pulsates as the gases expand and contract. These bubble pulsations create pressure waves that are weaker than the original shock wave but can still be damaging. If the detonation occurs at or just below the surface, a portion of the explosive power is released into the air and a pulsating gas bubble is not formed.

The detonation depth of an explosive is important because of the propagation effect known as surface-image interference. For underwater explosions near the sea surface, a distinct interference pattern arises from reflection from the water's surface. As the source depth or the source frequency decreases, these two paths increasingly, destructively interfere with each other, reaching total cancellation at the surface (barring surface reflection scattering loss). This effect can significantly reduce the peak pressures experienced near the water surface.

Because the largest proposed detonations would occur during a ship shock trial testing event, these detonations are discussed in further detail. Ship shock trials consist of a series of underwater detonations that propagate a shock wave through a ship's hull under deliberate and controlled conditions simulating near misses from underwater explosions. A representative ship from a new ship class is exposed to four detonations at a rate of up to two per week to allow time to perform detailed inspections of the ship's systems and assess the ability of the ship and crew to withstand near-miss situations.

Some parameters of past ship shock explosions using 10,000 lb. (4,536 kg) high blast explosive charges (source class E16) were predicted under prior analyses (U.S. Department of the Navy 2008). The shock wave would reach the seafloor and be reflected from it. The spherical bubble produced by each explosion would expand to a maximum radius of 62 ft. (19 m). The bubble would migrate upward and collapse beneath the surface, where it would re-expand and emerge into the atmosphere. The water that would be ejected would form a roughly hemispherical mass of plumes with an estimated maximum height of 540 ft. (165 m).

In addition to impacts due to propagation of the shock wave and acoustic waves, these large underwater detonations may cause a region of bulk cavitation near the surface due to the reflected shock wave. Cavitation occurs when compression (shock) waves propagate to the surface and are reflected back into the water as rarefaction (or negative pressure) waves. This causes a state of tension, or very low pressure, to occur within a large region of water. Since water cannot ordinarily sustain a significant amount of tension, it cavitates and the surrounding pressure drops to the vapor pressure of water. A water hammer pulse is generated when the upper and lower layers of the cavitation region rejoin (close). As an example, Figure 6-9 shows that estimated bulk cavitation region for an explosive source class E16 (7,251-14,500 lb. net explosive weight) detonation at a depth of 200 ft. (61 m) (U.S. Department of the Navy 2008). The maximum lateral extent (radius) of this cavitation area is predicted to be 2,250 ft. (686 m). A charge of this size or greater would only be detonated during ship shock trials.

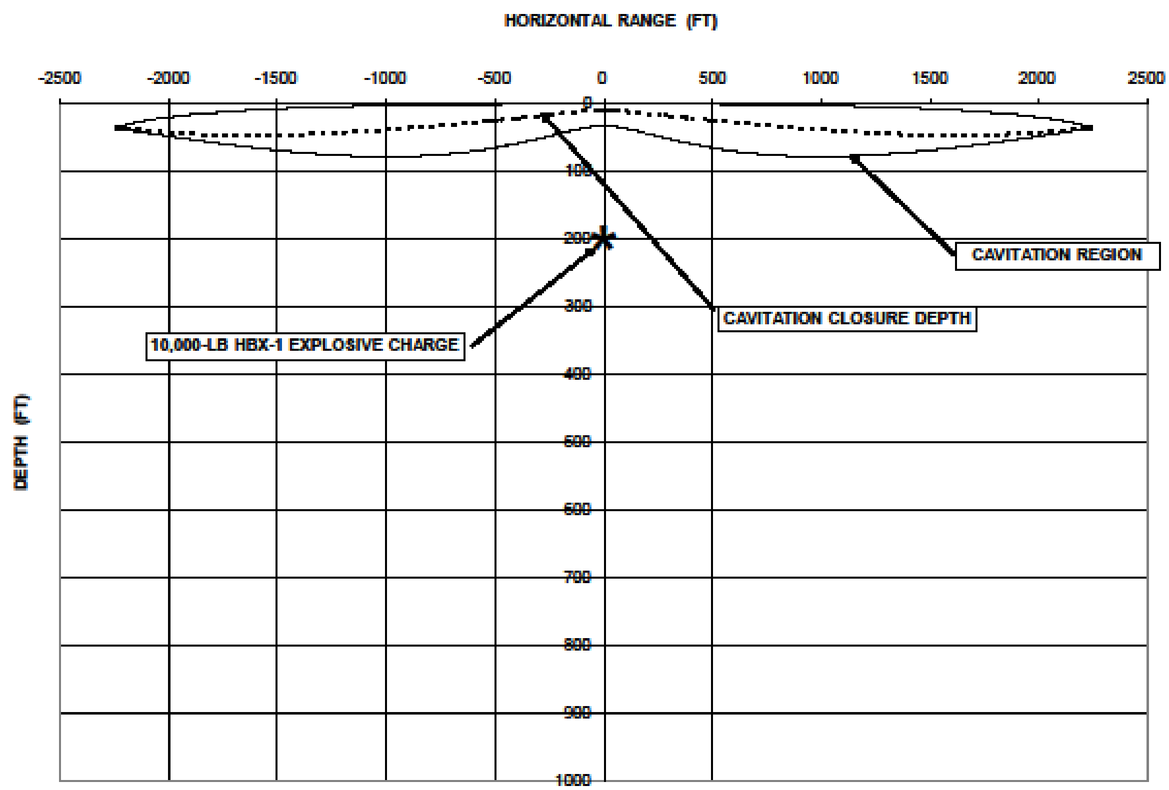


Figure 6-9. Calculated Bulk Cavitation Region and Closure Depth for a 10,000 lb. (4,536 kg) High Blast Explosive-1 Charge Detonated at a Depth of 200 ft. (61 m)

(U.S. Department of the Navy 2008)

The potential locations for ship shock trials were defined in the Final EIS for the Mesa Verde (LPD 19) Ship Shock Trial (U.S. Department of the Navy 2008). The locations of ship shock trials located off Norfolk, Virginia, and Jacksonville, Florida, would be based on operational requirements (proximity to support, ordnance storage/loading, and repair facilities), environmental features (avoidance of hardbottom and coral reefs), safety considerations, and Gulf Stream avoidance. In both locations, minimum water depth is 600 ft. (183 m). The charges are detonated at 200 ft. (61 m) below the water surface.

Section 6.1.3.5 (Behavioral Reactions) presents a review of observations and experiments involving marine mammals and reactions to impulsive sounds and underwater detonations. Energy from explosions is capable of causing mortality, direct injury, hearing loss, or a behavioral response depending on the level of exposure. The death of an animal will, of course, eliminate future reproductive potential and cause a long-term consequence for the individual that must then be considered for potential long-term consequences for the population. Exposures that result in long-term injuries such as 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 may recover quickly with little significant effect. 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). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council 2005).

Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds are likely within the audible range of most cetaceans, but the duration of individual sounds is very short. The direct sound from explosions used during Navy training and testing activities last less than a second, and most events involve the use of only one or a few explosions. Furthermore, events are dispersed in time and throughout the Study Area. These factors reduce the likelihood of these sources causing substantial auditory masking in marine mammals.

6.1.7.1 Range to Effects

The following section provides the range to effects from an explosion to specific criteria using the Navy's explosive propagation model. Marine mammals within these ranges would be predicted to receive the associated effect. The range to effects is important information in estimating the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher-level effects, especially physiological effects such as injury and mortality.

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on the explosive criteria (Section 6.1.4, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals) and the explosive propagation calculations from the Navy Acoustic Effects Model (Section 6.1.5.3). The range to effects are shown for a range of explosive bins (Section 6.1.5, Classification of Acoustic and Explosive Sources), from E2 (up to 0.5 lb. net explosive weight) to E17 (up to 58,000 lb. net explosive weight).

Figure 6-10 through Figure 6-15 show the range to slight lung injury and mortality for five representative animals of different masses for 0.5–58,000 lb. net explosive weight detonations. Modeled ranges for onset slight lung injury and onset mortality are based on the smallest calf weight in each category and therefore represents a conservative estimate (i.e., longer ranges) since populations contain many animals larger than calves and are therefore less susceptible to injurious effects. 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.

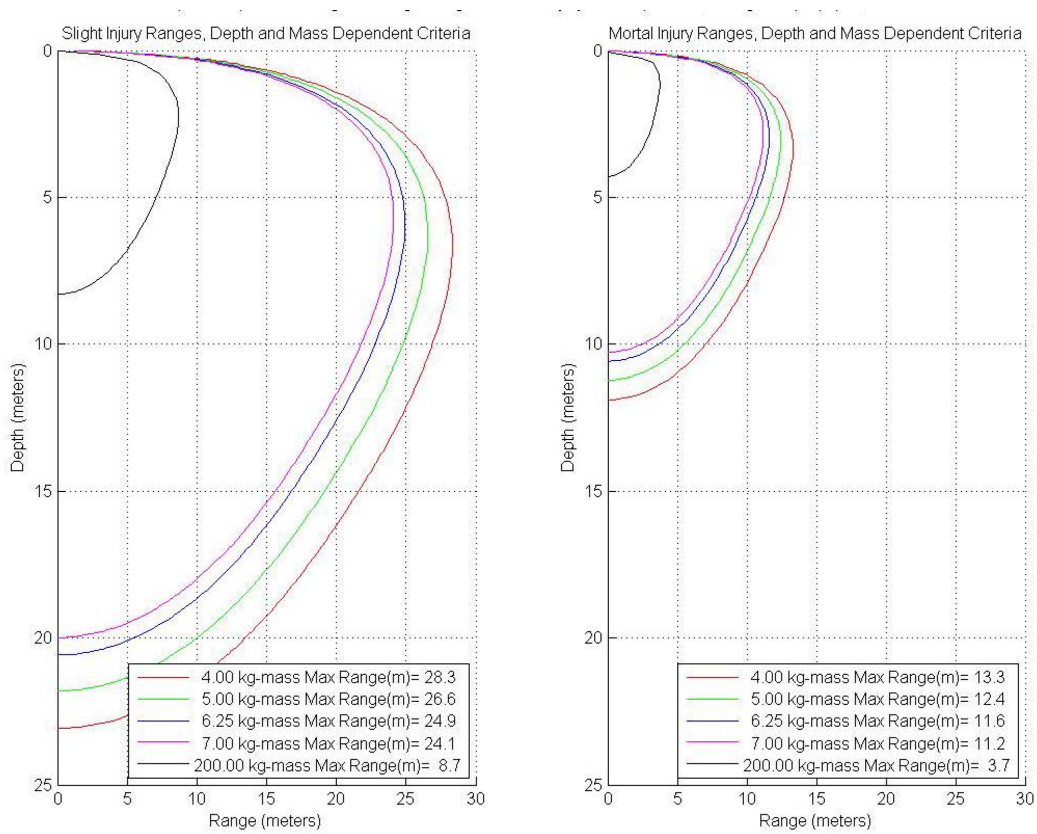


Figure 6-10. Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses (4.0, 5.0, 6.25, 7.0, and 200 kg) for a 0.5-Pound Net Explosive Weight Charge (Bin E2) Detonated at 1-m Depth

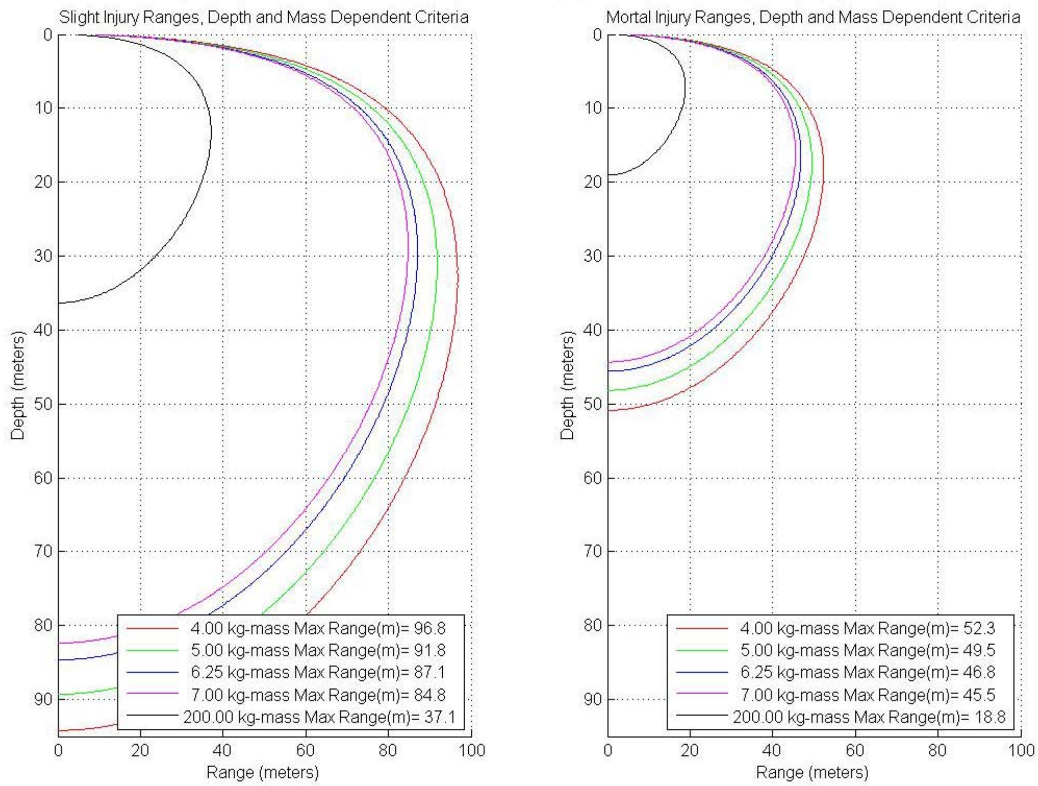


Figure 6-11. Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses (4.0, 5.0, 6.25, 7.0, and 200 kg) for a 10-Pound Net Explosive Weight Charge (Bin E5) Detonated at 1-m Depth

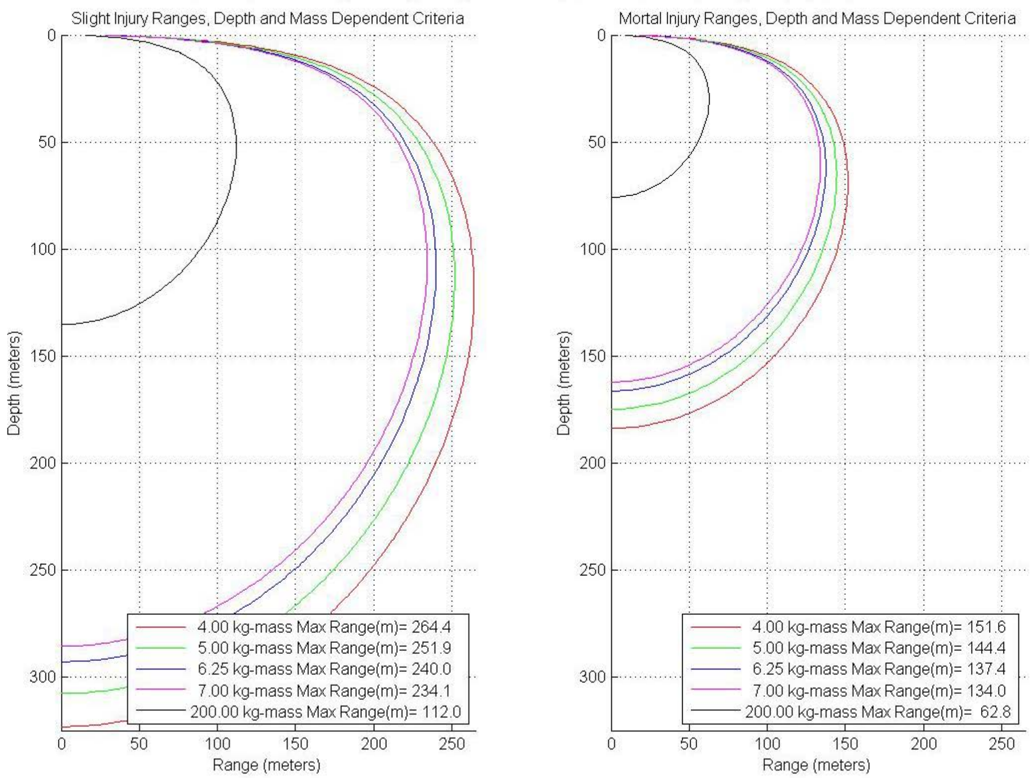


Figure 6-12. Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses (4.0, 5.0, 6.25, 7.0, and 200 kg) for a 250-Pound Net Explosive Weight Charge (Bin E9) Detonated at 1-m Depth

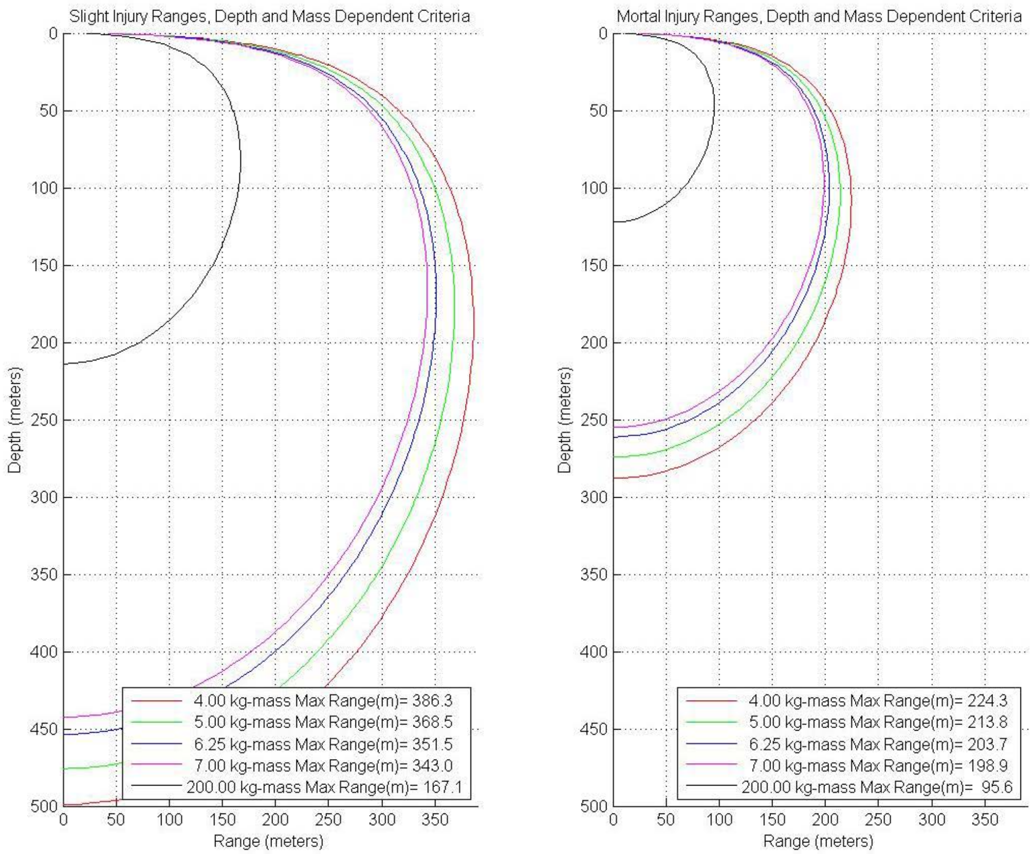


Figure 6-13. Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses (4.0, 5.0, 6.25, 7.0, and 200 kg) for a 1,000-Pound Net Explosive Weight Charge (Bin E12) Detonated at 1-m Depth

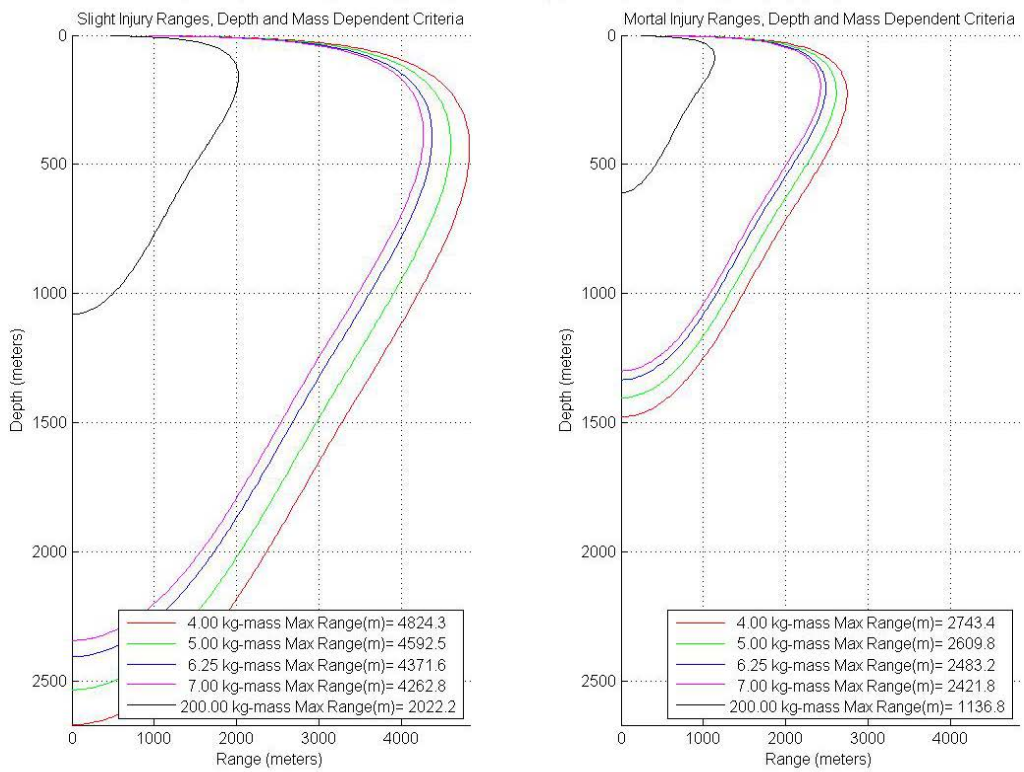


Figure 6-14. Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses (4.0, 5.0, 6.25, 7.0, and 200 kg) for a 14,500-Pound Net Explosive Weight Charge (Bin E16) Detonated at 61-m Depth

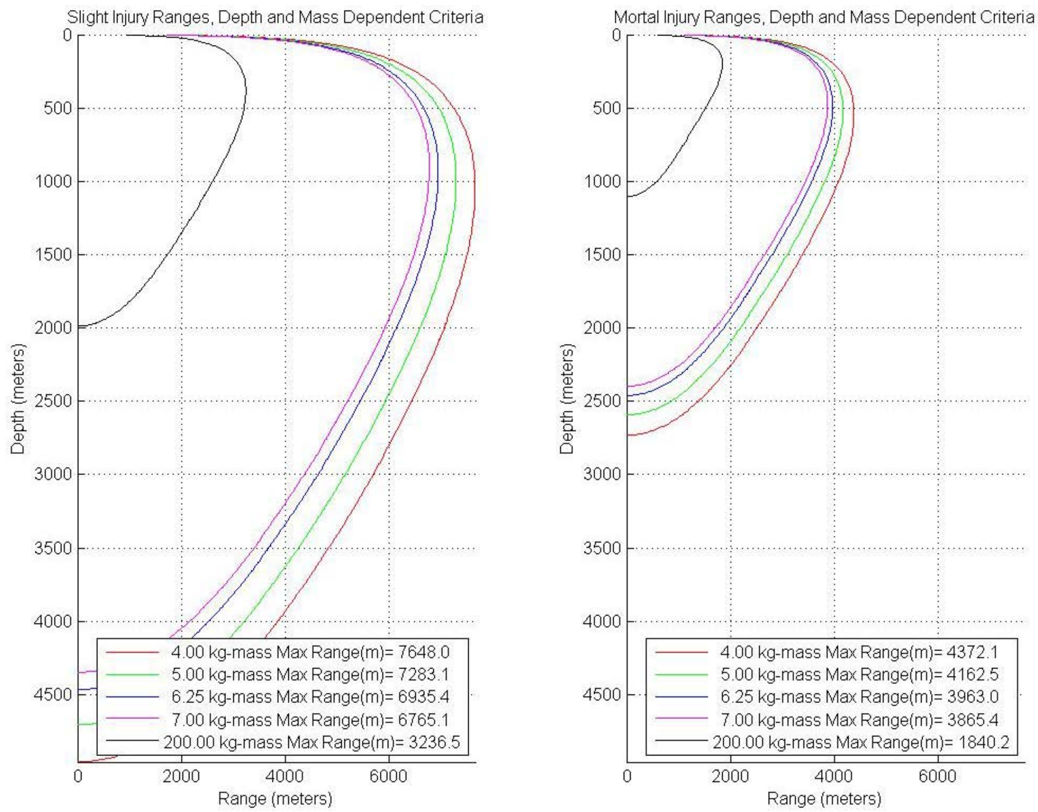


Figure 6-15. Threshold Profiles for Slight Lung Injury (left) and Mortality (right) Based on Five Representative Animal Masses (4.0, 5.0, 6.25, 7.0, and 200 kg) for a 58,000-Pound Net Explosive Weight Charge (Bin E17) Detonated at 61-m Depth

The following tables (Table 6-19 through Table 6-22) show the average ranges to the potential effect based on the thresholds described in Section 6.1.4, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts to Marine Mammals. Similar to slight lung injury and mortality ranges discussed above, behavioral, TTS, and PTS ranges also represent conservative estimates (i.e., longer ranges) based on assuming all impulses are 1 second in duration. In fact, most impulses are much less than 1 second and therefore contain less energy than what is being used to produce the estimated ranges below.

Table 6-19. Average Range to Effects from a Single Explosion for a Low-Frequency Cetacean Calf (200kg) across Representative Acoustic Environments within the Study Area

Criteria / Predicted Impact	Range to Effects (meters)					
	Bin E2 (0.5 lb. NEW)	Bin E5 (10 lb. NEW)	Bin E9 (250 lb. NEW)	Bin E12 (1,000 lb. NEW)	Bin E16 (14,500 lb. NEW)	Bin E17 (58,000 lb. NEW)
Onset Mortality (1% Mortality)	4	19	63	96	1,137	1,840
Onset Slight Lung Injury	9	37	112	167	2,022	3,237
Onset Slight GI Tract Injury	25	71	147	274	765	1,249
PTS	71	164	247	611	2,991	4,953
TTS	169	367	550	1,595	12,750	12,444
Behavioral Response	210	461	773	2,117	NA	NA

NEW: net explosive weight; NA – Behavioral Response Not Analyzed for bins E16 and E17 because these are single explosive events

Table 6-20. Average Range to Effects from a Single Explosion for a Mid-Frequency Cetacean Calf (5kg) across Representative Acoustic Environments within the Study Area

Criteria / Predicted Impact	Range to Effects (meters)					
	Bin E2 (0.5 lb. NEW)	Bin E5 (10 lb. NEW)	Bin E9 (250 lb. NEW)	Bin E12 (1,000 lb. NEW)	Bin E16 (14,500 lb. NEW)	Bin E17 (58,000 lb. NEW)
Onset Mortality (1% Mortality)	11	46	134	199	2,422	3,865
Onset Slight Lung Injury	24	85	234	343	4,263	6,765
Onset Slight GI Tract Injury	25	71	147	274	765	1,249
PTS	26	76	153	297	766	1,201
TTS	83	202	364	832	2,878	4,282
Behavioral Response	111	266	455	1,119	NA	NA

NEW: net explosive weight; NA – Behavioral Response Not Analyzed for bins E16 and E17 because these are single explosive events

Table 6-21. Average Range to Effects from a Single Explosion for a High-Frequency Cetacean Calf (4kg) across Representative Acoustic Environments within the Study Area

Criteria / Predicted Impact	Range to Effects (meters)					
	Bin E2 (0.5 lb. NEW)	Bin E5 (10 lb. NEW)	Bin E9 (250 lb. NEW)	Bin E12 (1,000 lb. NEW)	Bin E16 (14,500 lb. NEW)	Bin E17 (58,000 lb. NEW)
Onset Mortality (1% Mortality)	12	50	144	214	2,610	4,163
Onset Slight Lung Injury	27	92	252	369	4,593	7,283
Onset Slight GI Tract Injury	25	71	147	274	765	1,249
PTS	132	313	473	1,198	5,973	10,322
TTS	290	799	928	3,575	21,297	35,129
Behavioral Response	458	1,021	1,151	4,371	NA	NA

NEW: net explosive weight; NA – Behavioral Response Not Analyzed for bins E16 and E17 because these are single explosive events

Table 6-22. Average Range to Effects from a Single Explosion for Phocid Seal Pup (4kg) across Representative Acoustic Environments within the Study Area

Criteria / Predicted Impact	Range to Effects (meters)					
	Bin E2 (0.5 lb. NEW)	Bin E5 (10 lb. NEW)	Bin E9 (250 lb. NEW)	Bin E12 (1,000 lb. NEW)	Bin E16 (14,500 lb. NEW)	Bin E17 (58,000 lb. NEW)
Onset Mortality (1% Mortality)	13	52	152	224	2,743	4,372
Onset Slight Lung Injury	28	97	264	386	4,824	7,648
Onset Slight GI Tract Injury	25	71	147	274	765	1,249
PTS	70	158	359	824	2,914	4,733
TTS	150	433	787	1,870	12,655	11,663
Behavioral Response	194	561	967	2,305	NA	NA

NEW: net explosive weight; NA – Behavioral Response Not Analyzed for bins E16 and E17 because these are single explosive events

6.1.7.2 Avoidance Behavior and Mitigation Measures as Applied to Explosions

As discussed above (Section 6.1.5.4, Model Assumptions and Limitations), within the Navy Acoustic Effects Model, animats (virtual animals) do not move horizontally or react in any way to avoid sound at any level. In reality, various researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Richardson et al. 1995; Tyack et al. 2011; Watkins 1986; Wursig et al. 1998). Section 6.1.3.5 (Behavioral Reactions) reviews research and observations of marine mammals' reactions to sound sources including seismic surveys and explosives. The Navy Acoustic Effects Model also does not account for the implementation of mitigation, which would prevent many of the model-predicted injurious and mortal exposures to explosives. Therefore, the model-estimated mortality and Level A effects are further analyzed considering avoidance and implementation of mitigation measures (see section 6.1.7 Quantitative Analysis).

If explosive activities are preceded by multiple vessel traffic or hovering aircraft, harbor porpoises and beaked whales are assumed to move beyond the range to onset mortality before detonations occur, as discussed in Section 6.1.5.5.1 (Avoidance of Human Activity). Table 6-20 and Table 6-21 show the ranges to onset mortality for mid-frequency and high frequency cetaceans for a representative range of charge sizes. The range to onset mortality for all net explosive weights (excluding ship shock charges) is generally less than 214 m, which is conservatively based on range to onset mortality for a calf. Because the Navy Acoustic Effects Model does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for these species- that they would tolerate staying in an area of high human activity. Therefore, harbor porpoises and beaked whales that were model-estimated to experience mortality are assumed to move into the range of potential injury prior to the start of the explosive activity for the activities listed in Table 6-23.

Table 6-23: Activities Using Explosives Preceded by Multiple Vessel Movements or Hovering Helicopters

ACTIVITIES
Training
~~[A-S] MISSILEX~~
~~Airborne Mine Neutralization Systems~~
~~Airborne Projectile-Based Mine Clearance System~~
Civilian Port Defense
GUNEX [S-S] - Boat - Medium Caliber
GUNEX [S-S] - Ship - Medium Caliber
COMPTUEX
FIREX
Group Sail
JTFEX/SUSTAINEX
Maritime Security Operations- Anti-Swimmer Grenade
Mine Neutralization - EOD
Mine Neutralization - ROV
MISSILEX [A-S]
MISSILEX [S-S]
SINKEX
UNDET
Testing
[A-S] MISSILEX
Airborne Mine Neutralization Systems
Airborne Projectile-Based Mine Clearance System
Airborne Towed Mine Sweeping Test
ASW Tracking Test - Helo
At-Sea Explosives Testing
MCM Mission Package Testing
Mine Countermeasure/Neutralization Testing
NSWC: Mine Countermeasure/Neutralization Testing
NSWC: Stationary Source Testing
NUWC: Pierside Integrated Swimmer Defense
Pierside Integrated Swimmer Defense
~~Rocket Test~~
Ship Shock Trials
Sonobuoy Lot Acceptance Testing
Torpedo (explosive) Testing

The Navy Acoustic Effects Model does not consider mitigation, discussed in detail in Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures. As explained in Section 6.1.5.6 (Implementing Mitigation to Reduce Sound Exposures), to account for the implementation of mitigation measures, the acoustic analysis assumes a model-predicted mortality or injury would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during the use of explosives, considering the mitigation effectiveness (Table 6-24) and sightability of a species based on g(0) (see Table 6-6). The mitigation effectiveness is considered over two regions of an activity's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset PTS. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness x Sightability, g(0)]; these animals are instead assumed to be present within the range to injury and range to TTS, respectively.

During an activity with a series of explosions (not concurrent multiple explosions)(see Table 6-25), an animal is expected to exhibit an initial startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 6-19 through Table 6-21. Animals not observed by Lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion. Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Kastelein et al. 2005a; Mooney et al. 2008; Popov and Supin 2009).

An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the Navy Acoustic Effects Model does not account for avoidance behavior, the model-estimated effects are based on unlikely behavior – that animals would remain in the vicinity of potentially injurious sound sources. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS are considered to actually be TTS due to avoidance.

Table 6-24: Consideration of Mitigation in Acoustic Effects Analysis for Explosives

Activity[1,2]	Mitigation Effectiveness Factor for Acoustic Analysis		Mitigation Platform
	Injury Zone	Mortality Zone	
Training			
~~[A-S] GUNEX (HF/Phocids)~~	~~0.5~~	~~0.5~~	~~Aircraft~~
~~[A-S] GUNEX (MF/LF)~~	~~1~~	~~1~~	~~Aircraft~~
~~Airborne Mine Neutralization Systems (HF/Phocids)~~	~~-~~	~~1~~	~~Both[3]~~
~~Airborne Mine Neutralization Systems (MF/LF)~~	~~1~~	~~1~~	~~Both[3]~~
~~Airborne Projectile-Based Mine Clearance System (HF/Phocids)~~	~~-~~	~~1~~	~~Both[3]~~
~~Airborne Projectile-Based Mine Clearance System (MF/LF)~~	~~1~~	~~1~~	~~Both[3]~~
BOMBEX [A-S] (HF/Phocids/LF)	-	1	Aircraft
BOMBEX [A-S] (MF)	0.5	1	Aircraft
Civilian Port Defense	1	1	Vessel
COMPTUEX (IEER/ MINEX)	0.5	0.5	Both[3]
Group Sail (IEER)	0.5	0.5	Aircraft
GUNEX [A-S] - Medium Caliber [HF/Phocids]	0.5	0.5	Aircraft
GUNEX [A-S] - Medium Caliber [MF/LF]	1	1	Aircraft
GUNEX [S-S] - Boat - Medium Caliber (HF/Phocids)	0.5	0.5	Vessel
GUNEX [S-S] - Boat - Medium Caliber (MF/LF)	1	1	Vessel
GUNEX [S-S] - Ship - Medium Caliber (HF/Phocids/MF)	0.5	0.5	Vessel
GUNEX [S-S] - Ship - Medium Caliber (LF)	1	1	Vessel
JTFEX-SUSTAINEX/SUSTAINEX (IEER)	0.5	0.5	Aircraft
Maritime Security Operations- Anti-Swimmer Grenade	1	1	Vessel
Mine Neutralization - EOD	0.5	1	Vessel
Mine Neutralization - ROV	1	1	Vessel
SINKEX (HF/Phocids/LF)	-	1	Aircraft
SINKEX (MF)	0.5	1	Aircraft
TRACKEX/TORPEX - MPA Sonobuoy	0.5	0.5	Aircraft
UNDET	1	1	Vessel
Testing			
[A-S] GUNEX (HF/Phocids)	0.5	0.5	Aircraft
[A-S] GUNEX (MF/LF)	1	1	Aircraft
Airborne Mine Neutralization Systems (HF/Phocids)	-	1	Both[3]
Airborne Mine Neutralization Systems (MF/LF)	1	1	Both[3]
Airborne Projectile-Based Mine Clearance System (HF/Phocids)	-	1	Both[3]
Airborne Projectile-Based Mine Clearance System (MF/LF)	1	1	Both[3]
Airborne Towed Mine Sweeping Test (HF/Phocids)	-	1	Both[3]
Airborne Towed Mine Sweeping Test (MF/LF)	1	1	Both[3]
Aircraft Carrier Sea Trial	1	1	Vessel
ASW Tracking Test - Helo	0.5	0.5	Aircraft
At-Sea Explosives Testing	1	1	Vessel
MCM Mission Package Testing	1	1	Vessel
Mine Countermeasure/Neutralization Testing	1	1	Vessel
NSWC: Mine Countermeasure/Neutralization Testing	1	1	Vessel
Ship Shock Trials	0.5	1	Both[4]
Sonobuoy Lot Acceptance Testing	1	1	Vessel
Torpedo (Explosive) Testing	-	1	Aircraft

[1] Ranges to effect differ for functional hearing groups based on weighted threshold values. HF: high frequency cetaceans; MF: mid-frequency cetaceans; LF: low frequency cetaceans

[2] If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of Lookouts, and size of the mitigation zone, mitigation is not considered in the acoustic effects analysis of that activity and the activity is not listed in this table. For activities in which only mitigation in the mortality zone is considered in the analysis, no value is provided for the injury zone.

[3] Activity employs both vessel and aircraft based Lookouts. The larger g(0) value (aerial or vessel) is used.

[4] Activity employs vessel and/or aircraft based Lookouts. If vessels are the only platform, a sufficient number of vessel-based Lookouts will be used to effectively mitigate the area in a manner comparable to aerial mitigation.

Table 6-25: Activities with Multiple Non-concurrent Explosions

ACTIVITIES
Training
~~[A-S] GUNEX~~
~~Airborne Mine Neutralization Systems~~
BOMBEX [A-S]
Civilian Port Defense
FIREX
~~GUNEX [A-S] - Medium Caliber~~
~~GUNEX [S-S] - Ship - Large Caliber~~
~~GUNEX [S-S] - Boat - Medium Caliber~~
Maritime Security Operations- Anti-Swimmer Grenade
Mine Neutralization - EOD
Mine Neutralization - ROV
SINKEX
~~UNDET~~
Testing
Airborne Mine Neutralization Systems
Airborne Projectile-Based Mine Clearance System
MCM Mission Package Testing
Mine Countermeasure/Neutralization Testing
NSWC: Mine Countermeasure/Neutralization Testing
NSWC: Ordnance Testing
NSWC: Stationary Source Testing
NUWC: Pierside Integrated Swimmer Defense
Pierside Integrated Swimmer Defense
Sonobuoy Lot Acceptance Testing

6.1.7.3 Predicted Impacts

Tables 6-26 through 6-30 present the predicted impacts on marine mammals separated between training and testing activities, and between annual and nonannual events. Nonannual events, those events that may only take place a few times over the 5-year period and do not reoccur every year, are considered separately since these impacts would not be assessed each year. This acoustic effects analysis uses the Navy Acoustic Effects Model (Section 6.1.5.3, Navy Acoustic Effects Model) followed by post-model consideration of avoidance and implementation of mitigation to predict effects using the explosive criteria and thresholds described in Section 6.1.4, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts to Marine Mammals.

The Navy Acoustic Effects Model does not account for several factors (Section 6.1.5.4, Model Assumptions and Limitations) that must be considered in the overall explosive analysis. When there is uncertainty in model input values, a conservative approach is often chosen to assure that potential effects are not under-estimated. As a result, the Navy Acoustic Effects Model provides estimates that are conservative (over-estimates the likely impacts). The following is a list of several such factors that cause the model to overestimate potential effects:

- The onset mortality criterion is based on 1 percent of the animals receiving an injury that would not be recoverable and lead to mortality. Therefore, many animals that are estimated to suffer mortality in this analysis may actually recover from their injuries.
- The onset slight lung injury criteria is based on 1 percent of the animals exposed at the threshold receiving a slight lung injury in which full recovery would be expected. Therefore, many animals that are estimated to suffer slight lung injury in this analysis may actually not incur injuries.
- The metrics used for the threshold for slight lung injury and mortality (i.e., acoustic impulse) are based on the animal's mass. The smaller an animal, the more susceptible that individual is to these effects. In this analysis, all individuals of a given species are assigned the weight of that species newborn calf or pup weight. Since many individuals in a population are obviously larger than a newborn calf or pup of that species, this assumption causes the acoustic model to overestimate the number of animals that may suffer slight lung injury or mortality. As discussed in the explanation of onset mortality and onset slight lung injury criteria in Section 6.1.4.1.1, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.
- Many explosions from ordnances such as bombs and missiles actually occur upon impact with above-water targets. However, for this analysis, sources such as these were modeled as exploding at 1 m depth. This overestimates the amount of explosive and acoustic energy entering the water and therefore overestimates effects on marine mammals.

Explosive detonations would not take place in bearded and ringed seal habitat, and impacts from explosive energy or sound are not predicted under the Proposed Action for these species. There are no model-estimated impacts on marine mammals from explosions associated with the testing activity aircraft carrier sea trial that could occur once per 5-year period.

These predicted effects shown below are the result of the acoustic analysis, including acoustic effect modeling followed by consideration of animal avoidance of multiple exposures, avoidance of areas with high level of activity by sensitive species, and mitigation. It is important to note that acoustic impacts presented in Tables 6-26 through 6-30 are the total number of predicted effects and not necessarily the number of individuals affected. An animal could be predicted to receive more than one acoustic impact over the course of a year. Species presented in tables had species density values (i.e., theoretically present to some degree) within the areas modeled for the Proposed Action, although all predicted effects may still indicate "0" (zero) after summing all impacts and applying standard arithmetic rounding rules (i.e., numbers less than 0.5 round down to 0.0). Species that are not presented in the tables did not have density estimates for the affected area and therefore would not be expected to be present. Impacts on these species for the indicated activities, under the Proposed Action, are so unlikely as to be discountable.

Table 6-26. Predicted Impacts per Year from Explosions for Annually Recurring Training Activities

Species	Behavioral Response	TTS	PTS	GI Tract Injury	Onset Slight Lung Injury	Onset Mortality[1]
Mysticetes						
Blue whale*	0	0	0	0	0	0
Bryde's whale	0	0	0	0	0	0
Minke whale	9	30	4	1	1	0
Fin whale*	1	1	0	0	0	0
Humpback whale*	0	1	0	0	0	0
North Atlantic right whale*	0	1	0	0	0	0
Sei whale*	1	1	0	0	0	0
Odontocetes – Delphinids						
Atlantic spotted dolphin	15	34	3	0	9	3
Atlantic white-sided dolphin	4	7	1	0	2	1
Bottlenose dolphin	27	45	3	1	4	2
Clymene dolphin	1	2	0	0	1	0
Common dolphin	19	41	3	0	14	5
False killer whale	0	0	0	0	0	0
Fraser's dolphin	0	0	0	0	0	0
Killer whale	0	1	0	0	0	0
Melon-headed whale	1	0	0	0	0	0
Pantropical spotted dolphin	2	4	0	0	1	0
Pilot whale	6	12	1	0	2	1
Pygmy killer whale	0	0	0	0	0	0
Risso's dolphin	8	14	1	0	2	1
Rough-toothed dolphin	0	0	0	0	0	0
Spinner dolphin	1	1	0	0	0	0
Striped dolphin	6	11	1	0	6	2
White-beaked dolphin	1	2	0	0	0	0
Odontocetes – Sperm Whale						
Sperm whale*	1	1	0	0	0	0
Odontocetes – Beaked Whales						
Blainville's beaked whale	0	0	0	0	0	0
Cuvier's beaked whale	0	0	0	0	0	0
Gervais' beaked whale	0	0	0	0	0	0
Northern bottlenose whale	0	0	0	0	0	0
Sowerby's beaked whale	0	0	0	0	0	0
True's beaked whale	0	0	0	0	0	0
Odontocetes – *Kogia* Species and Porpoises						
Dwarf and pygmy sperm whales (*Kogia* spp.)	1	5	2	0	0	0
Harbor porpoise	94	497	177	1	21	2
Phocid Seals						
Gray seal	0	0	0	0	0	0
Harbor seal	1	2	0	0	0	0
Harp seal	0	0	0	0	0	0

* ESA-listed species; PTS: permanent threshold shift; TTS: temporary threshold shift

[1] These mortalities are considered in the take request for training activities in Table 5-1 as unspecified "any small odontocete in any given year."

Table 6-27. Predicted Impacts per Event from Explosions for Civilian Port Defense Occurring Biennially

Species	Behavioral Response	TTS	PTS	GI Tract Injury	Onset Slight Lung Injury	Onset Mortality
Mysticetes						
Blue whale*	0	0	0	0	0	0
Bryde's whale	0	0	0	0	0	0
Minke whale	0	0	0	0	0	0
Fin whale*	0	0	0	0	0	0
Humpback whale*	0	0	0	0	0	0
North Atlantic right whale*	0	0	0	0	0	0
Sei whale*	0	0	0	0	0	0
Odontocetes – Delphinids						
Atlantic spotted dolphin	0	0	0	0	0	0
Atlantic white-sided dolphin	0	0	0	0	0	0
Bottlenose dolphin	0	0	0	0	0	0
Clymene dolphin	0	0	0	0	0	0
Common dolphin	0	0	0	0	0	0
False killer whale	0	0	0	0	0	0
Fraser's dolphin	0	0	0	0	0	0
Killer whale	0	0	0	0	0	0
Melon-headed whale	0	0	0	0	0	0
Pantropical spotted dolphin	0	0	0	0	0	0
Pilot whale	0	0	0	0	0	0
Pygmy killer whale	0	0	0	0	0	0
Risso's dolphin	0	0	0	0	0	0
Rough-toothed dolphin	0	0	0	0	0	0
Spinner dolphin	0	0	0	0	0	0
Striped dolphin	0	0	0	0	0	0
White-beaked dolphin	0	0	0	0	0	0
Odontocetes – Sperm Whale						
Sperm whale*	0	0	0	0	0	0
Odontocetes – Beaked Whales						
Blainville's beaked whale	0	0	0	0	0	0
Cuvier's beaked whale	0	0	0	0	0	0
Gervais' beaked whale	0	0	0	0	0	0
Northern bottlenose whale	0	0	0	0	0	0
Sowerby's beaked whale	0	0	0	0	0	0
True's beaked whale	0	0	0	0	0	0
Odontocetes – *Kogia* Species and Porpoises						
Dwarf and pygmy sperm whales (*Kogia* spp.)	0	0	0	0	0	0
Harbor porpoise	0	7	1	0	0	0

* ESA-listed species; PTS: permanent threshold shift; TTS: temporary threshold shift

Table 6-28. Predicted Impacts per Year from Explosions for Annually Recurring Testing Activities

Species	Behavioral Response	TTS	PTS	GI Tract Injury	Onset Slight Lung Injury	Onset Mortality[1]
Mysticetes						
Blue whale*	0	0	0	0	0	0
Bryde's whale	0	0	0	0	0	0
Minke whale	4	11	2	0	0	0
Fin whale*	0	1	0	0	0	0
Humpback whale*	0	0	0	0	0	0
North Atlantic right whale*	0	0	0	0	0	0
Sei whale*	0	1	0	0	0	0
Odontocetes – Delphinids						
Atlantic spotted dolphin	7	24	0	0	7	2
Atlantic white-sided dolphin	2	6	0	0	1	1
Bottlenose dolphin	10	23	1	0	3	1
Clymene dolphin	1	1	0	0	1	0
Common dolphin	12	28	0	0	12	4
False killer whale	0	0	0	0	0	0
Fraser's dolphin	0	0	0	0	0	0
Killer whale	0	1	0	0	0	0
Melon-headed whale	1	1	0	0	0	0
Pantropical spotted dolphin	2	2	0	0	4	1
Pilot whale	3	11	0	0	1	0
Pygmy killer whale	0	0	0	0	0	0
Risso's dolphin	8	14	0	0	2	0
Rough-toothed dolphin	0	0	0	0	0	0
Spinner dolphin	0	1	0	0	1	0
Striped dolphin	7	11	0	0	7	1
White-beaked dolphin	0	1	0	0	0	0
Odontocetes – Sperm Whales						
Sperm whale*	1	0	0	0	0	0
Odontocetes – Beaked Whales						
Blainville's beaked whale	0	0	0	0	0	0
Cuvier's beaked whale	0	0	0	0	0	0
Gervais' beaked whale	0	0	0	0	0	0
Northern bottlenose whale	0	0	0	0	0	0
Sowerby's beaked whale	0	0	0	0	0	0
True's beaked whale	0	0	0	0	0	0
Odontocetes – *Kogia* Species and Porpoises						
Dwarf and pygmy sperm whales (*Kogia* spp.)	1	2	1	0	0	0
Harbor porpoise	485	348	110	0	7	1
Phocid Seals						
Gray seal	6	6	1	0	0	0
Harbor seal	6	6	1	0	0	0
Harp seal	2	2	0	0	0	0
Hooded seal	1	1	0	0	0	0

* ESA-listed species; PTS: permanent threshold shift; TTS: temporary threshold shift
[1] These mortalities are considered in the take request for testing activities in Table 5-1 as unspecified "any small odontocete in any given year."

Table 6-29. Predicted Impacts for Aircraft Carrier Ship Shock Trials (up to four 58,000-lb. Net Explosive Weight Detonations) Occurring Once per 5-Year Period

Species	TTS	PTS	GI Tract Injury	Onset Slight Lung Injury	Onset Mortality[1]
Mysticetes					
Blue whale*	0	0	0	0	0
Bryde's whale	0	0	0	0	0
Minke whale	26	0	0	8	3
Fin whale*	3	0	0	0	0
Humpback whale*	1	0	0	0	0
North Atlantic right whale*	0	0	0	0	0
Sei whale*	4	0	0	0	0
Odontocetes – Delphinids					
Atlantic spotted dolphin	1,098	0	0	1,683	109
Atlantic white-sided dolphin	123	0	0	116	30
Bottlenose dolphin	175	0	0	95	26
Clymene dolphin	0	0	0	73	11
Common dolphin	1,449	0	0	1,955	106
False killer whale	0	0	0	0	0
Fraser's dolphin	1	0	0	0	0
Killer whale	2	0	0	2	0
Melon-headed whale	23	0	0	24	1
Pantropical spotted dolphin	40	0	0	57	5
Pilot whale	87	0	0	140	22
Pygmy killer whale	3	0	0	3	0
Risso's dolphin	52	0	0	46	14
Rough-toothed dolphin	1	0	0	0	0
Spinner dolphin	15	0	0	23	2
Striped dolphin	1,486	0	0	2,344	113
White-beaked dolphin	0	0	0	3	1
Odontocetes – Sperm Whale					
Sperm whale*	11	0	0	3	2
Odontocetes – Beaked Whales					
Blainville's beaked whale	1	0	0	3	0
Cuvier's beaked whale	0	0	0	1	0
Gervais' beaked whale	1	0	0	4	0
Northern bottlenose whale	2	0	0	3	0
Sowerby's beaked whale	0	0	0	0	0
True's beaked whale	0	0	0	1	0
Odontocetes – *Kogia* Species and Porpoises					
Dwarf and pygmy sperm whales (*Kogia* spp.)	3	1	0	3	0

* ESA-listed species; PTS: permanent threshold shift; TTS: temporary threshold shift

[1] Based on conservativeness of the onset mortality criteria and impulse modeling (see Section 6.1.4.1 [Mortality and Injury from Explosions] and Section 6.1.5.4 [Model Assumptions and Limitations]); past observations of no marine mammal mortalities associated with ship shock trials (see Section 6.1.3 [Summary of Observations During Previous Navy Activities]), and implementation of mitigation (see Chapter 11 [Means of Effecting the Least Practicable Adverse Impacts- Mitigation Measures]), the mortality results presented in this table are over-estimated. The 10 mortalities in the take request for CVN Ship Shock Trials in Section 6.1.7.5.2 (Odontocetes) presented as unspecified "any small odontocete in any given year" are informed by the acoustic analysis results presented in this table.

Table 6-30. Predicted Impacts Per Event for the Guided Missile Destroyer and Littoral Combat Ship Shock Trials (up to four 14,500-lb. Net Explosive Weight Detonations) Occurring Three Times Per 5-Year Period

Species	TTS	PTS	GI Tract Injury	Onset Slight Lung Injury	Onset Mortality[1]
Mysticetes					
Blue whale*	0	0	0	0	0
Bryde's whale	0	0	0	0	0
Minke whale	5	0	0	1	0
Fin whale*	1	0	0	0	0
Humpback whale*	0	0	0	0	0
North Atlantic right whale*	0	0	0	0	0
Sei whale*	1	0	0	0	0
Odontocetes – Delphinids					
Atlantic spotted dolphin	58	0	0	82	7
Atlantic white-sided dolphin	11	0	0	15	2
Bottlenose dolphin	31	0	0	25	3
Clymene dolphin	0	0	0	3	1
Common dolphin	79	0	0	118	8
False killer whale	0	0	0	0	0
Fraser's dolphin	0	0	0	0	0
Killer whale	1	0	0	0	0
Melon-headed whale	2	0	0	2	0
Pantropical spotted dolphin	4	0	0	5	1
Pilot whale	5	0	0	6	1
Pygmy killer whale	0	0	0	0	0
Risso's dolphin	10	0	0	11	2
Rough-toothed dolphin	0	0	0	0	0
Spinner dolphin	2	0	0	2	0
Striped dolphin	74	0	0	124	4
White-beaked dolphin	0	0	0	0	0
Odontocetes – Sperm Whale					
Sperm whale*	3	0	0	1	0
Odontocetes – Beaked Whales					
Blainville's beaked whale	0	0	0	0	0
Cuvier's beaked whale	0	0	0	0	0
Gervais' beaked whale	0	0	0	0	0
Northern bottlenose whale	1	0	0	1	0
Sowerby's beaked whale	0	0	0	0	0
True's beaked whale	0	0	0	0	0
Odontocetes – *Kogia* Species and Porpoises					
Dwarf and pygmy sperm whales (*Kogia* spp.)	1	0	0	0	0

* ESA-listed species; PTS: permanent threshold shift; TTS: temporary threshold shift

[1] Based on conservativeness of the onset mortality criteria and impulse modeling (see Section 6.1.4.1 [Mortality and Injury from Explosions] and Section 6.1.5.4 [Model Assumptions and Limitations]); past observations of no marine mammal mortalities associated with ship shock trials (see Section 6.1.3 [Summary of Observations During Previous Navy Activities]), and implementation of mitigation [see Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts- Mitigation Measures)], the mortality results presented in this table are over-estimated. The 15 mortalities in the take request for the two DDG and one LCS Ship Shock Trials in Section 6.1.7.5.2 (Odontocetes) presented as unspecified "any small odontocete in any given year" are informed by the acoustic analysis results presented in this table.

6.1.7.4 Training Activities

As described in Chapter 1 (Introduction and Description of Activities), training activities involving explosions could be conducted throughout the Study Area but would be concentrated in the VACAPES and JAX Range Complexes, followed in descending order by the Navy Cherry Point, GOMEX, Northeast, and Key West Range Complexes. A few activities could also occur in areas outside of range complexes or OPAREAS, but within the Study Area. These events would be concentrated in the Northeast U.S. Continental Shelf and Southeast U.S. Continental Shelf Large Marine Ecosystems and the Gulf Stream Open Ocean Area, with lesser activities in the Gulf of Mexico Large Marine Ecosystem and the North Atlantic Gyre Open Ocean Area. Activities that involve underwater detonations and explosive ordnance typically occur more than 3 nm from shore.

Predicted effects on marine mammals from exposures to explosions during annually recurring training activities are shown in Table 6-26 and during the biennial training activity, Civilian Port Defense, in Table 6-27. Approximately 15 percent of modeled activities involve multiple detonations (multiple detonations, as defined for this analysis, are described in Section 6.1 (Estimated Take of Marine Mammals by Impulsive and Non-impulsive Sources) and are therefore evaluated for potential behavioral responses from marine mammals.

6.1.7.4.1 Mysticetes

Table 6-19 presents predicted ranges to specified effects for low-frequency cetaceans (mysticetes). Effects are predicted primarily within the VACAPES, JAX, and Navy Cherry Point Range Complexes, in the Northeast U.S. Continental Shelf and Southeast U.S. Continental Shelf Large Marine Ecosystems and the Gulf Stream Open Ocean Area. There are no impacts on mysticetes from explosives within the biennial civilian port defense activities.

North Atlantic right whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The acoustic analysis predicts one TTS exposure to a North Atlantic right whale annually from recurring activities. Long-term consequences for individuals or populations would not be expected. Training activities that use explosives, with the exception of training with explosive sonobuoys, are not conducted in the southeast North Atlantic right whale mitigation area. Training activities that use explosives would not occur in the northeast North Atlantic right whale mitigation area. Although, the sound and energy from explosions associated with training activities may be detectable within the mitigation areas.

Blue~~, humpback,~~ and Bryde's whales may be exposed to sound or energy from explosions associated with training activities throughout the year, although the acoustic analysis predicts that no individuals would be impacted. Long-term consequences for individuals or populations would not be expected.

Humpback whales may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that one humpback whale could be exposed annually to sound from explosions that may cause TTS. This could happen anywhere within the Study Area. All predicted impacts would be to the Gulf of Maine stock because this is the only humpback whale stock present within the Study Area.

Sei whales may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that one sei whale could be exposed annually to sound from explosions that may cause TTS and one sei whale could exhibit a behavioral reaction. This could happen anywhere within the Study Area. Predicted effects would be to the Nova Scotia stock because this is the only sei whale stock present within the Study Area.

Fin whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The acoustic analysis predicts one TTS and one behavioral response for fin whales annually.

Minke whales may be exposed to sound or energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that minke whales could be exposed to sound annually from training activities that may result in 9 behavioral responses, 30 TTS, 4 PTS, 1 gastrointestinal tract injury, and 1 slight lung injury (see Table 6-26 for predicted numbers of effects). As with mysticetes overall, effects are primarily predicted within the VACAPES Range Complex, followed by JAX, and Navy Cherry Point Range Complexes. All predicted effects on minke whales would be to the Canadian east coast stock because this is the only stock present within the Study Area.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Long-term consequences to populations would not be expected.

Research and observations (Section 6.1.2.5, Behavioral Reactions) show that if mysticetes are exposed to the sound from explosions they may react in a number of ways which may include alerting; startling; breaking off feeding dives and surfacing; diving or swimming away; or showing no response at all. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual mysticetes or populations.

6.1.7.4.2 Odontocetes

Sperm whales may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts one TTS and one behavioral response for sperm whales per year. Long-term consequences for individuals or populations would not be expected.

Dolphins and small whales (delphinids) may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that delphinids could be exposed to sound that may result in mortality, injury, temporary hearing loss and behavioral responses (see Table 6-26 for predicted numbers of effects). A total of 15 mortalities, 41 slight lung injuries, and 1 gastrointestinal tract injury, 13 PTS, 174 TTS, 91 behavioral responses are predicted per year for delphinids. The majority of these exposures occur within the VACAPES and GOMEX Range Complexes. Most delphinid species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico. Predicted effects on delphinids within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks. Bottlenose dolphins are divided into multiple coastal and one oceanic stock along the east coast. The majority of exposures to bottlenose dolphins from training activities involving explosives would be to the oceanic stock. While the Navy does not anticipate delphinid mortalities from underwater detonations during mine neutralization activities involving time-delay diver placed charges, there is a possibility of a marine mammal approaching too close to an underwater detonation when there is insufficient time to delay or stop without jeopardizing human safety.

Beaked whales may be exposed to sound and energy from explosions associated with training activities throughout the year, although acoustic modeling predicts that no beaked whales would be impacted. Long-term consequences for individuals or populations would not be expected.

Pygmy and dwarf sperm whales (*Kogia* species) may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that pygmy and dwarf sperm whales could be exposed to sound annually that may result in 1 behavioral response, 5 TTS, and 2 PTS (see Table 6-26 for predicted numbers of effects). The majority of these exposures occur within the VACAPES and GOMEX Range Complexes. *Kogia* species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico Oceanic. Predicted effects on pygmy and dwarf sperm whales within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks.

Harbor porpoises may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that harbor porpoises could be exposed to sound that may result in 94 behavioral responses, 497 TTS, 177 PTS, 1 gastrointestinal tract injury, 21 slight lung injuries, and 2 mortalities annually; and 7 TTS and 1 PTS biannually for civilian port defense activities (see Table 6-26 and Table 6-27 for predicted numbers of effects). Research and observations (Section 6.1.2.5, Behavioral Reactions) of harbor porpoises show that this small species is wary of human activity and will avoid anthropogenic sound sources in many situations at levels down to 120 dB re 1 µPa. Harbor porpoises may startle and leave the immediate area of the training exercise but return within a few days after the event ends. As discussed above, harbor porpoises may leave the area before a detonation, allowing the animal to avoid more significant impacts such as hearing loss, injury, or mortality. Significant behavioral reactions seem more likely than with most other odontocetes. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred costs reducing the likelihood of long-term consequences for the individual or population. Predicted impacts on this species are mostly in the VACAPES Range Complex, with a few impacts in the Northeast Range Complex, generally within the Northeast U.S. Continental Shelf Large Marine Ecosystem. All harbor porpoises within the Study Area belong to the Gulf of Maine/Bay of Fundy Stock and therefore all predicted impacts would be incurred to this stock.

Research and observations (Section 6.1.2.5, Behavioral Reactions) show that if odontocetes are exposed to the sound from explosions they may react in a number of ways which may include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, or showing no response at all. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual odontocete or populations.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts. Long-term consequences to populations would not be expected.

Onset mortality and onset slight lung injury criteria use conservative thresholds to predict the onset of effect as discussed in Section 6.1.4, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals. The thresholds are based upon newborn calf masses, and therefore these effects are over-estimated by the acoustic model assuming most animals within the population are larger than a newborn calf. As explained above, at the threshold for onset mortality and onset slight lung injury is the impulse at which one percent of animals exposed would be expected to actually be injured or killed, with likelihood of effect increasing with proximity to the explosion. Considering these factors, these impacts would rarely be expected to actually occur. Nevertheless, it is possible for odontocetes to be injured or killed by an explosion. Most odontocete species have populations in the tens of thousands, so that even if a few individuals in the population were removed, long-term consequences for the population would not be expected.

6.1.7.4.3 Phocid Seals

Phocid seals may be exposed to sound and energy from explosions associated with training activities throughout the year. The acoustic analysis predicts that phocid seals could be exposed to sound that may result in 1 behavioral responses and 2 TTS per year from annually recurring training activities. The predicted effects are in the Northeast Range Complexes within the Northeast U.S. Continental Shelf Large Marine Ecosystem.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Long-term consequences to populations would not be expected.

Research and observations (Section 6.1.2.5, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. Significant behavioral reactions would not be expected in most cases. Overall, predicted effects are low and mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

~~Phocid seals may be exposed to sound and energy from explosions associated with training activities throughout the year, although the acoustic analysis predicts that no phocid seals would be impacted. Long-term consequences for individuals or populations would not be expected.~~

6.1.7.4.4 Conclusion

Training activities under the Proposed Action include the use of explosions as described in Chapter 1, Introduction and Description of Activities. These activities do not overlap bowhead whale, beluga whale, or narwhal habitat. Therefore, it is very unlikely that these marine mammal species would be exposed to noise or energy from explosions.

Pursuant to the MMPA, the use of explosive sources for annually recurring training activities

- *may expose marine mammals up to 912 times annually and 4,560 times over a 5-year period to sound or energy levels that would be considered Level B harassment.*
- *may expose marine mammals up to 262 times annually and 1,310 times over a 5-year period to sound or energy levels that would be considered Level A harassment.*
- *may expose up to 17 marine mammals annually and 85 times over a 5-year period to explosive energy that may cause mortality.*

Pursuant to the MMPA, the use of explosive sources for the training activity civilian port defense conducted biennially

- *may expose marine mammals up to 7 times during each event and 21 times over a 5-year period to sound or energy levels that would be considered Level B harassment.*
- *may expose marine mammals up to 1 times during each event and 3 times over a 5-year period to sound or energy levels that would be considered Level A harassment.*
- *would not be expected to expose marine mammals to sound or energy levels that may cause mortality.*

6.1.7.5 Testing Activities

As described in Chapter 1 (Introduction and Description of Activities), testing activities could use underwater detonations and explosive ordnance throughout the Study Area, but would be concentrated in the VACAPES Range Complex, JAX Range Complex, Northeast Range Complexes, Naval Surface Warfare Center, Panama City Division Testing Range, GOMEX Range Complex, and the Key West Range Complex. A few activities per year also occur outside of Range Complexes, OPAREAS, and Training Ranges, but within the overall AFTT Study Area. These events would be concentrated in the Gulf Stream and Gulf of Mexico Large Marine Ecosystems, with notable numbers of testing activities also occurring in the Southeast and Northeast U.S. Continental Shelf Large Marine Ecosystems and within the North Atlantic Gyre open ocean area. Testing activities using explosions do not normally occur within 3 nm of shore; the exception is the designated underwater detonation area near Naval Surface Warfare Center, Panama City Division Testing Range, which is located nearshore, partially within the surf zone. One aircraft carrier ship shock trial would take place during the 5-year period. This event could take place in one of two locations (VACAPES or JAX Range Complex) during fall, spring, or summer. The aircraft carrier ship shock trial would use up to four 58,000 lb. net explosive weight charges, one at a time on separate days, over a several week period. One guided missile destroyer ship shock trial and two Littoral Combat Ship shock trials would take place during the 5-year period. These ship shock trial would use up to four 14,500 lb. net explosive weight charges, one at a time, over a several week period. These events could take place in the JAX Range Complex during fall, spring, or summer, or year-round within the VACAPES Range Complex.

Predicted acoustic effects on marine mammals from exposure to explosions during annually recurring testing activities are shown in Table 6-28. Approximately 15 percent of modeled activities involve multiple detonations (multiple detonations, as defined for this analysis, are described in Section 6.1 (Estimated Take of Marine Mammals by Impulsive and Non-impulsive Sources) and are therefore evaluated for potential behavioral responses from marine mammals. Predicted effects from shock trials are substantial and are shown in Table 6-29 and Table 6-30.

6.1.7.5.1 Mysticetes

Section 6.1.7.1 (Range to Effects) discusses predicted ranges to specific impacts for low-frequency cetaceans (mysticetes). Impacts are predicted primarily within the VACAPES Range Complex, followed by Naval Surface Warfare Center, Panama City Division Testing Range and Northeast Range Complex, for testing activities other than ship shock trials.

North Atlantic right whales may be exposed to sound or energy from explosions associated with testing activities throughout the year, although the acoustic analysis predicts no impacts on North Atlantic right whales due to annually recurring testing activities or ship shock trials. Testing activities that use explosives would not occur in the North Atlantic right whale mitigation areas, although the sound and energy from explosions associated with testing activities may be detectable within the mitigation areas.

Blue, humpback, and Bryde's whales may be exposed to sound or energy from explosions associated with testing activities throughout the year, although the acoustic analysis predicts that no individuals would be impacted by annually recurring testing activities. The acoustic analysis predicts 1 TTS to a humpback whale and no impacts to blue or Bryde's whales due to ship shock trials over a 5-year period.

Sei whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts 1 TTS for a sei whale yearly due to annually recurring testing activities, and 7 TTS due to exposure to explosive sound and energy from ship shock trials over a 5-year period.

Fin whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts 1 TTS to fin whales per year from annually recurring testing activities and 6 TTS per 5-year period due to ship shock trials.

Minke whales may be exposed to sound or energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts that minke whales could be exposed to sound and energy from explosives annually that may result in 4 behavioral responses, 11 TTS, and 2 PTS, in addition to 41 TTS, 11 slight lung injury, and 3 mortalities due to exposure to explosive sound and energy from ship shock trials over a 5-year period. Based on conservativeness of the onset mortality criteria and impulse modeling (see Section 6.1.4.1 [Mortality and Injury from Explosions] and Section 6.1.5.4 [Model Assumptions and Limitations]); past observations of no marine mammal mortalities associated with ship shock trials [see Section 6.1.3 (Summary of Observations During Previous Navy Activities)], the predicted minke whale mortalities for CVN Ship Shock Trial are considered overestimates and highly unlikely to occur. All predicted effects on minke whales would be to the Canadian East Coast stock because this is the only stock present within the Study Area.

Explosive criteria for predicting onset slight lung injury and onset mortality are based upon newborn calf weights; therefore, these effects are over-estimated by the model, assuming most animals within the population are larger than a newborn calf. Furthermore, as explained in Section 6.1.4.1.1 (Mortality and Slight Lung Injury), the criteria for slight lung injury and mortality is very conservative (e.g., overestimates the effect). The threshold for onset mortality and onset slight lung injury is the impulse at which one percent of animals exposed would be expected to actually be injured or killed, with likelihood of effect increasing with proximity to the explosion. Marine mammal mortalities have not been observed during monitoring of past explosive testing events, including ship shock trials (see Section 6.1.3.2, Observations During Use of Explosives). Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) are designed to avoid potential impacts from underwater detonations, especially higher order effects such as injury or mortality. Considering the above discussion and the low overall number of predicted effects, these effects would rarely be expected to actually occur. Long term consequences for the individual or population would not be expected.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce the predicted impacts. Long-term consequences to populations would not be expected.

Research and observations (Section 6.1.2.5, Behavioral Reactions) show that if mysticetes are exposed to explosions they may react in a number of ways, which may include alerting, startling, breaking off feeding dives and surfacing, diving or swimming away, or showing no response at all. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual mysticetes or populations.

6.1.7.5.2 Odontocetes

Sperm whales may be exposed to sound and energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts behavioral response for 1 sperm whale per year due to annually recurring testing activities; and up to 20 TTS, 6 slight lung injuries, and 2 mortalities for sperm whales over a 5-year period as a result of ship shock trials in the VACAPES or JAX Range Complex. Based on conservativeness of the onset mortality criteria and impulse modeling (see Section 6.1.4.1 [Mortality and Injury from Explosions] and Section 6.1.5.4 [Model Assumptions and Limitations]); past observations of no marine mammal mortalities associated with ship shock trials [see Section 6.1.3 (Summary of Observations During Previous Navy Activities)], the predicted sperm whale mortalities for CVN Ship Shock Trial are considered overestimates and highly unlikely to occur.

Dolphins and small whales (delphinids) may be exposed to sound and energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts that delphinids could be exposed to sound that may result in 10 mortalities, 39 slight lung injuries, 1 PTS, 124 TTS, and 53 behavioral responses per year due to annually recurring testing activities (see Table 6-28 for predicted numbers of effects). Annual predicted explosive impacts on delphinids occur primarily in the

VACAPES Range Complex, as well as the Naval Surface Warfare Center, Panama City Division Testing Range but a few impacts could occur throughout the Study Area. The acoustic analysis predicts that delphinids could be exposed to sound that may result in 5,386 TTS, 7,743 slight lung injuries, and 527 mortalities over a 5-year period during ship shock trials which would take place in either the VACAPES or JAX Range Complex (Table 6-29 and Table 6-30). Based on conservativeness of the onset mortality criteria and impulse modeling (see Section 6.1.4.1 [Mortality and Injury from Explosions] and Section 6.1.5.4 [Model Assumptions and Limitations]); past observations of no marine mammal mortalities associated with ship shock trials [see Section 6.1.3 (Summary of Observations During Previous Navy Activities)], and implementation of mitigation [see Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts- Mitigation Measures)], the mortality results predicted by the acoustic analysis are over-estimated and are not expected to occur. Therefore, the Navy conservatively estimates that 10 small odontocetes mortalities could occur during the CVN Ship Shock Trial and 5 small odontocetes mortalities could occur due to each DDG or LCS Ship Shock Trial. Most delphinid species are separated into two stocks within the Study Area: the Western North Atlantic and Gulf of Mexico. Predicted effects on delphinids within the Gulf of Mexico are presumed to primarily impact the Gulf of Mexico stocks, whereas the majority of effects predicted offshore of the east coast would impact the Western North Atlantic stocks. Bottlenose dolphins are divided into multiple coastal and one oceanic stock along the east coast. The majority of exposures to bottlenose dolphins are likely to the oceanic stocks.

Beaked whales may be exposed to sound and energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts that no beaked whales would be impacted due to annually recurring testing activities. The acoustic analysis predicts 7 TTS and 15 slight lung injuries to beaked whale species over a 5-year period due to ship shock trials.

Pygmy and dwarf sperm whales (*Kogia* species) may be exposed to sound and energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts that pygmy or dwarf sperm whales could be exposed to energy or sound from underwater explosions that may result in 1 behavioral response, 2 TTS, and 1 PTS per year as a result of annually recurring testing activities. These impacts could happen anywhere throughout the Study Area where testing activities involving explosives occur. Additionally, the acoustic analysis predicts 6 TTS, 1 PTS, and 3 slight lung injury to a *Kogia* species over a 5-year period due to ship shock trials either in the VACAPES or JAX Range Complex.

Harbor porpoises may be exposed to sound and energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts that harbor porpoises could be exposed to sound that may result in 485 behavioral responses, 348 TTS, 110 PTS, 7 slight lung injuries, and 1 mortality per year due to annually recurring testing activities. Predicted impacts on this species are primarily within the VACAPES and Northeast Range Complexes. Impacts would primarily occur within the Northeast U.S. Continental Shelf Large Marine Ecosystem. The acoustic analysis predicts no impacts on harbor porpoises as a result of ship shock trials. All harbor porpoises within the Study Area belong to the Gulf of Maine/Bay of Fundy Stock and therefore, all predicted impacts would be to this stock. Research and observations (Section 6.1.2.5, Behavioral Reactions) of harbor porpoises show that this species is wary of human activity and will avoid anthropogenic sound sources, in many situations at levels down to 120 dB re 1 µPa. Harbor porpoises may startle and leave the immediate area of the testing exercise, but return within a few days after the event ends. Animals may also leave the area before an event begins based on activity related to underwater detonation placement or target area set-up. Therefore, these animals could avoid more significant impacts such as hearing loss, injury, or mortality. Significant behavioral reactions are more likely than with most other marine mammals. Animals that do exhibit a significant behavioral reaction would likely recover from any incurred cost reducing the likelihood of long-term consequences for the individual. Any long-term consequences, such as reduced fitness to a few individuals, are unlikely to cause long-term consequences for harbor porpoise populations.

Research and observations (Section 6.1.2.5, Behavioral Reactions) show that if delphinids are exposed to explosions, they may react by alerting, ignoring the stimulus, changing their behaviors or vocalizations, or avoiding the area by swimming away or diving. Overall, predicted effects are low. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

Onset mortality and onset slight lung injury criteria use conservative thresholds to predict the onset of effect as discussed in Section 6.1.4, Thresholds and Criteria for Predicting Acoustic and Explosive Impacts on Marine Mammals. The threshold for onset mortality and onset slight lung injury is the impulse at which one percent of animals exposed would be expected to actually be injured or killed, with likelihood of effect increasing with proximity to the explosion. The thresholds are based upon newborn calf masses; and therefore, these effects are over-estimated by the acoustic model, assuming most animals within the population are larger than a newborn calf. Marine mammal mortalities have not been observed during monitoring of past explosive testing events, including ship shock trials (see Section 6.1.3.2, Observations During Use of Explosives). Considering these factors, and the mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) that are designed to avoid higher order effects such as injury and death, these impacts would rarely be expected to actually occur. Nevertheless, it is possible for odontocetes to be injured or killed by an explosion. Most odontocetes species have populations in the tens of thousands, so that even if a few individuals in the population were removed, long-term consequences for the population would not be expected.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Long-term consequences to populations would not be expected.

6.1.7.5.3 Phocid Seals

Phocid seals may be exposed to sound and energy from explosions associated with testing activities throughout the year. The acoustic analysis predicts that phocid seals could be exposed to sound that may result in 15 behavioral responses, 15 TTS, and 2 PTS per year from annually recurring testing activities. The predicted effects are in the Northeast Range Complexes within the Northeast U.S. Continental Shelf Large Marine Ecosystem. The model predicts no impacts on phocid seals from exposure to explosive energy and sound associated with ship shock trials.

Recovery from a threshold shift (i.e., partial hearing loss) can take a few minutes to a few days, depending on the severity of the initial shift. PTS would not fully recover. Threshold shifts do not necessarily affect all hearing frequencies equally, so some threshold shifts may not interfere with an animal hearing biologically relevant sounds. It is uncertain whether some permanent hearing loss over a part of a marine mammal's hearing range would have long-term consequences for that individual, although many mammals lose hearing ability as they age. Long-term consequences to populations would not be expected.

Research and observations (Section 6.1.2.5, Behavioral Reactions) show that pinnipeds in the water are tolerant of anthropogenic noise and activity. Significant behavioral reactions would not be expected in most cases. Overall, predicted effects are low and mitigation measures discussed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) would further reduce potential impacts. Occasional behavioral reactions to intermittent explosions are unlikely to cause long-term consequences for individual animals or populations.

6.1.7.5.4 Conclusion

Testing activities under the Proposed Action include the use of explosions as described in Chapter 1, Introduction and Description of Activities. These activities do not overlap bowhead whale, beluga whale, or narwhal habitat. Therefore, it is very unlikely that these marine mammal species would be exposed to noise or energy from explosions.

Pursuant to the MMPA, the use of explosive sources for annually recurring testing activities

- *may expose marine mammals up to 1,061 times annually and 5,305 times over a 5-year period to sound or energy levels that would be considered Level B harassment.*
- *may expose marine mammals up to 162 times annually and 810 times over a 5-year period to sound or energy levels that would be considered Level A harassment.*
- *may expose up to 11 marine mammals annually and 55 times over a 5-year period to explosive energy that may cause mortality.*

Pursuant to the MMPA, the use of explosive sources for the testing activity aircraft carrier ship shock trial conducted once per 5-year period

- *may expose marine mammals up to 4,607 times to sound or energy levels that would be considered Level B harassment.*
- *may expose marine mammals up to 6,591 times to sound or energy levels that would be considered Level A harassment.*
- *though the model estimates up to 445 marine mammal mortalities may occur, based on conservativeness of the model criteria discussed above and in sections 6.1.4.1.1 (Mortality and Slight Lung Injury) and 6.1.7.3 (Predicted Impacts) and past monitoring results discussed in Section 6.1.3 (Summary of Observations During Previous Navy Activities), this event may expose marine mammals up to 10 times over a 5-year period to explosive energy that may cause mortality.*

Pursuant to the MMPA, the use of explosive sources for the testing activity guided missile destroyer and Littoral Combat Ship shock trials conducted three times per 5-year period

- *may expose marine mammals up to 867 times over a 5-year period to sound or energy levels that would be considered Level B harassment.*
- *may expose marine mammals up to 1,188 times over a 5-year period to sound or energy levels that would be considered Level A harassment.*
- *though the model estimates up to 87 marine mammals mortalities may occur, based on conservativeness of the model criteria discussed above and in sections 6.1.4.1.1 (Mortality and Slight Lung Injury) and 6.1.7.3 (Predicted Impacts) and past monitoring results discussed in Section 6.1.3 (Summary of Observations During Previous Navy Activities)], this event may expose marine mammals up to 15 times over a 5-year period to explosive energy that may cause mortality.*

6.1.8 IMPACTS FROM PILE DRIVING

Construction of the elevated causeway system, a temporary pier allowing offloading of supply ships, would require pile driving and pile removal. Construction of the elevated causeway system during training would only occur once per year under the Proposed Action at one of the following locations: in the VACAPES Range Complex (Joint Expeditionary Base West [Little Creek], Virginia or Joint Expeditionary Base East [Fort Story], Virginia) or in the Navy Cherry Point Range Complex (Marine Corps Base Camp Lejeune, North Carolina). The length of the pier, and therefore the number of piles required, would be determined by the distance from shore to the appropriate water depth for ship off-loading. Construction of the elevated causeway system would occur once per year at one of three locations.

Impact pile driving creates repetitive impulsive sound. An impact pile driver generally operates in the range of 36 to 50 blows per minute. Vibratory pile driving creates a nearly continuous sound made up of a series of short duration rapid impulses at a much lower source level than impact pile driving. The sounds are emitted both in the air and in the water.

The intensity of pile driving sounds is influenced by the type of piles, hammers, and the physical environment in which the activity takes place. Table 6-31 shows representative airborne pile driving sound pressure levels that have been recorded from other construction activities in recent years. Although the airborne sound emitted during pile driving and removal would be influenced by site characteristics, these represent reasonable sound pressure levels that could be anticipated.

Table 6-31. Airborne Sound Pressure Levels from Representative Pile Driving Events

Project & Location	Pile Size & Type	Installation Method	Water Depth	Measured Sound Pressure Levels
Friday Harbor Ferry Terminal, WA[1]	24-in. Steel Pipe Pile	Impact	~12 m (40 ft.)	112 dB re 20 µPa (rms) at 160 ft.
Keystone Ferry Terminal, WA[2]	30-in. Steel Pipe Pile	Vibratory	~9 m (30 ft.)	98 dB re 20 µPa (rms) at 36 ft.

Sources: [1](Laughlin 2005) [2](Laughlin 2010)
rms: root mean square; WA: Washington

Pile driving for elevated causeway system training would occur in shallower water, and sound could be transmitted on direct paths through the water, be reflected at the water surface or bottom, or travel through bottom substrate. Soft substrates such as sand bottom at the proposed elevated causeway system locations, would absorb or attenuate the sound more readily than hard substrates (rock), which may reflect the acoustic wave. Most acoustic energy would be concentrated below 1,000 Hz. Average underwater sound levels for driving piles similar to those that would be installed for elevated causeway systems are shown in Table 6-32.

Table 6-32. Average Pile Driving Underwater Sound Levels

Pile Size &Type	Installation Method	Water Depth	Average Sound Pressure Level (peak)	Average Sound Pressure Level (rms)
0.61-m (24 in.) Steel Pipe Pile	Impact	5 m (15 ft.)	203 dB re 1 µPa (peak) at 10 m*	190 dB re 1 µPa (rms) at 10 m*
0.61-m (24 in.) Steel Pipe Pile	Vibratory	<7 m (23 ft.)	170 dB re 1 µPa (peak) at 10 m**	151 dB re 1 µPa (rms) at 10 m**

*(California Department of Transportation 2009)
**(Illingworth & Rodkin 2010)
dB: decibel; ft.: foot; in.: inch; m: meter; µPa: micro pascal; rms: root mean square

6.1.8.1 Predicted Effects

Underwater noise effects from pile driving were modeled using a conservative estimate of geometric spreading loss of sound in shallow coastal waters. A spreading loss of 15*Log(radius) was used to estimate range (r) to the relevant pile driving criteria. A calculation of marine mammal exposures is then estimated by:

- Exposure estimate = $(n * \pi r^2)/2$ * days of pile installation/removal

  Where:

  n = density estimate used for each species/season
  r = range to pile driving noise criteria threshold(s)
  $\pi \approx 3.1415926$

The exposure estimate was calculated separately for the impact and the vibratory pile driving activities and combined to predict the total number of expected exposures. Four species of marine mammals have a density estimate occurring near the coastal pile driving locations. The highest density estimate was for bottlenose dolphins around Joint Expeditionary Base Little Creek-Fort Story, Virginia Beach, VA. An average density of 13.75 animals per square kilometer was derived from Barco et al. (1999) for the coastal areas near the base. The resulting tables of marine mammal exposures are listed in Table 6-33 and Table 6-34.

Table 6-33. Predicted Effects on Marine Mammals from Pile Driving Activities Associated with the Construction and Removal of the Elevated Causeway System at Joint Expeditionary Base Fort Story or Little Creek, Virginia

Species	Impact Pile Driving		Vibratory Pile Driving		Total Predicted Exposures	
	Level A 180 dB rms	Level B 160 dB rms	Level A 180 dB rms	Level B 120 dB rms	MMPA Level A	MMPA Level B
Bottlenose Dolphin	1	302	0	294	1	596
North Atlantic Right Whale	0	0	0	0	0	0
Fin Whale	0	0	0	0	0	0
Humpback Whale	0	0	0	0	0	0

Note: This represents a single event at either location; Effect predictions were identical due to the proximity of the proposed sites.
rms: root mean square

Table 6-34. Predicted Effects on Marine Mammals from Pile Driving Activities Associated with the Construction and Removal of the Elevated Causeway System at Marine Corps Base Camp Lejeune, North Carolina

Species	Impact Pile Driving		Vibratory Pile Driving		Total Predicted Exposures	
	Level A 180 dB rms	Level B 160 dB rms	Level A 180 dB rms	Level B 120 dB rms	MMPA Level A	MMPA Level B
Bottlenose Dolphin	0	4	0	743	0	747
North Atlantic Right Whale	0	0	0	0	0	0
Fin Whale	0	0	0	0	0	0
Humpback Whale	0	0	0	0	0	0

rms: root mean squared

6.1.8.2 Training Activities

Training activities under the Proposed Action include pile driving associated with constructing and removing the elevated causeway system. This activity would take place nearshore and within the surf zone, once per year at either Marine Corps Base Camp Lejeune, North Carolina; Joint Expeditionary Base Fort Story, Virginia; or Joint Expeditionary Base Little Creek, Virginia. The two areas in Virginia are located within the Northeast U.S. Continental Shelf Large Marine Ecosystem, and the area in North Carolina is located within the Southeast U.S. Continental Shelf Large Marine Ecosystem. The pile driving locations are adjacent to Navy pierside locations in industrialized waterways that carry a high volume of vessel traffic in addition to Navy vessels using the pier. These coastal areas tend to have high ambient noise levels due to natural and anthropogenic sources and have limited numbers of sensitive marine mammal species present.

Impulses from the impact hammer are broadband and carry most of their energy in the lower frequencies. The impulses are within the hearing range of most marine mammals and can produce a shock wave that is transmitted to the sediment and water column (Reinhall and Dahl 2011). Impact pile driving has the potential to cause some permanent hearing loss if the animal is exposed within 47 meters of the pile driving location. However, given the low abundance of marine mammals and the short duration of the activity, it is very unlikely that a marine mammal would be exposed to sound levels high enough to cause injury.

Beyond this range to effects for impact pile driving, only behavioral impacts are expected to occur out to a maximum distance of 1 km. The impulses produced are less than 1 second each and can occur at a rate of 30-50 impulses per minute. Despite the short duration of each impulse, the rate of impulses has the potential to result in some auditory masking in marine mammals and has the potential to cause some temporary physiological stress. However, given the low abundance of marine mammals, the short duration of the activity, and the likelihood that an exposed animal will avoid the immediate area, it is unlikely that a marine mammal would be exposed to noise that would result in a prolonged behavioral response, and any behavioral effect would be temporary and not significant.

Sound produced from a vibratory hammer is similar in frequency range as that of the impact hammer, except the source levels are much lower than the impact hammer. Since the vibrations oscillate at a rate of 1,700 cycles per minute, the sound source is treated as a continuous sound source in this assessment. The range to effect for the injury zone at less than 3 m is much smaller than the impact pile driving range. Given the low abundance of marine mammals and the mitigation measures, it is unlikely that a marine mammal would be exposed to injurious levels of sound from the vibratory hammer. Though the vibratory hammer produces a much lower source level than the impact hammer, marine mammal behavioral effects can occur out to a range of 22 km due to a much lower behavioral threshold (sound pressure level of 120 dB re 1µPa). Therefore, the potential to behaviorally affect marine mammals is greater, although the threshold used likely overestimates the number of biologically significant reactions, especially at ranges greater than a few kilometers. The vibratory hammer has the potential to cause auditory masking in marine mammals, but the effect would be temporary and would result in the animals most likely avoiding the immediate area if the effects were to be significant to the individuals. Any avoidance of the area is expected to be temporary and only occur while the vibratory hammer is in use.

6.1.8.2.1 Conclusion

Pile driving activities associated with training under the Proposed Action may cause nearshore species of marine mammals (e.g., bottlenose dolphins) to avoid the area near the event, although the activity potentially impacts a small area over a short duration and happens infrequently (once per year). Therefore, long-term consequences to individuals or populations are unlikely. Proposed activities do not overlap the habitats of blue whale, sperm whale, sei whale, bowhead whale, or ringed seal. Therefore, these species would not be impacted by pile driving noise. Pile driving activities do not occur within or near North Atlantic right whale critical habitat and therefore would not affect this resource.

Pursuant to the MMPA, the use of pile driving for training activities under the Proposed Action

- *may expose bottlenose dolphins to sound levels up to 747 times per year and 3,735 times over a 5-year period that would be considered Level B harassment.*
- *is not expected to result in Level A harassment of marine mammals.*

The conclusions above are presented without full consideration of mitigation measures presented in Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures.

6.1.9 ESTIMATED TAKE OF LARGE WHALES BY VESSEL STRIKE

Marine mammals that spend extended periods at or just below the surface or are unresponsive to vessel sound are thought to be susceptible to vessel collisions (Gerstein 2002; Laist and Shaw 2006; Nowacek et al. 2004). Marine mammals such as dolphins, porpoises and pinnipeds that can move quickly throughout the water column are not as susceptible to vessel strikes.

Species specific information available on marine mammals involved in vessel strikes in the Study Area comes from NMFS, Northeast Science Center and Southeast Science Center (unpublished data 1995-2012). These data are from all types of vessels (Navy, commercial and recreational), but give an indication of which species are vulnerable to ship strike in the Study Area. Records indicate the following percentage of strikes by species: humpback whale (28 percent), North Atlantic right whale (19 percent), fin whale (17 percent), unknown species (16 percent), sei whale (6 percent), minke whale (5 percent), Cuvier's beaked whale (3 percent), Bryde's whale (2 percent), sperm whale (2 percent), Blainville's beaked whale (1 percent), and Gervais' beaked whale (1 percent). Data and information specific to the occurrence and impact of vessel strikes to a species or group are summarized in the following sections.

Mysticetes- Research suggests that the increasing noise in the ocean has made it difficult for whales to detect approaching vessels, which has indirectly raised the risk of vessel strike (Elvin and Taggart 2008). Some individuals may become habituated to low-frequency sounds from shipping and fail to respond to an approaching vessel (National Marine Fisheries Service 2008a). Because surface activity includes feeding, breeding, and resting, whales may be engaged in this activity and not notice an approaching vessel (Silber and Bettridge 2010). Even if they were to hear the vessel, most mysticetes generally move too slowly to avoid vessels approaching at high speeds.

Vessels strikes are generally a threat to mysticete species that forage at or near the surface (Waring et al. 2010). Some areas in the Northeast Range Complexes are important feeding areas to these species in the summer months, so strike risk would be higher while these whales are on the feeding grounds.

Vessel strikes are considered a primary threat to North Atlantic right whale survival (Firestone 2009; Fonnesbeck et al. 2008; Knowlton and Brown 2007; Nowacek et al. 2004; Vanderlaan et al. 2009; Vanderlaan et al. 2008). Studies of North Atlantic right whales tagged in April 2009 on the Stellwagen Bank feeding grounds found that right whales spent most of their time at a depth of 6.5 ft. (2 m), which makes them less visible at the water's surface (Bocconcelli 2009; Parks and Wiley 2009). The Navy will continue to implement mitigation measures in important North Atlantic right whale foraging, calving, and migration habitats. These measures, including increased awareness, funding and communication with sightings systems, and specialized training on North Atlantic right whale observations and are detailed in Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures. These measures will likely reduce the risk of a strike to the point that a strike of this species is not likely to occur, and will likely reduce the risk of strike to all marine mammals.

Odontocetes - Based on NMFS vessel strike data (unpublished data 1995-2012), vessel strikes to odontocetes have been reported for the following species: killer whale (Van Waerebeek et al. 2007; Visser and Fertl 2000), short-finned and long-finned pilot whales (Aguilar et al. 2000; Van Waerebeek et al. 2007), bottlenose dolphin (Bloom and Jager 1994; Van Waerebeek et al. 2007; Wells and Scott 1997), white-beaked dolphin (Van Waerebeek et al. 2007), short-beaked common dolphin (Van Waerebeek et al. 2007), spinner dolphin (Camargo and Bellini 2007; Van Waerebeek et al. 2007), striped dolphin (Van Waerebeek et al. 2007), Atlantic spotted dolphin (Van Waerebeek et al. 2007), and pygmy sperm whales (*Kogia breviceps*) (Van Waerebeek et al. 2007). Beaked whales documented in vessel strikes include Arnoux's beaked whale (Van Waerebeek et al. 2007), Cuvier's beaked whale (Aguilar et al. 2000; Van Waerebeek et al. 2007), and several species of *Mesoplodon* (Van Waerebeek et al. 2007). Sperm whales are vulnerable to vessel strikes when they spend extended periods of time "rafting" at the surface to restore oxygen levels within their tissues after deep dives (Jaquet and Whitehead 1996; Watkins et al. 1999).

Most vessel strikes of marine mammals reported involve commercial vessels and occur over or near the continental shelf (Laist et al. 2001). Navy vessels operate differently from commercial vessels in ways important to the prevention of whale collisions. The ability of a ship to detect a marine mammal and avoid a collision depends on a variety of factors including environmental conditions, ship design, vessel size, number of watch personnel, and the behavior of the animal. The majority of ships participating in AFTT training and testing activities have a number of advantages for avoiding ship strikes compared to most commercial or private vessels. Key points in discussion of Navy vessels in relationship to potential ship strike include:

- Many Navy 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.
- Navy ships are generally much more maneuverable than commercial merchant vessels if marine mammals are spotted and the need to change direction necessary. Navy ships operate at the slowest speed possible consistent with either transit needs, or training or testing need (see Section 1.6.4 [Other Stressors – Vessel Strikes]). While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include better ability to spot and avoid objects in the water including marine mammals.
- Navy overall crew size is much larger than merchant ships allowing for more potential observers on the bridge. At all times when vessels are underway, trained lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including marine mammals. Additional lookouts, beyond already stationed bridge watch and navigation teams, are stationed during some training events.
- Navy lookouts receive extensive training including Marine Species Awareness Training designed to provide marine species detection cues and information necessary to detect marine mammals.

Additional information on mitigation measure designed to reduce the potential impact of vessel strikes on marine mammals is provided in Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures.

To determine the appropriate number of MMPA incidental takes for potential vessel strikes, the Navy assessed the probability of Navy vessels hitting individuals of different species of large whales that occur in the AFTT Study Area incidental to specified training and testing activities. To do this, the Navy considered unpublished ship strike data compiled and provided by NMFS, Northeast Science Center and Southeast Science Center (1995-2012) and information in this application regarding trends in the amount of vessel traffic related to their training and testing activities in the HSTT Study Area. It is Navy policy (Chief of Naval Operations Instruction [OPNAVINST] 3100.6) to report any marine mammal strikes by Navy vessels. By an informal agreement, the information is collected by Office of the Chief of Naval Operations Environmental Readiness and provided to NMFS on an annual basis. Only Navy and the U.S. Coast Guard report vessel strike in this manner so all statistics are skewed by a lack of comprehensive reporting by all vessels that may experience vessel strike.

6.1.9.1 AFTT Historic Navy Vessel Strikes

The majority of the training and testing activities under the Proposed Action involve some level of vessel activity. Section 1.6.4 (Other Stressors – Vessel Strikes) discusses the types of activities that include the use of vessels, where they are used, and the speed and size characteristics of vessels used.

Navy and NMFS reports for the Study Area (unpublished data, 1995-2012) indicate that between 1995 and March 2012, Navy vessels were involved in 19 large whale strikes (see Figure 6-16). Eight of the strikes resulted in a confirmed death; but in 11 of the 19 strikes, the fate of the animal was undetermined. It is possible that some of the 11 reported strikes resulted only in recoverable injury or were not marine mammals at all, but another large marine species (e.g., whale shark). However, it is prudent to consider that all the strikes could have resulted in the death of a marine mammal. The maximum number of strikes in any given year was three strikes, which occurred in the years 2001 and 2004. The highest average number of strikes over any 5-year period was two strikes per year from 2001 to 2005. The average number of strikes for the entire 18-year period is 1.055 strikes per year. Since the implementation of the U.S. Navy's Marine Species Awareness Training in 2007, strikes in the Study Area have decreased to an average of 0.5 strikes per year. Over the last 5 years on the east coast, the Navy was involved in only two strikes, with no confirmed marine mammal deaths as the result of a vessel strike.

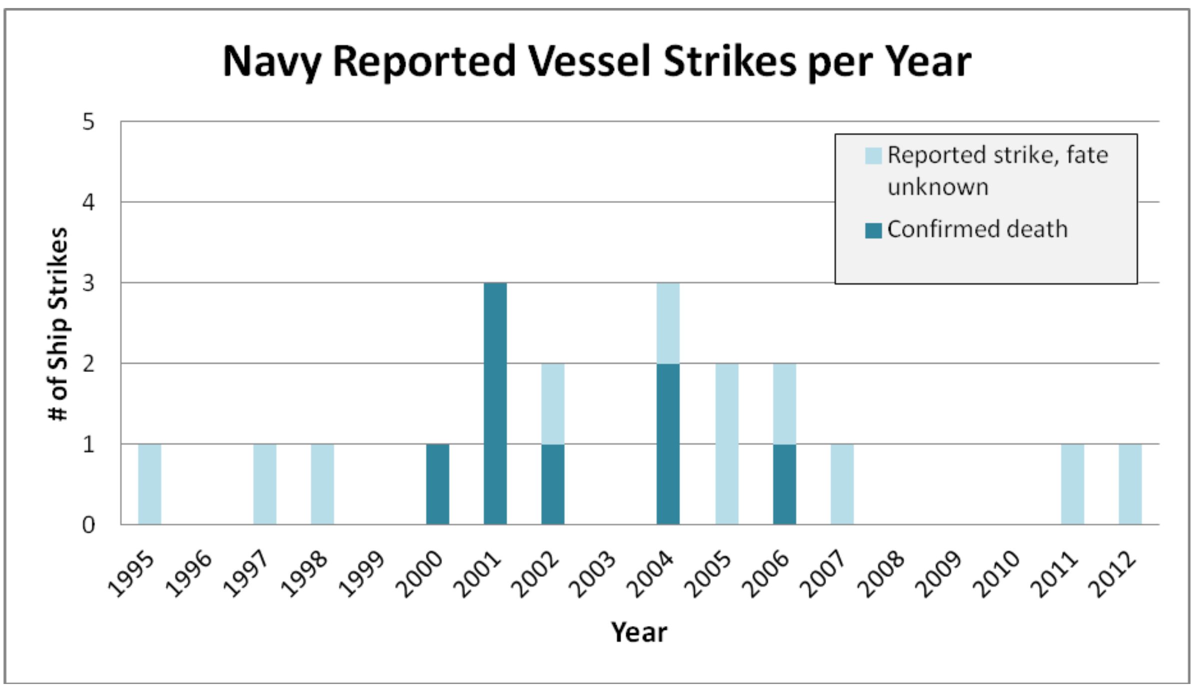


Figure 6-16. Navy Vessel Strikes by Type and Year (1995-2012)

6.1.9.2 Probability of Navy Ship Strike of Large Whale Species

To calculate the probability of a Navy vessel striking a whale from training activities in the Study Area, the Navy used the probability of a strike estimated from the 1995—2012 Navy and NMFS vessel strike data (unpublished data, 1995-2012). There were 19 reported whale strikes during this 18-year period; thus, the probability of a collision between a Navy vessel and a whale = 1.055 (19 strikes/18 years). These values were used as the rate parameter to calculate a series of Poisson probabilities (a Poisson distribution is often used to describe random occurrences when the probability of an occurrence is small (e.g., count data such as cetacean sighting data, or in this case strike data, are often described as a Poisson or over-dispersed Poisson distribution). To estimate the Poisson probabilities of 1, 2, 3, 4, 5 etc. occurrences, a simple computation can be generated: $P(X) = P(X-1)\mu/X$.

$P(X)$ is the probability of occurrence in a unit of time (or space), and μ is the mean number of occurrences in a unit of time (or space). For the 18-year period from 1995—2012, μ is assumed to equal to 1.055.

To estimate zero occurrences (in this case, no whales being struck), the formula $P(0)=e^{-\mu}$ would apply. Inserting 1.055 into the equation yields a value of P(0) = 0.3482, hence the statement “there is slightly more than a 63 percent probability of a large whale of any species not being struck by a Navy vessel in the Study Area.” Thus, continuing the computation series:

P(1) = (0.3482 * 1.055)/1 = 0.3673 (or a 37 percent probability of striking one whale in 1 year)
P(2) = (0.3673 * 1.055)/2 = 0.1938 (or a 19 percent probability of striking two whales in 1 year)
P(3) = (0.1938 * 1.055)/3 = 0.0681 (or a 7 percent probability of striking three whales in 1 year)
P(4) = (0.0681 * 1.055)/4 = 0.0180 (or a 2 percent probability of striking four whales in 1 year)
P(5) = (0.0180 * 1.055)/5 = 0.0038 (or a 0.3 percent probability of striking five whales in 1 year)

While the Poisson distribution shows that the probability of striking three or more whales in a single year is low, it did occur in the years 2001 and 2004. When averaging the available data over 5-year increments, the highest average over a period for which data are available is two strikes per year.

6.1.9.3 Training Activities

Based on available NMFS data (unpublished data 1995-2012) and a consideration of mitigation measures (Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), the Navy predicts that the fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species have the potential to be struck by a vessel as a result of training activities in the Study Area. A number of the reported whale strikes were unidentified to species; therefore, the Navy cannot quantifiably predict that the proposed takes will be of any particular species. During training activities, vessels may transit into bowhead whale or ringed seal habitat areas; however, these transits are expected to be very infrequent and the Navy does not anticipate it will strike these species. Therefore, the Navy is seeking take authorization for a combination of the following species: fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species. The Navy estimates it may strike and take, by injury or mortality, an average of two marine mammals per year, with a maximum of three in any given year. Of the ESA-listed species in the Study Area, the Navy anticipates no more than three humpback whales, two fin whales, one sei whale, one blue whale, and one sperm whale would be struck over a 5-year period based on the percentages that those species have been involved in vessel collisions. The Navy does not anticipate it will strike a North Atlantic right whale as a result of training activities because of the extensive measures in place to reduce the risk of a strike to the species. Refer to Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) for a full list of these measures.

Pursuant to the MMPA, the use of vessels during training activities under the Proposed Action

- *may result in Level A harassment or mortality to the fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species.*
- *is not expected to result in Level B harassment of marine mammals.*

6.1.9.4 Testing Activities

Of the 19 reported Navy vessel strikes since 1995, only one strike was attributed to a testing event in 2001. Therefore, for testing events that will not occur on a training platform, the Navy estimates it could potentially take one marine mammal by injury or mortality over the course of the 5-year AFTT regulations. A number of the reported whale strikes were unidentified to species; therefore, the Navy cannot quantifiably predict that the proposed takes will be of any particular species. The Navy seeks take authorization for any the following species: fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, or unidentified whale species. The Navy does not anticipate it will strike a North Atlantic right whale as a result of testing activities because of the extensive measures in place to reduce the risk of a strike to the species. Refer to Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) for a full list of these measures.

Pursuant to the MMPA, the use of vessels during testing activities under the Proposed Action

- *may result in Level A harassment or mortality of a fin whale, humpback whale, minke whale, sei whale, Bryde's whale, sperm whale, blue whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, and unidentified whale species.*
- *is not expected to result in Level B harassment of marine mammals.*

6.2 Summary of All Estimated Numbers and Species Taken

The summary of the Navy’s final take request based on the analysis in Section 6 (Numbers and Species Taken) is provided in Table 5-1 and Table 5-2.

7 IMPACTS ON MARINE MAMMAL SPECIES OR STOCKS

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 Tables 5-1 and 5-2 represent estimated takes under the MMPA, they are conservative (i.e., over predictive) estimates, primarily by behavioral disturbance.
- The mitigation measures described in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) are designed to reduce sound exposure and explosive effects on marine mammals to levels below those that may cause injury and to achieve the least practicable adverse effect on marine mammal species or stocks.
- Range complexes where intensive training and testing have been occurring for decades have populations of multiple species with strong site fidelity (including resident beaked whales at some locations) and increases in the number of some species.

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. This overestimates reactions qualifying as harassment under MMPA because there is no established scientific correlation between short-term sonar use, underwater detonations, and pile driving and pile removal, and long term abandonment or significant alteration of behavioral patterns in marine mammals.

Consideration of negligible impact is required for NMFS to authorize incidental take of marine mammals. By definition, 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.

A sound-producing activity can cause a variety of behavioral reactions in animals ranging from very minor and brief, to more severe reactions such as aggression or prolonged flight. The acoustic stimuli can cause a stress reaction (i.e., startle or annoyance); they may act as a cue to an animal that has experienced a stress reaction in the past to similar sounds or activities, or that acquired a learned behavioral response to the sounds from conspecifics. An animal may choose to deal with these stimuli or ignore them based on the severity of the stress response, the animal's past experience with the sound, and the other stimuli that are present in the environment. If an animal chooses to react to the acoustic stimuli, then the behavioral responses fall into two categories: alteration of natural behavior patterns and avoidance. The specific type and severity of these reactions helps determine the costs and ultimate consequences to the individual and population.

The potential costs to a marine animal from an involuntary or behavioral response include no measurable cost, expended energy reserves, increased stress, reduced social contact, missed opportunities to secure resources or mates, displacement, and stranding or severe evasive behavior (which may potentially lead to secondary trauma or death). Animals suffer costs on a daily basis from a host of natural situations such as dealing with predator or competitor pressure. If the costs to the animal from an acoustic-related activity fall outside of its normal daily variations, then individuals must recover from significant costs to avoid long-term consequences.

The importance of the disruption and degree of consequence for individual marine mammals often has much to do with the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as sonar use, underwater detonation, and pile driving and pile removal events within the Study Area usually have minimal consequences or no lasting effects for marine mammals. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences. However, prolonged disturbance, as might occur if a stationary and noisy activity were established near a concentrated area, is a more important concern. The long-term implications would depend on the degree of habituation within the population. If the marine mammals fail to habituate or become sensitized to disturbance and, as a consequence, are excluded from an important area or are subject to stress while at the important area, long-term effects could occur to individuals or the population.

The Context of Behavioral Disruption and TTS–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 using applicable criteria. Consequences to populations are much more difficult to predict and empirical measurement of population effects from anthropogenic stressors is limited (National Research Council 2005). To predict indirect, long-term, and cumulative effects, 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 Population Consequences of Acoustic Disturbance framework. 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 robust mitigation procedures proposed in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), AFTT training and testing activities are anticipated to have a negligible impact on marine mammals within the Study Area.

Conclusion. The Navy concludes that the proposed training and testing activities would result in Level B, Level A, or mortality takes, as summarized in Table 5-1 and 5-2. Based on best available science, the Navy concludes that exposures to marine mammal species and stocks due to the Proposed Action would result in only short-term effects on most individuals exposed and would likely not affect annual rates of recruitment or survival for the following reasons:

- Most non-impulsive and impulsive acoustic exposures are within the non-injurious TTS or behavioral effects zones (Level B harassment);
- Although the numbers presented in Table 5-1 and Table 5-2 represent estimated takes under MMPA thresholds, they are overpredictive estimates of harassment, primarily by behavioral disturbance; and

- The protective measures described in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) are designed to reduce vessel strike potential and sound exposure to levels below those that may cause injurious impacts and to achieve the least practicable adverse effect on marine mammal species or stocks.

An analysis of the potential impacts of the proposed activities on species recruitment or survival is presented in Chapter 6 (Numbers and Species Taken) for each species or species group, based on life history information, estimated take levels, and an analysis of estimated take levels in comparison to the overall population. The species-specific analyses, in combination with the mitigation measures provided in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures) support the conclusion that proposed training and testing activities would have a negligible impact on marine mammal species or stocks within the Study Area.

8 IMPACTS ON SUBSISTENCE USE

Potential marine mammal impacts resulting from the Proposed Action will be limited to individuals located in the Study Area that have no subsistence requirements. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

9 IMPACTS ON MARINE MAMMAL HABITAT AND THE LIKELIHOOD OF RESTORATION

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 AFTT EIS/OEIS and was determined to have no impact on marine mammal habitat. A summary of the analysis from the AFTT EIS/OEIS is included below.

One NMFS-managed marine mammal species, the North Atlantic right whale, has designated critical habitat in the Study Area (Figure 4-1). After an assessment of the potential impacts of training and testing activities on marine mammal critical habitat in the Study Area, the Navy has determined that acoustic sources, energy sources, physical disturbances and strikes, entanglement, ingestion, and indirect stressors will have no effect on the assumed primary constituent elements of the North Atlantic right whale critical habitat (i.e., water temperature and depth in the southeast and copepods in the northeast).

Water Quality. The AFTT EIS/OEIS analyzed the potential effects on water quality from military expended materials. Training and testing activities may introduce water quality constituents into the water column. Based on the analysis of the AFTT 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. For example, in the case of Royal Demolition Explosive, 98 percent of the products are common seawater constituents and the remainder is rapidly diluted below threshold effect level. Explosion by-products associated with high order detonations present no secondary stressors to marine mammals through sediment or water. However, low order detonations and unexploded ordnance present elevated likelihood of impacts on marine mammals.

Indirect effects of explosives and unexploded ordnance to marine mammals via sediment is possible in the immediate vicinity of the ordnance. Degradation products of Royal Demolition Explosive are not toxic to marine organisms at realistic exposure levels (Rosen and Lotufo 2010). Relatively low solubility of most explosives and their degradation products means that concentrations of these contaminants in the marine environment are relatively low and readily diluted. Furthermore, while explosives and their degradation products were detectable in marine sediment approximately 6–12 in. (0.15–0.3 m) away from degrading ordnance, the concentrations of these compounds were not statistically distinguishable from background beyond 3–6 ft. (1–2 m) from the degrading ordnance. Taken together, it is possible that marine mammals could be exposed to degrading explosives, but it would be within a very small radius of the explosive (1–6 ft. [0.3–2 m]).

Equipment used by the Navy within the Study Area, including ships and other marine vessels, aircraft, and other equipment, are also potential sources of by-products. 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 attributable to training and testing activities in the Study Area emanates from multiple sources including low-frequency and hull-mounted mid-frequency active sonar, high-frequency and non-hull mounted mid-frequency active sonar, and explosives and other impulsive sounds. Such sound sources include improved extended echo ranging sonobuoys; anti-swimmer grenades; mine countermeasure and neutralization activities; ordnance testing; gunnery, missile, and bombing exercises; torpedo testing, sinking exercises; ship shock trials; vessels; and aircraft. Sound produced from training and testing activities in the Study Area is temporary and transitory. The sounds produced during training and testing activities can be widely dispersed or concentrated in small areas for varying periods. Any anthropogenic noise attributed to training and testing activities in the Study Area would be temporary and the affected area would be expected to immediately return to the original state when these activities cease.

Prey Distribution and Abundance. If fish are exposed to explosions and impulsive sound sources, they may show no response at all or may have a behavioral reaction. Occasional behavioral reactions to intermittent explosions and impulsive sound sources are unlikely to cause long-term consequences for individual fish or populations. Animals that experience hearing loss (PTS or TTS) 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. It is uncertain whether some permanent hearing loss over a part of a fish's hearing range would have long-term consequences for that individual. It is possible for fish to be injured or killed by an explosion. 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 and Hempen 1997). At greater distance from the detonation point, the extent of mortality or injury depends on a number of factors including fish size, body shape, orientation, and species (Keevin and 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 and Finneran 2006; O'Keeffe 1984; O'Keeffe and Young 1984; Wiley et al. 1981; Yelverton et al. 1975). Species with gas-filled organs have higher mortality than those without them (Continental Shelf Associates Inc. 2004; 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). Stunning from pressure waves could also temporarily immobilize fish, making them more susceptible to predation. The abundances of various fish and invertebrates near the detonation point could be altered for a few hours before animals from surrounding areas repopulate the area; however these populations would likely be replenished as waters near the detonation point are mixed with adjacent waters. Repeated exposure of individual fish to sounds from underwater explosions is not likely and most acoustic effects are expected to be short-term and localized. Long-term consequences for fish populations 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 is to vessel strike stressors is limited to those fish groups that are large, slow-moving, and may occur near the surface, such as sturgeon, ocean sunfish, whale sharks, basking sharks, and manta rays. With the exception of sturgeon, these species are distributed widely in offshore portions of the Study Area. Any isolated cases of a Navy vessel striking an individual could injure that individual, impacting the fitness of an individual fish. 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, they could have a detectable behavioral or physiological response (e.g., swimming away and increased heart rate) as the passing vessel displaces them. 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. However, most marine invertebrates' ability to sense sounds is very limited. In most cases, marine invertebrates would not respond to impulsive and non-impulsive sounds, although they may detect and briefly respond to nearby low-frequency sounds. These short-term responses would likely be inconsequential to invertebrate populations. Explosions and pile driving would likely 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. Therefore, 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 activities 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.

10 IMPACTS ON MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

The Proposed Action is 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 (Impacts on Marine Mammal Habitat and the Likelihood of Restoration), there will be no impacts on marine mammals resulting from loss or modification of marine mammal habitat.

11 MEANS OF EFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS – MITIGATION MEASURES

This chapter describes the Navy mitigation measures that are designed to help reduce or avoid potential impacts to marine mammals resulting from the Proposed Action. For organizational purposes, the measures are divided into: (1) Lookout procedural measures, (2) mitigation zone procedural measures, and (3) mitigation areas.

11.1 LOOKOUT PROCEDURAL MEASURES

Surface ships, which for the purpose of this chapter also include surfaced submarines, have personnel assigned to stand watch at all times when the vessel is underway. Standard watch personnel may perform watch duties in conjunction with job responsibilities that extend beyond looking at the water or air (such as supervision of other personnel). Lookouts perform similar duties to standard personnel standing watch, which may include satisfying safety of navigation and mitigation requirements. The procedural measures described below primarily consist of having Lookouts during specific training and testing activities.

The Navy will have two types of Lookouts for the purposes of conducting visual observations: (1) those positioned on surface ships, and (2) those positioned in aircraft or on boats. Lookouts positioned on surface ships will be dedicated solely to diligent observation of the air and surface of the water. They will have multiple observation objectives, which include but are not limited to detecting the presence of biological resources and recreational or fishing boats, observing the mitigation zones described in Section 11.2 (Mitigation Zone Procedural Measures), and monitoring for vessel and personnel safety concerns. ~~Lookouts positioned on surface ships will typically be personnel already standing watch or existing members of the bridge watch team who become temporarily relieved of job responsibilities that would divert their attention from observing the air or surface of the water (e.g., navigation of a vessel).~~

Due to aircraft and boat manning and space restrictions, Lookouts positioned in aircraft or on boats may include the aircraft crew, pilot, or boat crew. Lookouts positioned in aircraft and boats may be responsible for tasks in addition to observing the air or surface of the water (e.g., navigation of a helicopter or rigid hull inflatable boat). However, aircraft and boat Lookouts will, to the maximum extent practicable and consistent with aircraft and boat safety and training and testing requirements, comply with the observation objectives described above for Lookouts positioned on surface ships.

11.1.1 UNITED STATES NAVY MARINE SPECIES AWARENESS TRAINING

All personnel standing watch on the bridge, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare helicopter crews, civilian equivalents, and Lookouts will successfully complete the United States Navy Marine Species Awareness Training prior to standing watch or serving as a Lookout.

11.1.2 LOOKOUTS

11.1.2.1 Acoustic Stressors – Non-Impulsive Sound

11.1.2.1.1 Low-Frequency and Hull-mounted Mid-Frequency Active Sonar

With the exception of vessels less than 65 ft. (20 m) in length, the Littoral Combat Ship (and similar vessels which are minimally manned), ships using low-frequency or hull-mounted mid-frequency active sonar sources associated with anti-submarine warfare and mine warfare activities at sea will have two Lookouts at the forward position of the vessel. For the purposes of this document, low-frequency active sonar does not include surface towed array surveillance system (SURTASS) low-frequency active sonar.

While using low-frequency or hull-mounted mid-frequency active sonar sources associated with anti-submarine warfare and mine warfare activities at sea, the Littoral Combat Ship (and similar vessels which are minimally manned) and vessels less than 65 ft. (20 m) in length will have one Lookout at the forward position of the vessel due to space and manning restrictions.

Ships conducting active sonar activities while moored or at anchor (including pierside testing or maintenance) will maintain one Lookout.

11.1.2.1.2 High-Frequency and Non-hull Mounted Mid-frequency Active Sonar

The Navy will have one Lookout on the surface ship or in an aircraft conducting high-frequency or non-hull mounted mid-frequency active sonar activities associated with anti-submarine warfare and mine warfare activities at sea.

11.1.2.2 Acoustic Stressors – Explosives and Impulsive Sound

11.1.2.2.1 Improved Extended Echo Ranging Sonobuoys

The Navy will have one Lookout in the aircraft conducting improved extended echo ranging sonobuoy activities.

11.1.2.2.2 Explosive Sonobuoys using 0.6–2.5 Pound Net Explosive Weight

Lookout measures do not currently exist for explosive sonobuoy exercises using 0.6–2.5 lb. net explosive weight. The Navy is proposing to add this measure. Aircraft conducting explosive sonobuoy exercises using 0.6–2.5 lb. net explosive weight will have one Lookout.

11.1.2.2.3 Anti-Swimmer Grenades

The Navy will have one Lookout on the surface vessel conducting anti-swimmer grenade activities.

11.1.2.2.4 Mine Countermeasure and Neutralization Activities using Positive Control Firing Devices

For activities involving diver placed mines under positive control, activities using up to 100 lb. net explosive weight (bin E8) detonation will have a total of two Lookouts (one Lookout positioned in each of the two support vessels). In addition, when aircraft are used, the pilot or member of the aircrew will serve as an additional Lookout. All divers placing the charges on mines will support the Lookouts while performing their regular duties. The divers will report all marine mammal sightings to their dive support vessel.

For general mine countermeasure and neutralization activities under positive control using up to a 500 lb. net explosive weight detonation (bin E10 and below), vessels greater than 200 ft. will have two Lookouts, while vessels less than 200 ft. will have one Lookout.

For general mine countermeasure and neutralization activities under positive control using a 501–650 lb. net explosive weight (bin E11) detonation, the Navy will use two Lookouts (one positioned in an aircraft and one in a support vessel).

11.1.2.2.5 Mine Countermeasure and Neutralization Activities using Diver Placed Time-Delay Firing Devices

When mine countermeasure and neutralization activities using diver placed charges are conducted with a time-delay firing device, the detonation is fused with a specified time-delay by the personnel conducting the activity and is not authorized until the area is clear at the time the fuse is initiated. During these activities, the detonation cannot be terminated once the fuse is initiated due to human safety concerns. During activities using up to a 20 lb. net explosive weight (bin E6) detonation, the Navy will have four Lookouts and two small rigid hull inflatable boats (two Lookouts positioned in each of the two boats). In addition, when aircraft are used, the pilot or member of the aircrew will serve as an additional Lookout. All divers placing the charges on mines will support the Lookouts while performing their regular duties. The divers will report all marine mammal sightings to their dive support vessel.

11.1.2.2.6 Ordnance Testing – Line Charge Testing

The Navy will have one Lookout on the surface vessel conducting line charge testing.

11.1.2.2.7 Gunnery Exercises – Small- and Medium-Caliber using a Surface Target

The Navy will have one Lookout on the surface vessel or aircraft conducting small- or medium-caliber gunnery exercises against a surface target.

11.1.2.2.8 Gunnery Exercises – Large-Caliber using a Surface Target

The Navy will have one Lookout on the surface vessel or aircraft conducting large-caliber gunnery exercises against a surface target.

11.1.2.2.9 Missile Exercises up to 250 Pound Net Explosive Weight using a Surface Target

When aircraft are conducting missile exercises against a surface target, the Navy will have one Lookout positioned ~~on a surface vessel or~~ in an aircraft.

11.1.2.2.10 Missile Exercises up to 500 Pound Net Explosive Weight using a Surface Target

When aircraft are conducting missile exercises against a surface target, the Navy will have one Lookout positioned ~~on a surface vessel or~~ in an aircraft.

11.1.2.2.11 Bombing Exercises

The Navy will have one Lookout positioned in an aircraft conducting bombing exercises.

11.1.2.2.12 Explosive Torpedo Explosive Testing

The Navy will have one Lookout positioned in an aircraft during explosive torpedo testing.

11.1.2.2.13 Sinking Exercises

The Navy will have two Lookouts (one positioned in an aircraft and one on a surface vessel) during sinking exercises.

11.1.2.2.14 Ship Shock Trials

For the two ship shock trial mitigation measures described below, trained marine species observers are different from Lookouts in that they are contracted civilians with experience in locating and identifying animals from shipboard and aerial platforms. Both the Lookouts and marine species observers for ship shock trials will be dedicated to only observing for marine species and will perform no other operational or test duties.

11.1.2.2.14.1 10,000-Pound Charge (HBX)

Prior to commencing, during, and after completion of ship shock trials using up to 10,000-lb. charges, the Navy will have Lookouts or trained marine species observers positioned either in an aircraft or on multiple surface vessels (e.g., Marine Animal Response Team vessels). If aircraft are used, there will be at least four Lookouts (at least two positioned in an aircraft, and at least two positioned on a surface vessel). If vessels are the only platform, a sufficient number (at least four positioned on surface vessels) will be used to provide visual observation of the mitigation zone comparable to that achieved by aerial surveys.

11.1.2.2.14.2 40,000-Pound Charge (HBX)

Prior to commencing and after completion of ship shock trials using up to 40,000-lb. charges, the Navy will have a minimum of two Lookouts or trained marine species observers positioned in an aircraft. During ship shock trials using up to 40,000-lb. charges, the Navy will have at least four Lookouts or trained marine species observers (at least two positioned in an aircraft, and at least two positioned on a surface vessel).

11.1.2.2.15 At-Sea Explosive Testing

The Navy will have a minimum of one Lookout on each surface vessel supporting at-sea explosive testing.

11.1.2.2.16 Elevated Causeway System – Pile Driving

The Navy will have one Lookout positioned on the platform (which could include the shore, an elevated causeway, or on a ship) that will maximize the potential for sightings during pile driving and pile removal.

11.1.2.2.17 Weapons Firing Noise

11.1.2.2.17.1 Gunnery Exercises – Large-Caliber

The Navy will have one Lookout on the surface vessel conducting explosive and non-explosive large-caliber gunnery exercises. This may be the same Lookout described in Section 11.1.2.2.8 (Gunnery Exercises – Large-Caliber using a Surface Target) when that activity is conducted from a surface vessel against a surface target.

11.1.2.3 Physical Strike and Disturbance

11.1.2.3.1 Vessels and In-Water Devices

11.1.2.3.1.1 Vessels

While underway, surface ships (including full power propulsion testing) will have a minimum of one Lookout.

11.1.2.3.1.2 Towed In-Water Devices

The Navy will have one Lookout during activities using towed in-water devices (e.g., towed mine neutralization).

11.1.2.3.2 Non-Explosive Practice Munitions

11.1.2.3.2.1 Small-, Medium-, and Large-Caliber Gunnery Exercises using a Surface Target

The Navy will have one Lookout during activities involving non-explosive practice munitions (e.g., small-, medium-, and large-caliber gunnery exercises) using a surface target.

11.1.2.3.2.2 Bombing Exercises

The Navy will have one Lookout during non-explosive bombing exercises.

11.2 Mitigation Zone Procedural Measures

A mitigation zone is designed solely for the purpose of reducing potential impacts on marine mammals from training and testing activities. Mitigation zones are measured as the radius from a source. Unique to each activity category, each radius represents a distance that the Navy will visually observe to help reduce the potential for injury to marine species. Visual detections of applicable marine species will be communicated immediately to the appropriate watch station for information dissemination and appropriate action. If the presence of marine mammals is detected acoustically, Lookouts posted in aircraft and on surface vessels will increase the vigilance of their visual surveillance. As a reference, aerial surveys are typically made by flying at 1,500 ft. (457 m) altitude or lower at the slowest safe speed when practicable.

Many of the proposed activities have mitigation measures that are currently being implemented, as required by previous environmental documents or consultations. Most of the current mitigation zones for activities that involve the use of impulsive and non-impulsive sources were originally designed to reduce the potential for onset of temporary threshold shift (TTS). For the AFTT EIS/OEIS, the Navy updated the acoustic propagation modeling to incorporate updated hearing threshold metrics (i.e., upper and lower frequency limits), updated density data, as well as factors such as an animal's likely presence at various depths. An explanation of the acoustic propagation modeling process can be found in the Marine Species Modeling Team (2012) technical report.

As a result of the updates described above to the acoustic propagation modeling, in some cases the ranges to effects are much larger than those output by previous models. Due to the ineffectiveness and unacceptable operational impacts associated with mitigating such large areas, the Navy is unable to mitigate for onset of TTS for every activity. However, in some cases the ranges to effects are smaller than previous models estimated, and the mitigation zones were adjusted accordingly to provide consistency across the measures. The Navy developed each proposed mitigation zone to avoid or reduce the potential for onset of the lowest level of injury (PTS), out to the predicted maximum range. Mitigating to the predicted maximum range to PTS consequently also mitigates to the predicted maximum range to onset mortality (1 percent mortality), onset slight lung injury, and onset slight gastrointestinal tract injury, since the maximum range to effects for these criteria are shorter than for PTS. Furthermore, in most cases, the predicted maximum range to PTS also consequently covers the predicted average range to TTS. Table 11-1 summarizes the predicted average range to TTS, average range to PTS, maximum range to PTS, and recommended mitigation zone for each activity category, based on the Navy acoustic propagation modeling results.

The mitigation zones were based on the longest range for all the functional hearing groups, based on the hearing threshold metrics for marine mammals and sea turtles. A majority of the mitigation zones were driven by either the high-frequency cetacean or the sea turtle functional hearing groups. Therefore, the mitigation zones are even more protective for the remaining functional hearing groups (low-frequency cetaceans, mid-frequency cetaceans, and pinnipeds), and likely cover a larger portion of the potential range to onset of TTS. In some instances, the Navy recommends mitigation zones that are larger or smaller than the predicted maximum range to PTS based on the effectiveness and operational assessment for each measure. As described in the AFTT EIS/OEIS, the Navy will only recommend implementing mitigation that results in avoidance or reduction of an impact to a resource and that has acceptable operational impacts to a particular proposed activity.

Table 11-1. Predicted Range to Effects and Recommended Mitigation Zones

Activity Category	Representative Source (Bin)*	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Non-Impulsive Sound					
Low-Frequency and Hull-Mounted Mid-Frequency Active Sonar	SQS-53 ASW hull-mounted sonar (MF1)	4,251 yd. (3,887 m)	281 yd. (257 m)	<292 yd. (<267 m)	6 dB power down at 1,000 yd. (914 m); 4 dB power down at 500 yd. (457 m); and shutdown at 200 yd. (183 m)
High-Frequency and Non-Hull Mounted Mid-Frequency Active Sonar	AQS-22 ASW dipping sonar (MF4)	226 yd. (207 m)	<55 yd. (<50 m)	<55 yd. (<50 m)	200 yd. (183 m)
Explosive and Impulsive Sound					
Improved Extended Echo Ranging Sonobuoys	Explosive sonobuoy (E4)	434 yd. (397 m)	156 yd. (143 m)	563 yd. (515 m)	600 yd. (549 m)
Explosive Sonobuoys using 0.6–2.5 lb. NEW	Explosive sonobuoy (E3)	290 yd. (265 m)	113 yd. (103 m)	309 yd. (283 m)	350 yd. (320 m)
Anti-Swimmer Grenades	Up to 0.5 lb. NEW (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Mine Countermeasure and Neutralization Activities using Positive Control Firing Devices	NEW dependent (see Table 11-2)				
Mine Neutralization Diver Placed Mines using Time-Delay Firing Devices	Up to 20 lb. NEW (E6)	647 yd. (592 m)	232 yd. (212 m)	469 yd. (429 m)	1,000 yd. (915 m)
Ordnance Testing (Line Charge Testing)	Numerous 5 lb. charges (E4)	434 yd. (397 m)	156 yd. (143 m)	563 yd. (515 m)	900 yd. (823 m)**
Gunnery Exercises – Small- and Medium-Caliber (Surface Target)	40 mm projectile (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Gunnery Exercises – Large-Caliber (Surface Target)	5 in. projectiles (E5 at the surface***)	453 yd. (414 m)	186 yd. (170 m)	526 yd. (481 m)	600 yd. (549 m)
Missile Exercises up to 250 lb. NEW (Surface Target)	Maverick missile (E9)	949 yd. (868 m)	398 yd. (364 m)	699 yd. (639 m)	900 yd. (823 m)
Missile Exercises up to 500 lb. NEW (Surface Target)	Harpoon missile (E10)	1,832 yd. (1,675 m)	731 yd. (668 m)	1,883 yd. (1,721 m)	2,000 yd. (1.8 km)

ASW = anti-submarine warfare; JAX = Jacksonville; NEW = net explosive weight; PTS = permanent threshold shift; TTS = temporary threshold shift; VACAPES = Virginia Capes

* This table does not provide an inclusive list of source bins; bins presented here represent the source bin with the largest range to effects within the given activity category.
** Recommended mitigation zones are larger than the modeled injury zones to account for multiple types of sources or charges being used.
*** The representative source bin E5 has different range to effects depending on the depth of activity occurrence (at the surface or at various depths).
**** See discussion below regarding ship shock trial mitigation zones.

Table 11-1. Predicted Range to Effects and Recommended Mitigation Zones (Continued)

Activity Category	Representative Source (Bin)*	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Bombing Exercises	MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2,500 yd. (2.3 km)**
Torpedo (Explosive) Testing	MK-48 torpedo (E11)	1,632 yd. (1.5 km)	697 yd. (637 m)	2,021 yd. (1.8 km)	2,100 yd. (1.9 km)
Sinking Exercises	Various sources up to the MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2.5 nm (4.6 km)**
Ship Shock Trials in JAX Range Complex	10,000 lb. charge (HBX)	5.8 nm (10.8 km)	2.7 nm (4.9 km)	4.8 nm (8.9 km)	3.5 nm (6.5 km)****
	40,000 lb. charge (HBX)	9.2 nm (17 km)	3.6 nm (6.6 km)	6.4 nm (11.9 km)	3.5 nm (6.5 km)****
Ship Shock Trials in VACAPES Range Complex	10,000 lb. charge (HBX)	9 nm (16.7 km)	2 nm (3.6 km)	4.7 nm (8.7 km)	3.5 nm (6.5 km)****
	40,000 lb. charge (HBX)	10.3 nm (19.2 km)	3.7 nm (6.8 km)	7.6 nm (14 km)	3.5 nm (6.5 km)****
At-Sea Explosive Testing	Various sources less than 10 lb. NEW (E5 at various depths***)	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	1,600 yd. (1.4 km)**
Elevated Causeway System – Pile Driving	24 in. steel impact hammer	1,094 yd. (1,000 m)	51 yd. (46 m)	51 yd. (46 m)	60 yd. (55 m)

ASW = anti-submarine warfare; JAX = Jacksonville; NEW = net explosive weight; PTS = permanent threshold shift; TTS = temporary threshold shift; VACAPES = Virginia Capes

* This table does not provide an inclusive list of source bins; bins presented here represent the source bin with the largest range to effects within the given activity category.

** Recommended mitigation zones are larger than the modeled injury zones to account for multiple types of sources or charges being used.

*** The representative source bin E5 has different range to effects depending on the depth of activity occurrence (at the surface or at various depths).

**** See discussion below regarding ship shock trial mitigation zones.

Table 11-2. Predicted Range to Effects and Recommended Mitigation Zones for Mine Countermeasure and Neutralization Activities using Positive Control Firing Devices

Charge Size Net Explosive Weight (Bins)	General Mine Countermeasure and Neutralization Activities using Positive Control Firing Devices*				Mine Countermeasure and Neutralization Activities using Diver Placed Charges under Positive Control**			
	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
2.6–5 lb. (E4)	434 yd. (474 m)	197 yd. (180 m)	563 yd. (515 m)	600 yd. (549 m)	545 yd. (498 m)	169 yd. (155 m)	301 yd. (275 m)	350 yd. (320 m)
6–10 lb. (E5)	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	800 yd. (732 m)	587 yd. (537 m)	203 yd. (185 m)	464 yd. (424 m)	500 yd. (457 m)
11–20 lb. (E6)	766 yd. (700 m)	288 yd. (263 m)	648 yd. (593 m)	800 yd. (732 m)	647 yd. (592 m)	232 yd. (212 m)	469 yd. (429 m)	500 yd. (457 m)
21–60 lb. (E7)***	1,670 yd. (1,527 m)	581 yd. (531 m)	964 yd. (882 m)	1,200 yd. (1.1 km)	1,532 yd. (1,401 m)	473 yd. (432 m)	789 yd. (721 m)	800 yd. (732 m)
61–100 lb. (E8)****	878 yd. (802 m)	383 yd. (351 m)	996 yd. (911 m)	1,600 yd. (1.4 m)	969 yd. (886 m)	438 yd. (400 m)	850 yd. (777 m)	850 yd. (777 m)
250–500 lb. (E10)	1,832 yd. (1,675 m)	731 yd. (668 m)	1,883 yd. (1,721 m)	2,000 yd. (1.8 km)				Not Applicable
501–650 lb. (E11)	1,632 yd. (1,492 m)	697 yd. (637 m)	2,021 yd. (1,848 m)	2,100 yd. (1.9 km)				Not Applicable

PTS: permanent threshold shift; TTS: temporary threshold shift
*These mitigation zones are applicable to all mine countermeasure and neutralization activities conducted in all locations that Chapter 1 specifies.
**These mitigation zones are only applicable to mine countermeasure and neutralization activities involving the use of diver placed charges. These activities are conducted in shallow-water and the mitigation zones are based only on the functional hearing groups with species that occur in these areas (mid-frequency cetaceans and sea turtles).
***The E7 bin was only modeled in shallow-water locations so there is no difference for the diver placed charges category.
****The E8 bin was only modeled for surface explosions, so some of the ranges are shorter than for sources modeled in the E7 bin which occur at depth.

11.2.1 Acoustic Stressors

11.2.1.1 Non-Impulsive Sound

11.2.1.1.1 Low-frequency and Hull-mounted Mid-frequency Active Sonar

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Training and testing activities that involve the use of low-frequency and hull-mounted mid-frequency active sonar (including pierside testing) will use Lookouts for visual observation from a surface vessel immediately before and during the exercise. Mitigation zones for these activities involve powering down the sonar by 6 dB when a marine mammal is sighted within 1,000 yd. (914 m), and by an additional 4 dB when sighted within 500 yd. (457 m) from the source, for a total reduction of 10 dB. Active transmissions will cease if a marine mammal is visually detected within 200 yd. (183 m). Active transmission will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., (4) the vessel has transited more than 2,000 yd. (1.8 km) beyond the location of the last sighting, or (5) if the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel's bow wave (and there are no other marine mammal sightings within the mitigation zone). Active transmission may resume when dolphins are bowriding because they are out of the main transmission axis of the active sonar while in the shallow-wave area of the vessel bow.

11.2.1.1.2 High-Frequency and Non-Hull Mounted Mid-Frequency Active Sonar

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a surface vessel or aircraft (with the exception of platforms operating at high altitudes) immediately before and during active transmission within a mitigation zone of 200 yd. (183 m) from the active sonar source. For activities involving helicopter deployed dipping sonar, visual observation will commence 10 min. before the first deployment of active dipping sonar. Helicopter dipping and sonobuoy deployment will not begin if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. If the source can be turned off during the activity, active transmission will cease if a marine mammal is visually detected within the mitigation zone. Active transmission will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 10 min. for an aircraft-deployed source, (4) the mitigation zone has been clear from any additional sightings for a period of 30 min. for a vessel-deployed source, (5) the vessel or aircraft has repositioned itself more than 400 yd. (366 m) away from the location of the last sighting, or (6) if the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel's bow wave (and there are no other marine mammal sightings within the mitigation zone).

11.2.1.2 Explosives and Impulsive Sound

11.2.1.2.1 Improved Extended Echo Ranging Sonobuoys

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include pre-exercise aerial observation and passive acoustic monitoring, which will begin 30 min. before the first source/receiver pair detonation and throughout the duration of the exercise within a mitigation zone of 600 yd. (549 m) around an Improved Extended Echo Ranging sonobuoy. The pre-exercise aerial observation will include the time it takes to deploy the sonobuoy pattern (deployment is conducted by aircraft dropping sonobuoys in the water). Improved Extended Echo Ranging sonobuoys will not be deployed if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone (around the intended deployment location). Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

Passive acoustic monitoring would be conducted with Navy assets, such as sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft and on surface vessels in order to increase vigilance of their visual surveillance.

11.2.1.2.2 Explosive Sonobuoys using 0.6–2.5 Pound Net Explosive Weight

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include pre-exercise aerial monitoring during deployment of the field of sonobuoy pairs (typically up to 20 minutes) and throughout the duration of the exercise within a mitigation zone of 350 yd. (320 m) around an explosive sonobuoy. Explosive sonobuoys will not be deployed if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone (around the intended deployment location). Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 10 min.

Passive acoustic monitoring will also be conducted with Navy assets, such as sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft in order to increase vigilance of their visual surveillance.

11.2.1.2.3 Anti-Swimmer Grenades

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a small boat immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around an anti-swimmer grenade. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the activity has been repositioned more than 400 yd. (366 m) away from the location of the last sighting.

11.2.1.2.4 Mine Countermeasure and Neutralization Activities using Positive Control Firing Devices

For a summary of the estimated range to effects for each of the charge sizes in this category, see Table 11-2. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

General mine countermeasure and neutralization activity mitigation will include visual surveillance from surface vessels or aircraft beginning 30 min. before, during, and 30 min. after the completion of the exercise within the mitigation zones around the detonation site as identified in Table 11-2. For activities involving explosives in bin E11 (501–650 lb. net explosive weight), aerial observation of the mitigation zone will be conducted. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

In addition to the above, for mine neutralization activities involving diver placed charges, visual observation will be conducted by either two boats (rigid hull inflatable boats), or one boat and one helicopter. Survey boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius and human safety zone) and travel in a circular pattern around the detonation location. When using two boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees. Helicopters will travel in a circular pattern around the detonation location when used. For activities within the Navy Cherry Point Range Complex, no detonations will take place within 3.2 nm (6 km) of an estuarine inlet and within 1.6 nm (3 km) of the shoreline.

11.2.1.2.5 Mine Neutralization Activities using Diver Placed Time-delay Firing Devices

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mine neutralization activities involving diver placed charges will not include time-delay longer than 10 min. Mitigation will include visual surveillance from small boats (rigid hull inflatable boats) or aircraft commencing 30 min. before, during, and until 30 min. after the completion of the exercise within a mitigation zone of 1,000 yd. (915 m) around the detonation site. During activities using time-delay firing devices involving up to a 20 lb. net explosive weight charge, visual observation will take place using two boats. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. The fuse initiation will cease if a marine mammal is visually detected within the mitigation zone. Fuse initiation will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

Survey boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius/human safety zone) and travel in a circular pattern around the detonation location. One Lookout from each boat will look inward toward the detonation site and the other Lookout will look outward away from the detonation site. When using two boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees. If available for use, helicopters will travel in a circular pattern around the detonation location.

11.2.1.2.6 Ordnance Testing – Line Charge Testing

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce. The mitigation zone is larger than the modeled injury zone to account for multiple types of sources or charges being used.

Mitigation will include visual observation from a surface vessel immediately before and during the exercise within a mitigation zone of 900 yd. (823 m) around the line charges. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.7 Gunnery Exercises – Small- and Medium-Caliber using a Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a surface vessel or aircraft immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around the intended impact location. Surface vessels will observe the mitigation zone from the firing position. When aircraft are firing, the aircrew will maintain visual watch of the mitigation zone during the activity. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the intended target location has been repositioned more than 400 yd. (366 m) away from the location of the last sighting.

11.2.1.2.8 Gunnery Exercises – Large-Caliber using a Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a surface vessel or aircraft immediately before and during the exercise within a mitigation zone of 600 yd. (549 m) around the intended impact location. Surface vessels will observe the mitigation zone from the firing position. When aircraft are firing, the aircrew will maintain visual watch of the mitigation zone during the activity. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.9 Missile Exercises up to 250 Pound Net Explosive Weight using a Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

When aircraft are firing, mitigation will include visual observation by the aircrew prior to commencement of the activity within a mitigation zone of 900 yd. (823 m) around the intended impact location ~~(when practicable)~~. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.10 Missile Exercises up to 500 Pound Net Explosive Weight using a Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

When aircraft are firing, mitigation will include visual observation by the aircrew prior to commencement of the activity within a mitigation zone of 2,000 yd. (1.8 km) around the intended impact location (when practicable). The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.11 Bombing Exercises

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from the aircraft immediately before the exercise and during target approach within a mitigation zone of 2,500 yd. (2.3 km) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Bombing will cease if a marine mammal is visually detected within the mitigation zone. Bombing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.12 Explosive Torpedo Testing

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation by aircraft (with the exception of platforms operating at high altitudes) immediately before, during, and after the exercise within a mitigation zone of 2,100 yd. (1.9 km) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) or jellyfish aggregations are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

In addition to visual observation, passive acoustic monitoring would be conducted with Navy assets, such as passive ships sonar systems or sonobuoys, already participating in the activity. Passive acoustic observation would be accomplished through the use of remote acoustic sensors, expendable sonobuoys, or via passive acoustic sensors on submarines when they participate in the Proposed Action. These assets would only detect vocalizing marine mammals within the frequency bands monitored by

Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to the Lookout posted in the aircraft in order to increase vigilance of the visual surveillance; and to the person in control of the activity for their consideration in determining when the mitigation zone is determined free of visible marine mammals.

11.2.1.2.13 Sinking Exercises

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation within a mitigation zone of 2.5 nm (4.6 km) around the target ship hulk. Sinking exercises will include aerial observation beginning 90 min. before the first firing, visual observations from surface vessels throughout the duration of the exercise, and both aerial and surface vessel observation immediately after any planned or unplanned breaks in weapons firing of longer than 2 hr. Prior to conducting the exercise, the Navy will review remotely sensed sea surface temperature and sea surface height maps to aid in deciding where to release the target ship hulk.

The Navy will also monitor using passive acoustics during the exercise. Passive acoustic monitoring would be conducted with Navy assets, such as passive ships sonar systems or sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft and on surface vessels in order to increase vigilance of their visual surveillance. Lookouts will also increase observation vigilance before the use of torpedoes or unguided ordnance with a net explosive weight of 500 lb. or greater, or if the Beaufort sea state is a 4 or above.

The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) or jellyfish aggregations are observed in the mitigation zone. The exercise will cease if a marine mammal is visually detected within the mitigation zone. The exercise will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min. Upon sinking of the vessel, the Navy will conduct post-exercise visual surveillance of the mitigation zone for 2 hr. (or until sunset, whichever comes first).

11.2.1.2.14 Ship Shock Trials

For a summary of the estimated range to effects for the two representative sources in this category (10,000-lb. and 40,000 lb. charges), see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce. The Navy develops detailed ship shock trial mitigation plans approximately 1 year prior to each ship shock trial event, and will continue to provide these plans to NMFS.

11.2.1.2.14.1 10,000-Pound Charge (HBX)

Mitigation will include aerial or shipboard observation prior to, during, and after completion of the event within a mitigation zone of 3.5 nm (6.5 km) around the shock trial location. Pre-planning will include selection of one primary and two secondary areas where marine mammal populations are expected to be the lowest during the event. The primary and secondary locations will be located greater than 2 nm (3.7 km) from the western boundary of the Gulf Stream.

The Navy will conduct aerial or shipboard visual observations of the mitigation zone at intervals of 5 hr., 3 hr., and 40 min. prior to detonation; and immediately before each detonation at the primary shock trial location. The detonation will be delayed if marine species (i.e., marine mammals, concentrations of floating vegetation [*Sargassum* or kelp patties], jellyfish aggregations, or flocks of seabirds) are visually observed within the mitigation zone. The detonation will re-commence if any one of the following conditions are met: (1) the species is observed exiting the mitigation zone, (2) the species is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min. The Navy will visually observe the mitigation zone immediately after each detonation for 3 hours. If any injured or dead marine mammals are detected in the mitigation zone during the post-detonation observation, the remainder of the activity will be halted until procedures for subsequent detonations can be reviewed and changed as necessary.

11.2.1.2.14.2 40,000-Pound Charges (HBX)

The Navy will conduct shipboard and aerial visual observations of the mitigation zone at intervals of 5 hr., 3 hr., and 40 min. prior to detonation; and immediately before each detonation at the primary shock trial location. The detonation will be delayed if marine species (i.e., marine mammals, concentrations of floating vegetation [*Sargassum* or kelp patties], jellyfish aggregations, or flocks of seabirds) are visually observed within the mitigation zone. The detonation will re-commence if any one of the following conditions are met: (1) the species is observed exiting the mitigation zone, (2) the species is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min. The Navy will visually observe the mitigation zone immediately after each detonation for 3 hours. Mitigation will also include aerial observation for the 2 days following the first two detonations and for the 7 days following the last detonation. If any injured or dead marine mammals are detected in the mitigation zone during the post-detonation aerial observation, the remainder of the activity will be halted until procedures for subsequent detonations can be reviewed and changed as necessary.

11.2.1.2.15 At-Sea Explosive Testing

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation during at-sea explosive testing, such as the sinking of a vessel by a sequential firing of multiple small charges (e.g., explosives in bin E5) for use as an artificial reef, will include visual observation from supporting surface vessels immediately before and during the activity within a mitigation zone of 1,600 yd. (1.4 km) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.16 Elevated Causeway System – Pile Driving

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a support vessel or from shore starting 30 min. prior to and during the exercise within a mitigation zone of 60 yd. (55 m) around the pile driver. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Pile driving will cease if a marine mammal is visually detected within the mitigation zone. Pile driving will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.17 Weapons Firing Noise

11.2.1.2.17.1 Gunnery Exercises – Large-Caliber

For all explosive and non-explosive large-caliber gunnery exercises conducted from a surface vessel, mitigation will include visual observation immediately before and during the exercise within a mitigation zone of 70 yd. (46 m) within 30 degrees on either side of the gun target line on the firing side of the vessel. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the vessel has repositioned itself more than 140 yd. (128 m) away from the location of the last sighting.

11.2.2 PHYSICAL STRIKE AND DISTURBANCE

11.2.2.1 Vessels and In-Water Devices

11.2.2.1.1 Vessels

Ships will avoid approaching marine mammals head on and will maneuver to maintain a mitigation zone of 500 yd. (457 m) around observed whales, and 200 yd. (183 m) around all other marine mammals (except bow riding dolphins), providing it is safe to do so. For additional information on species-specific mitigations pertaining to vessel strikes within mitigation areas, see Section 11.3, Mitigation Areas.

11.2.2.1.2 Towed In-Water Devices

The Navy will ensure that towed in-water devices avoid coming within a mitigation zone of 250 yd. (229 m) around any observed marine mammal, providing it is safe to do so.

11.2.2.2 Non-Explosive Practice Munitions

11.2.2.2.1 Gunnery Exercises – Small-, Medium-, and Large-Caliber using a Surface Target

Mitigation will include visual observation immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the intended target location has been repositioned more than 400 yd. (366 m) away from the location of the last sighting.

11.2.2.2.2 Bombing Exercises

Mitigation will include visual observation from the aircraft immediately before the exercise and during target approach within a mitigation zone of 1,000 yd. (914 m) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Bombing will cease if a marine mammal is visually detected within the mitigation zone. Bombing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.3 Mitigation Areas

The Navy is proposing to implement several mitigation measures within pre-defined habitat areas in the Study Area. For the purposes of this document, the Navy will refer to these areas as "mitigation areas." It is important to note that the Navy is recommending the implementation of the mitigation measures only within each area as described.

11.3.1 North Atlantic Right Whale Calving Habitat off the Southeast United States

The Navy will conduct several mitigation measures within pre-defined boundaries of a North Atlantic right whale mitigation area off the southeast United States during calving season between 15 November and 15 April. The southeast United States mitigation area is defined as follows (and depicted in Figure 4-1): a 5 nm (9.3 km) buffer around the coastal waters between 31°15' North and 30°15' North from the coast out 15 nm (27.8 km); and the coastal waters between 30°15' North and 28°00' North from the coast out 5 nm (9.3 km).

The Navy will not conduct the following activities within the mitigation area:

- High-frequency and non-hull mounted mid-frequency active sonar (excluding helicopter dipping)
- Missile activities (explosive and non-explosive)
- Bombing exercises (explosive and non-explosive)
- Underwater detonations
- Improved extended echo ranging sonobuoy exercises
- Torpedo exercises (explosive)
- Small-, medium-, and large-caliber gunnery exercises

The Navy will minimize to the maximum extent practicable the use of the following systems within the mitigation area:

- Helicopter dipping using active sonar
- Low-frequency and hull-mounted mid-frequency active sonar used for navigation training
- Low-frequency and hull-mounted mid-frequency active sonar used for object detection exercises

Before transiting through or conducting any training or testing activities within the mitigation area, the Navy will initiate prior communication with the Fleet Area Control and Surveillance Facility, Jacksonville to obtain Early Warning System North Atlantic right whale sightings data. The Fleet Area Control and Surveillance Facility, Jacksonville, will advise ships of all reported whale sightings in the vicinity of the mitigation area to help ships and aircraft reduce potential interactions with North Atlantic right whales. Commander Submarine Force United States Atlantic Fleet will coordinate any submarine operations that may require approval from the Fleet Area Control and Surveillance Facility, Jacksonville. When transiting within the mitigation area, all Navy vessels will exercise extreme caution and proceed at the slowest speed that is consistent with safety, mission, training, and operations. Vessels will implement speed reductions after they observe a North Atlantic right whale, if they are within 5 nm (9 km) of a sighting reported within the past 12 hr., or when operating at night or during periods of poor visibility. The Navy will minimize to the maximum extent practicable north-south transits through the mitigation area. The Navy may periodically travel in a north-south direction during training and testing activities due to operational requirements. If north-south directional travel is required during training or testing activities, the Navy will implement the increased caution and speed reductions described above when applicable.

11.3.2 North Atlantic Right Whale Foraging Habitat off the Northeast United States

Two important North Atlantic right whale foraging habitats, the Great South Channel and Cape Cod Bay, are located off the northeast United States. These two areas comprise the northeast United States mitigation area, which applies year-round and is defined as follows:

- Great South Channel: The area bounded by 41°40' North / 69°45' West; 41°00' North / 69°05' West; 41°38' North / 68°13' West; and 42°10' North / 68°31' West
- Cape Cod Bay: The area bounded by 42°04.8' North / 70°10' West; 42°12' North / 70°15' West; 42°12' North / 70°30' West; 41°46.8' North / 70°30' West and on the south and east by the interior shoreline of Cape Cod, Massachusetts

The Navy will not conduct the following activities within the boundaries of the mitigation area or within additional specified distances from the mitigation area:

- Improved extended echo ranging sonobuoy exercises in or within 3 nm (5.6 km) of the mitigation area
- Bombing exercises (explosive and non-explosive)
- Underwater detonations
- Torpedo exercises (explosive)

The Navy will minimize to the maximum extent practicable the use of the following systems within the boundaries of the mitigation area:

- Low-frequency and hull-mounted active sonar
- High-frequency and non-hull mounted mid-frequency active sonar, including helicopter dipping

Before transiting the mitigation area with a surface vessel, the Navy will conduct a prior web query or email inquiry to the National Oceanographic and Atmospheric Administration Fisheries Service Northeast United States Right Whale Sighting Advisory System in order to obtain the latest North Atlantic right whale sighting information. When transiting within the mitigation area, Navy vessels will exercise extreme caution and proceed at the slowest speed that is consistent with safety, mission, training, and operations. Vessels will implement speed reductions after they observe a North Atlantic right whale, if they are within 5 nm (9 km) of a sighting reported within the past week, or when operating at night or during periods of poor visibility. The Navy will implement the following additional vessel speed restrictions: surface vessels and submarines will maintain a speed of no more than 10 knots (19 km/hr.) during transit; and torpedo exercise firing vessel speeds will range from 10 knots (19 km/hr.) during normal firing, 18 knots (33.3 km/hr.) during submarine target firing, and in excess of 18 knots (33.3 km/hr.) during surface vessel target firing (speeds in excess of 18 knots will occur for a short time [e.g., 10–15 min.]).

The Navy will conduct all non-explosive torpedo testing during daylight hours in Beaufort sea states of 3 or less to increase the probability of marine mammal detection. Mitigation will include visual observation immediately before and during the exercise within the immediate vicinity of the activity. The Navy will have three Lookouts during non-explosive torpedo testing activities (one positioned on the surface support vessel and two in an aircraft during dedicated aerial surveys). An additional Lookout will be positioned on the submarine, when surfaced. The test scenario will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the immediate vicinity of the activity. The test scenario will cease if a marine mammal is visually detected within the immediate vicinity of the activity. The test scenario will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the immediate vicinity of the activity, (2) the animal is thought to have exited the immediate vicinity of the activity based on its course and speed, or (3) the immediate vicinity of the activity has been clear from any additional sightings for a period of 30 min.

11.3.3 NORTH ATLANTIC RIGHT WHALE MID-ATLANTIC MIGRATION CORRIDOR

A North Atlantic right whale migratory route is located off the mid-Atlantic coast of the United States. When transiting within the migration corridor, the Navy will practice increased vigilance, exercise extreme caution, and proceed at the slowest speed that is consistent with safety, mission, and training and testing objectives. This mitigation area is applicable from November 1 through April 30 and is defined as follows:

- Block Island Sound: The area bounded by 40˚51'53.7" North / 070˚36'44.9" West; 41˚20'14.1" North / 070˚49'44.1" West
- New York and New Jersey: 20 nm (37 km) seaward of the line between 40˚29'42.2" North / 073˚55'57.6" West
- Delaware Bay: 38˚52'27.4" North / 075˚01'32.1" West
- Chesapeake Bay: 37˚00'36.9" North / 075˚57'50.5" West
- Morehead City, North Carolina: 34˚41'32.0" North / 076˚40'08.3" West
- Wilmington, North Carolina, through South Carolina, and to Brunswick, Georgia: Within a continuous area 20 nm from shore and west back to shore bounded by 34˚10'30" North /

077˚49'12" West; 33˚56'42" North / 077˚31'30" West; 33˚36'30" North / 077˚47'06" West; 33˚28'24" North / 078˚32'30" West; 32˚59'06" North / 078˚50'18" West; 31˚50'00"North / 080˚33'12" West; 31˚27'00" North / 080˚51'36" West

11.3.4 PLANNING AWARENESS AREAS

For events involving active sonar, the Navy will avoid planning major exercises in planning awareness areas (Figure 11-1) when feasible. To the extent operationally feasible, the Navy will not conduct more than one of the four major exercises or similar scale events per year in the Gulf of Mexico planning awareness area. If national security needs require the conduct of more than four major exercises or similar scale events in the planning awareness areas per year, or more than one within the Gulf of Mexico planning awareness area per year, the Navy will provide NMFS with prior notification and include the information in any associated after-action or monitoring reports.

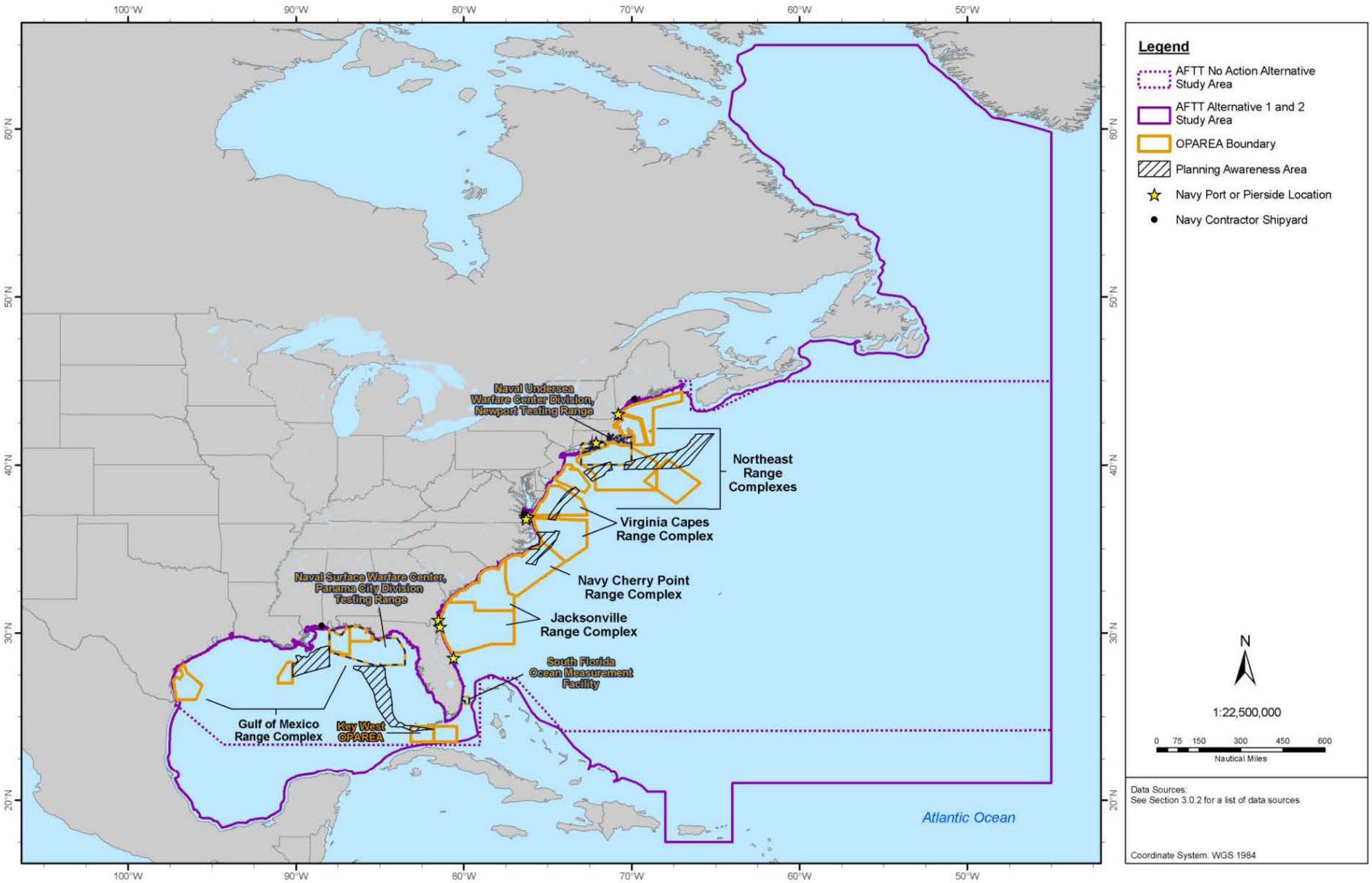


Figure 11-1. Navy Planning Awareness Areas

12 EFFECTS ON ARCTIC SUBSISTENCE HUNTING AND 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 Letters of Authorization, 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 (Impacts on Marine Mammal Species or Stocks) and Chapter 8 (Impacts on Subsistence Use), there are no anticipated impacts on any species or stocks migrating through the Study Area that might be available for subsistence use.

13 MONITORING AND REPORTING EFFORTS

13.1 OVERVIEW

The Navy is committed to demonstrating environmental stewardship while executing its National Defense Mission and complying with the suite of Federal environmental laws and regulations. As a complement to the Navy's commitment to avoiding and reducing impacts of the Proposed Action through mitigation (Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), the Navy will undertake monitoring efforts to track compliance with take authorizations and help investigate 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, mitigation and monitoring measures presented here 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. Since monitoring will be required for compliance with the final rule issued for the Proposed Action under the MMPA, details of the monitoring program will be developed in coordination with NMFS through the regulatory process. Discussions with resource agencies during the consultation and permitting processes may result in changes to the mitigation as described in this document.

13.2 INTEGRATED COMPREHENSIVE MONITORING PLAN TOP-LEVEL GOALS

The Integrated Comprehensive Monitoring Program is intended to coordinate monitoring efforts across all regions where the Navy trains and tests and to allocate the most appropriate level and type of effort for each range complex (U. S. Department of the Navy 2010). The current Navy monitoring program is composed of a collection of "range-specific" monitoring plans, each developed individually as part of Marine Mammal Protection Act and Endangered Species Act compliance processes as environmental documentation was completed. These individual plans establish specific monitoring requirements for each range complex and are collectively intended to address the Integrated Comprehensive Monitoring Program top-level goals.

A 2010 Navy-sponsored monitoring meeting in Arlington, Virginia, initiated a process to critically evaluate the current Navy monitoring plans and begin development of revisions and updates to both existing region-specific plans as well as the Integrated Comprehensive Monitoring Program. Discussions at that meeting as well as the following Navy and NMFS annual adaptive management meeting established a way ahead for continued refinement of the Navy's monitoring program. This process included establishing a Scientific Advisory Group of leading marine mammal scientists with the initial task of developing recommendations that would serve as the basis for a Strategic Plan for Navy monitoring. The Strategic Plan is intended to be a primary component of the Integrated Comprehensive Monitoring Program and provide a "vision" for Navy monitoring across geographic regions - serving as guidance for determining how to most efficiently and effectively invest the marine species monitoring resources to address Integrated Comprehensive Monitoring Program top-level goals and satisfy MMPA Letter of Authorization regulatory requirements.

The objective of the Strategic Plan is to continue the evolution of Navy marine species monitoring towards a single integrated program, incorporating Scientific Advisory Group recommendations, and establishing a more transparent framework for soliciting, evaluation, and implementing monitoring work across the range complexes and testing ranges. The Strategic Plan must consider a range of factors in addition to the scientific recommendations including logistic, operational, and funding considerations and will be revised regularly as part of the annual adaptive management process.

The Integrated Comprehensive Monitoring Program establishes top-level goals that have been developed in coordination with NMFS (U. S. Department of the Navy 2010). The following top-level goals will become more specific with regard to identifying potential projects and monitoring field work through the Strategic Plan process as projects are evaluated and initiated in the AFTT Study Area.

1) An increase in our understanding of the likely occurrence of marine mammals or Endangered Species-Act (ESA)-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, and density of species);
2) An increase in our understanding of the nature, scope, or context of the likely exposure of marine mammals and ESA-listed species to any of the potential stressor(s) associated with the action (e.g., tonal and impulsive sound), through better understanding of one or more of the following: (1) the action and the environment in which it occurs (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) associated with specific adverse effects, or; (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);
3) An increase in our 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)
4) An increase in our 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 effects on annual rates of recruitment or survival);
5) An increase in our understanding of the effectiveness of mitigation and monitoring measures;
6) A better understanding and record of the manner in which the authorized entity complies with the Incidental Take Authorization and Incidental Take Statement;
7) An increase in the probability of detecting marine mammals (through improved technology or methods), both specifically within the safety zone (thus allowing for more effective implementation of the mitigation) and in general, to better achieve the above goals; and
8) A reduction in the adverse impact of activities to the least practicable level, as defined in the MMPA.

13.3 Scientific Advisory Group Recommendations

Navy established the Scientific Advisory Group in 2011 with the initial task of evaluating current Navy monitoring approaches under the Integrated Comprehensive Monitoring Program and existing MMPA Letters of Authorization and developing objective scientific recommendations that would form the basis for this Strategic Plan. While recommendations were fairly broad and not prescriptive from a range complex perspective, the Scientific Advisory Group did provide specific programmatic recommendations that serve as guiding principles for the continued evolution of the Navy Marine Species Monitoring

Program and provide a direction for the Strategic Plan to move this development. 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.
- Striving to move away from a "box-checking" mentality. Monitoring studies should be designed and conducted according to scientific objectives, rather than on merely cataloging effort expended.
- Approach the monitoring program holistically and select projects that offer the best opportunity to advance understanding of the issues, as opposed to establishing range-specific requirements.

14 RESEARCH EFFORTS

14.1 OVERVIEW

The Navy provides a significant amount of funding and support to marine research. 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. Over the past 5 years the Navy has provided over $100 million for marine mammal research. The Navy sponsors 70 percent of all United States research concerning the effects of human-generated sound on marine mammals and 50 percent of such research conducted worldwide. This research is directly applicable to Atlantic Fleet Training and Testing activities, particularly with respect to the investigations of the potential impacts of underwater noise sources on marine mammals and other protected marine resources.

Major topics of Navy-supported research include the following:

- Better understanding of marine species distribution and important habitat areas;
- Developing methods to detect and monitor marine species before and during training;
- Understanding the impacts of sound on marine mammals, sea turtles, fish, and birds; and
- Developing tools to model and estimate potential impacts of sound.

The Marine Life Sciences Division of the Office of Naval Research currently coordinates six programs that examine the marine environment and are devoted solely to studying the impacts of noise and/or the implementation of technology tools that will assist the Navy in studying and tracking marine mammals. The six programs are:

- Environmental Consequences of Underwater Sound;
- Non-Auditory Biological Effects of Sound on Marine Mammals;
- Effects of Sound on the Marine Environment;
- Sensors and Models for Marine Environmental Monitoring;
- Effects of Sound on Hearing of Marine Animals; and
- Passive Acoustic Detection, Classification, and Tracking of Marine Mammals.

14.2 NAVY RESEARCH AND DEVELOPMENT

Overall, the Navy will continue to support and fund ongoing marine mammal research, and is planning to coordinate long-term monitoring and research of marine mammals throughout the AFTT Study Area. The Navy will continue to research and contribute to university and external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include mitigation and monitoring programs; data sharing with NMFS and via the literature for research and development efforts; and future research as described previously.

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