FINAL
REQUEST FOR LETTER OF AUTHORIZATION UNDER SECTION 101(A)(5)(A) OF THE MARINE MAMMAL PROTECTION ACT INCIDENTAL TO UNDERSEA WARFARE TRAINING RANGE ACTIVITIES

Submitted to:

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May 2008

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LIST OF ACRONYMS AND ABBREVIATIONS

°	Degree(s)
%	Percent
μPa	Micropascal(s)
μs	Microsecond(s)
ABR	Auditory Brainstem Response
ADC	Acoustic Device Countermeasures
ADCAP	Advanced Capability
ALFS	Airborne Low Frequency Sonar
ASW	Anti-submarine Warfare
ATOC	Acoustic Thermometry of Ocean Climate
AUTEC	Atlantic Undersea Test and Evaluation Center
BACI-P	Before-After Control-Impact Paired
BRS	Behavioral Response Study
BSS	Beaufort Sea State
C	Celsius
CASS	Comprehensive Acoustic Simulation System
CETAP	Cetacean and Turtle Assessment Program
CG	Guided Missile Cruiser
CHASN	Charleston
chl *a*	Chlorophyll *a*
CHPT	Cherry Point
cm	Centimeter(s)
CNO	Chief of Naval Operations
CO	Commanding Officer
COMPTUEX	Composite Training Unit Exercise
CREEM	Centre for Environmental and Ecological Modelling
CSG	Carrier Strike Group
CT	Computerized Toography
CTF	Cable Termination Facility
dB	Decibel(s)
dB re 1 μPa	Decibels Referenced to 1 Micropascal
dB re 1 μPa^2/Hz	Decibels Referenced to 1 Micropascal Squared per Hertz
dB re 1 μPa^2-s	Decibels Referenced to 1 Micropascal Squared Second
dB re 1 μPa-m	Decibels Referenced to 1 Micropascal at 1 Meter
DBDB-V	Digitized Bathymetric Data Base – Variable Resolution
DCS	Decompression Sickness
DDG	Guided Missile Destroyer
DICASS	Directional Command Activated Sonobuoy System
DoD	Department of Defense
DoN	Department of the Navy
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EL	Energy Flux Density Level
EMATT	Expendable Mobile Acoustic Torpedo Targets
ESA	Endangered Species Act
EWS	Early Warning System
EXTORP	Exercise Torpedo
FACSFAC	Fleet Area Control and Surveillance Facility
FFG	Frigate
FM	Frequency-Modulated
FR	Federal Register
FRTP	Fleet Response Training Plan
ft	Foot(Feet)
ft^2	Square Foot(Feet)

LIST OF ACRONYMS AND ABBREVIATIONS

GAM	Generalized Additive Model
GDEMV	Generalized Digital Environmental Model, Variable
GOMEX	Gulf of Mexico
GRAB	Gaussian Ray Bundle
HARPS	High Frequency Acoustic Recording Packages
HFA	High Frequency Active
HPA	Hypothalamic-Pituitary-Adrenal
hr	Hour(s)
HRC	Hawai'i Range Complex
HSO_3	Bisulfate
HSWRI	Hubbs-SeaWorld Research Institute
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
in.	Inch(es)
$in.^3$	Cubic Inch(es)
IUSS	Integrated Undersea Surveillance System
IWC	International Whaling Commission
JAX	Jacksonville
JTFEX	Joint Task Force Exercise
kg	Kilogram(s)
kHz	Kilohertz
km	Kilometer(s)
km^2	Square Kilometer(s)
kPa	Kilopascal(s)
kt	Knot(s)
L	Liter(s)
lb	Pound(s)
LFA	Low Frequency Active
LFS SRP	Low Frequency Sound Scientific Research Program
LOA	Letter of Authorization
m	Meter(s)
m^2	Square Meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MFA	Mid-frequency Active
mg	Milligram(s)
min	Minute(s)
MMEM	Marine Mammals Effect Model
MMPA	Marine Mammal Protection Act
MRA	Marine Resource Assessment
ms	Millisecond(s)
MSAT	Marine Species Awareness Training
mtDNA	Mitochondrial Deoxyribonucleic Acid
N	North
NAS	Naval Air Station
NAVEDTRA	Naval Education and Training Command Manual
NAVOCEANO	Naval Oceanographic Office
NEFSC	Northeast Fisheries Science Center
NGA	National GeoSpatial-Intelligence Agency
NITS	Noise-Induced Threshold Shift
NM	Nautical Mile(s)
NM^2	Square Nautical Mile(s)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODE	Navy Operating Area Density Estimate

LIST OF ACRONYMS AND ABBREVIATIONS

NS	Naval Station
NUWC	Naval Undersea Warfare Center
OAML	Oceanographic and Atmospheric Master Library
OEIS	Overseas Environmental Impact Statement
OF	Otto Fuel
ONR	Office of Naval Research
OOD	Officer of the Deck
OPAREA	Operating Area
OPR	Office of Protected Resources
PL	Public Law
PQS	Personal Qualification Standard
psf	Pound(s) per Square Foot
PTS	Permanent Threshold Shift
R&D	Research and Development
RDT&E	Research, Development, Test, and Evaluation
REXTORP	Recoverable Exercise Torpedo
RL	Received Level
rms	Root Mean Square
ROC	Range Operations Center
s	Second(s)
S	South
S.D.	Standard Deviation
SAB	South Atlantic Bight
SAR	Stock Assessment Report
SCORE	Southern California Offshore Range
SEFSC	Southeast Fisheries Science Center
SEL	Sound Exposure Level
SNS	Sympathetic Nervous System
SO_2	Sulfur Dioxide
SOSUS	Sound Surveillance System
SPL	Sound Pressure Level
SPORTS	Sonar Positional Reporting System
SSC	Space and Naval Warfare Systems Center
SST	Sea Surface Temperature
SURTASS	Surveillance Towed Array Sensor System
SVP	Sound Velocity Profile
TL	Transmission Loss
TS	Threshold Shift
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
UQC	Underwater Mobile Sound Communications
USCG	United States Coast Guard
USEPA	United States Environmental
USWTR	Undersea Warfare Training Range
VACAPES	Virginia Capes
VLA	Vertical Launch Anti-submarine
W	West
XBT	Expendable Bathythermograph
XO	Executive Officer
yd	Yard(s)
yr	Year(s)
ZOI	Zone of Influence

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1.0 DESCRIPTION OF ACTIVITIES

The proposed action is to place undersea cables and sensor nodes in a 1,713-square-kilometer (km^2) (500-square-nautical-mile [NM^2]) area of the ocean creating an undersea warfare training range (USWTR), and to use the area for antisubmarine warfare (ASW) training. Such training would typically involve up to three vessels and two aircraft using the range for any one training event, although events would typically involve fewer units. The instrumented area would be connected to the shore via a single trunk cable. The proposed action would require logistical support for ASW training, including the handling (launch and recovery) of exercise torpedoes (non-explosive) and submarine target simulators.

The ability to train year-round is required if the Navy is to meet the requirements and schedules associated with the *Fleet Response Training Plan* (DoN, 2007g) and the potential for surge situations (i.e., immediate deployment of forces). To meet potential surge situations, the *Fleet Response Training Plan* requires that the Navy have five or six carrier strike groups (CSGs) ready to deploy within 30 days of notification and an additional one or two CSGs ready to deploy within 90 days. To satisfy this requirement, the Navy must have access to training areas all year to ensure that a sufficient number of fully trained surface units are always prepared for deployment.

1.1 PURPOSE AND NEED

The purpose of the proposed action is to enable the United States (U.S.) Navy to train effectively in a shallow water environment (37 to 274 meters [m], or 120 to 900 feet [ft], in depth) at a suitable location for Atlantic Fleet ASW-capable units. The 37-to-274-m (120-to-900-ft) depth parameter for the range was derived from collectively assessing depth requirements of the platforms that would be using this range, and approximate the water depth of potential areas of conflict that the Navy has identified.

There are four fundamental reasons why the Navy needs to have an instrumented undersea warfare training range off the east coast of the U.S., these are

Worldwide Deployment to Littoral Areas. Atlantic Fleet units deploy worldwide, and shifts in the military strategic landscape require increased naval capability in the world's shallow, or littoral, seas, such as the Arabian Sea, the South China Sea, and the Korean Sea. Training effectively for these littoral environments requires the availability of realistic conditions in which actual potential combat situations can be adequately simulated:

> "*The 21st century environment is one of increasing challenges, due to the littoral environment in which we operate and advanced technologies that are proliferating around the world. Operations in the future will be centered on dominating near-land combat, rapidly achieving area control despite difficult sound propagation profiles and dense surface traffic. The operating environment will be cluttered and chaotic, and defeating stealthy enemies will be an exceptional challenge*." – Anti-Submarine Warfare Concept of Operations for the 21st Century.

Today's Operating Environment

- High traffic density and related noise
- Poor sound propagation due to shallow water characteristics
- High technology enemies
- Atypical challenges from rogue states and terrorists
- Long term operations near shore in a shallow water environment

Threat of Modern Diesel Submarines. The current global proliferation of extremely quiet submarines poses a critical threat to the maritime interests of the U.S. These silent diesel submarines, easily obtainable by potential adversaries, are capable of protracted, silent, submerged operations in confined, congested littoral regions where acoustic conditions make detection significantly more challenging than in deep water. These silent vessels can get well within 'smart' (i.e., self-guided) torpedo or anti-ship missile range of US forces before there is a likelihood of their being detected by passive sonar "listening." For this reason, use of, and training with, active sonar is crucial to today's ASW, US operational readiness, national defense, and homeland security. Such training is critical to our ability to deliver fighting forces overseas and to protect civilians and cargo in transit on the world's oceans.

US World Role. The role of the U.S. in keeping critical sea lanes open makes it imperative that US military forces are the best trained, prepared, and equipped in the world. ASW is a Navy core capability and is a critical part of that mission. The Navy is the only Department of Defense (DoD) service with an ASW responsibility, and must be trained and capable in littoral water operations to assure access for the U.S. and our allies to strategic areas worldwide.

Mission Readiness and Fulfillment. The Navy's primary mission is to maintain, train, equip, and operate combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. Training with the actual sensors and weapons systems aboard their own ships, submarines, or aircraft, in a complex operational setting with a realistic scenario is key to maintaining Fleet combat readiness and to survival in actual wartime conditions.

Timely and accurate feedback of training performance to exercise participants and the ability to rapidly reconstruct the training event contribute significantly to the quality of this complex training. These capabilities may only be realized through the use of an instrumented, at-sea training range. At present, the only operational Atlantic instrumented training range is located in a deep-water environment, requiring that results be extrapolated to apply to the critically different conditions of shallow water; speculation and interpretation are required to evaluate crew and equipment performance, reducing the authenticity of the feedback.

The proposed USWTR provides an environment:

- that is consistent with real-world threat situations.
- where training exercises can be conducted under safe and controlled conditions.
- with critically important real-time feedback that eliminates the need for iterative training events to validate and confirm results.

In addition, Section 5062 of Title 10 of the U.S. Code (U.S.C.) contains a legal mandate for such training as would be provided by the proposed range. Title 10 directs the Chief of Naval Operations (CNO) to organize, train, and equip all naval forces for combat. The CNO fulfills this direction by conducting training activities during a predeployment training cycle prior to deployment for actual operations. First, personnel learn and practice basic combat skills through basic-level or unit-level training. Basic skills are then refined at the intermediate and advanced levels in progressively more difficult, complex, and larger-scale exercises conducted at increasing tempos, referred to as integrated training. When predeployment training is complete, warfighters can function effectively independently, or as part of a coordinated fighting force, can accomplish multiple missions, and are able to fulfill Title 10’s mission and readiness mandate.

The ability to train year-round is required if the Navy is to meet the requirements and schedules associated with the *Fleet Response Training Plan* (DoN, 2007g) and the potential for surge situations (i.e., immediate deployment of forces). To meet potential surge situations, the *Fleet Response Training Plan* requires that the Navy have five or six carrier strike groups (CSGs) ready to deploy within 30 days of notification and an additional one or two CSGs ready to deploy within 90 days. To satisfy this requirement, the Navy must have access to training areas all year to ensure that a sufficient number of fully trained surface units are always prepared for deployment.

Finally, the training value of the proposed action ultimately benefits all DoD forces whose missions are in any way tied to maritime operations, homeland security, or are dependent on access to strategic littoral areas of the world. Silent submarines are an important threat to U.S. forces, civilians, and materiel, and potentially to national security. The increasing likelihood of combat in shallow, littoral areas, as opposed to the open ocean or under ice requires that the Navy is fully trained for these conditions. Such training can best be accomplished with an instrumented undersea warfare training range appropriately located in a shallow water environment.

1.2 DESCRIPTION OF THE ACTION AREA

The proposed Site A USWTR would be located offshore of northeastern Florida (see **Figure 1-1**). The center of the range would be approximately 111 kilometers (km) (60 nautical miles [NM]) from shore in the Jacksonville (JAX) Operating Area (OPAREA) (**Figure 1-1**).

The trunk cable would run approximately 93 km (50 NM) from the junction box near the edge of the range to land at Naval Station (NS) Mayport (**Figure 1-2**). The shoreside trunk cable conduit would be installed under the dunes to the east of the Cable Termination Facility (CTF), with the seaward end of the conduit connected to underground cable in a trench.

Commercial power and telecommunications connections would be made from the CTF to the NS Mayport infrastructure.

1.3 RANGE INSTALLATION

The USWTR instrumentation is a system of underwater acoustic transducer devices, called nodes, connected by cable to each other and to a landside facility where the collected range data are used to evaluate the performance of participants in shallow water training exercises. These transducer nodes are capable of both transmitting and receiving acoustic signals from ships operating within the USWTR (a transducer is an instrument that converts one form of energy into another; e.g., a sound into an electrical signal, as in a telephone). The acoustic signals that are sent from the exercise participants to the range nodes allow the position of the participants to be determined and stored electronically for both real-time and future evaluation. More specifically:

The USWTR would consist of no more than 300 transducer nodes spread on the ocean floor over a 1,713-km^2 (500-NM^2) area (**Figure 1-2**). The distance between nodes would vary from 2 to 6 km (1 to 3 NM), depending on water depth.

The transducer nodes would be either dome-shaped (**Figure 1-3**) or tethered (**Figure 1-4**). The overall shape and configuration would be designed to be consistent with local geographic conditions and to accommodate area activities such as fishing.

The nodes would be connected with commercial fiber optic undersea cable (approximately 3.1 centimeters (cm) [1.22 inch {in.}] in diameter), such as that used by the telecommunications industry. Approximately 1,110 km (600 NM) of cable would be used to connect the nodes.

The interconnect cable between each node would be buried, if deemed necessary, at individual locations within a range. The decision to bury would be based on activities that interact with the bottom, such as anchoring and extensive use of bottom-dragged fishing gear. The trunk cable connecting the range to the shore facilities would be buried to a depth of 1 to 3 m (3 to 9 ft). There would be a buried trunk cable running from shore to a junction box located at the edge of the range. Ocean-bottom burial equipment would be used to cut (hard bottom) or plow (soft sediment) a furrow approximately 10 cm (4 in.) wide into which the 5.8-cm (2.3-in.) cable would be placed. Cable installation would be accomplished using a tracked, remotely operated cable burial vehicle. The junction box would not be buried (**Figure 1-5**).

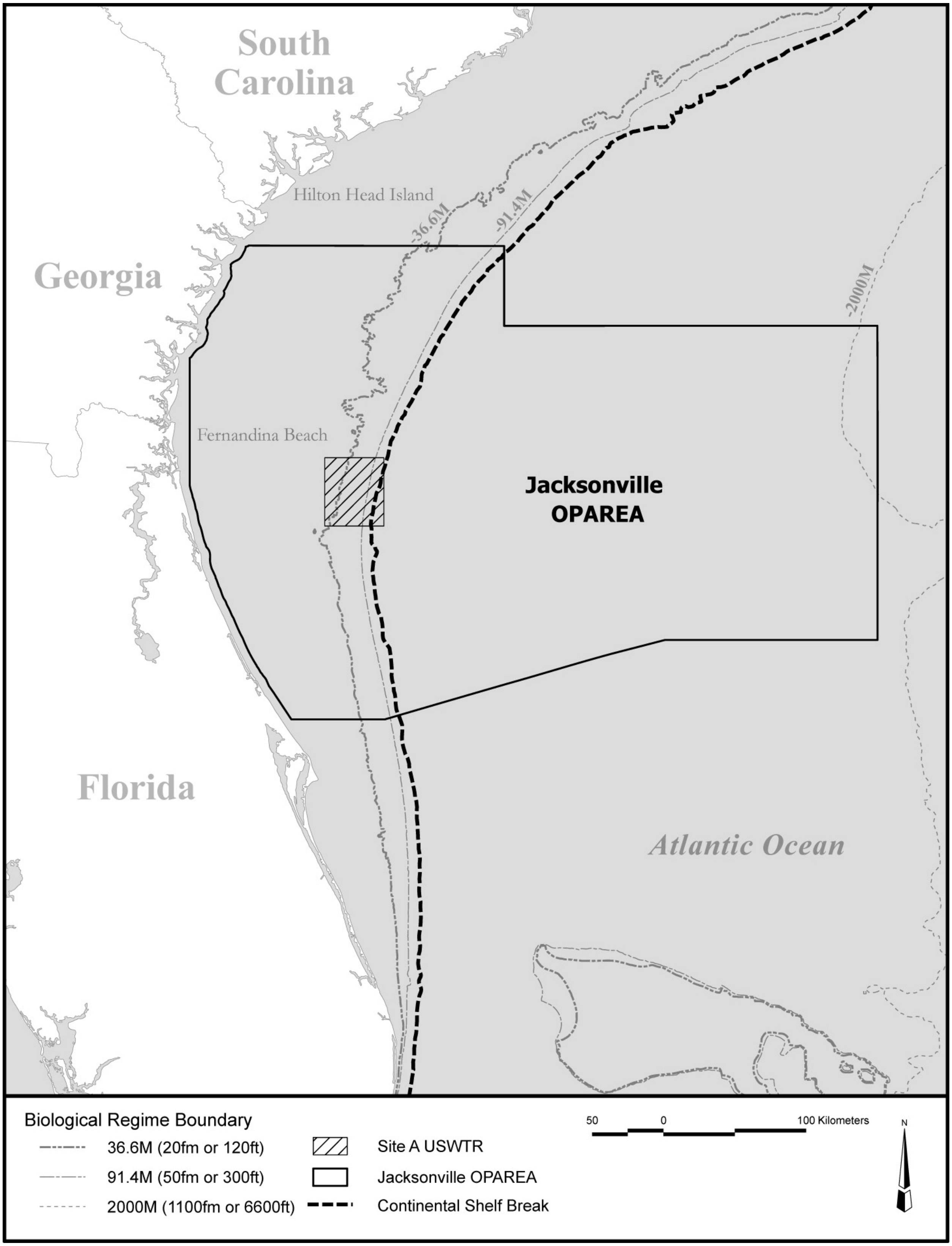


Figure 1-1. Location map of Site A range within the JAX OPAREA. Source: DoN (2007a)

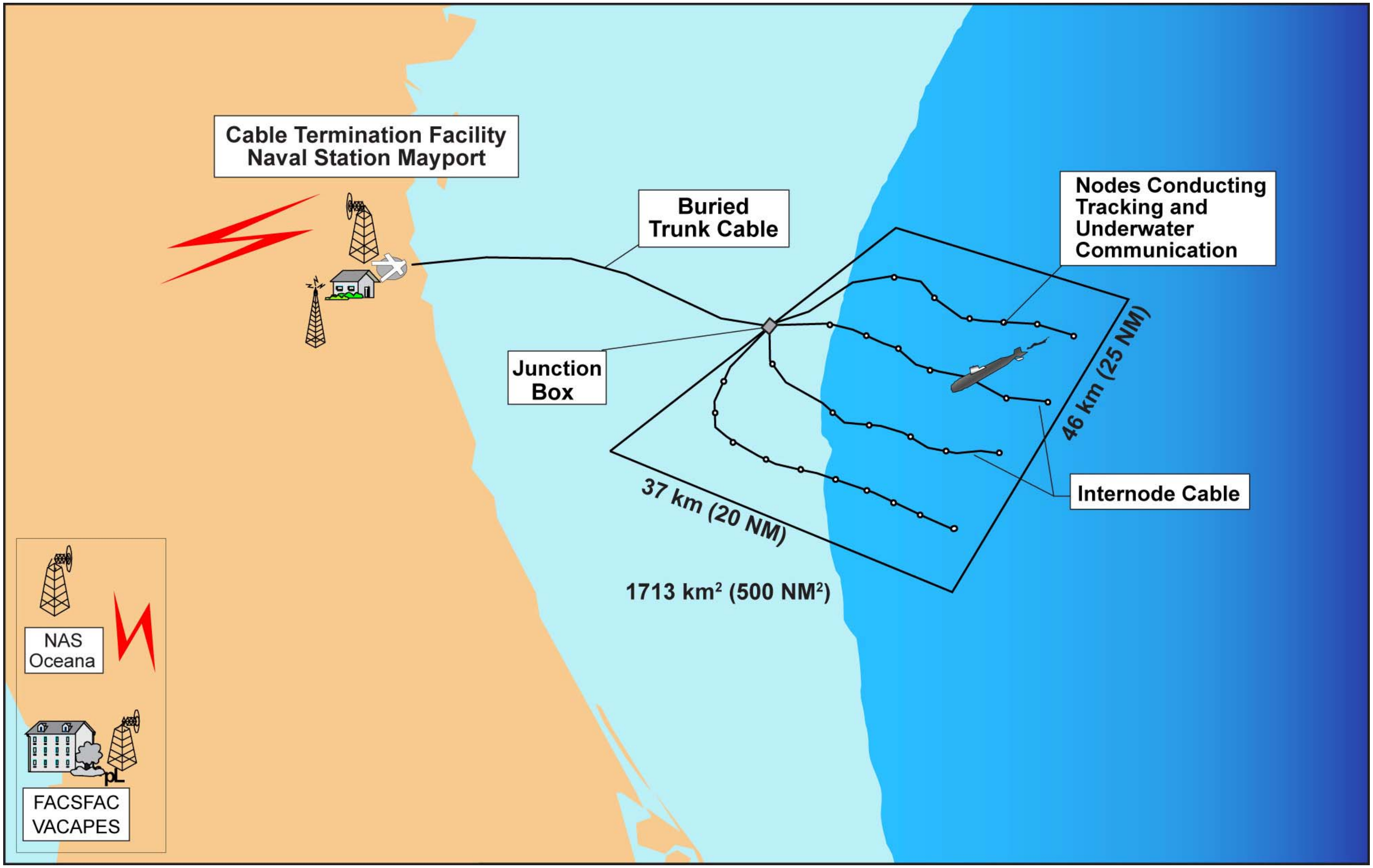


Figure 1-2. Depiction of the Site A range concept. Source: DoN (2007a)

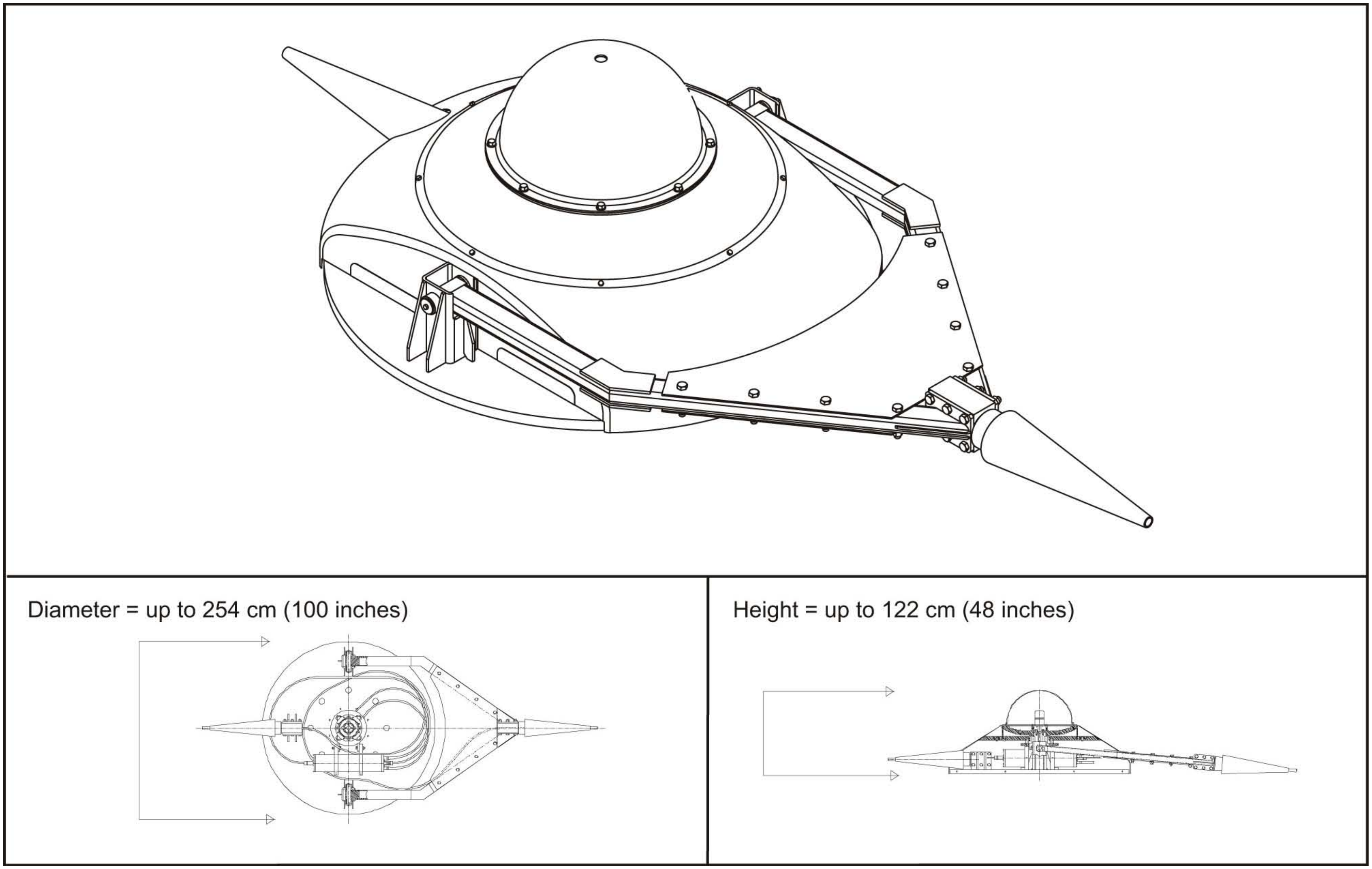


Figure 1-3. Representation of a dome-shaped USWTR transducer node. Source: DoN (2007a)

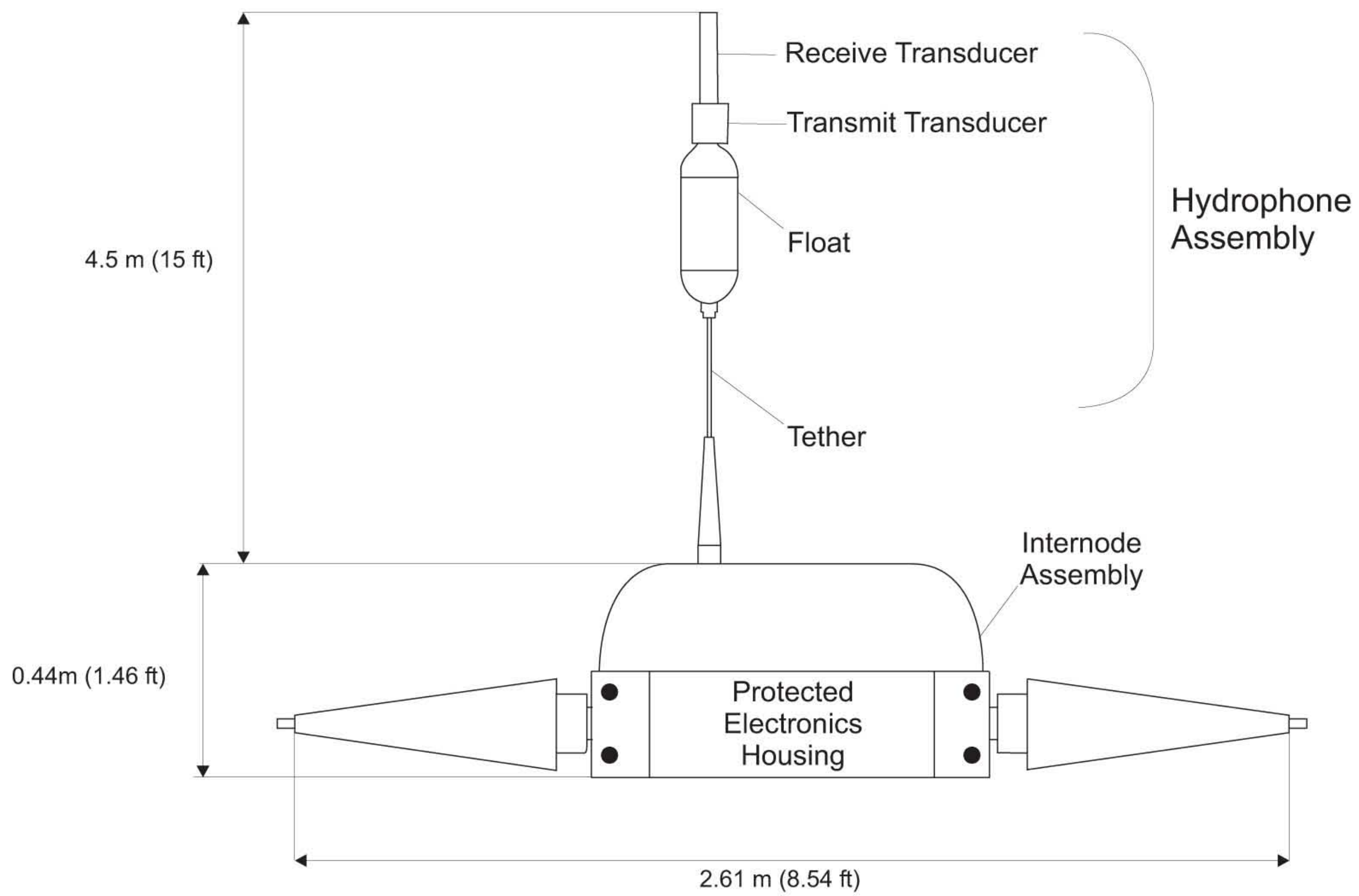
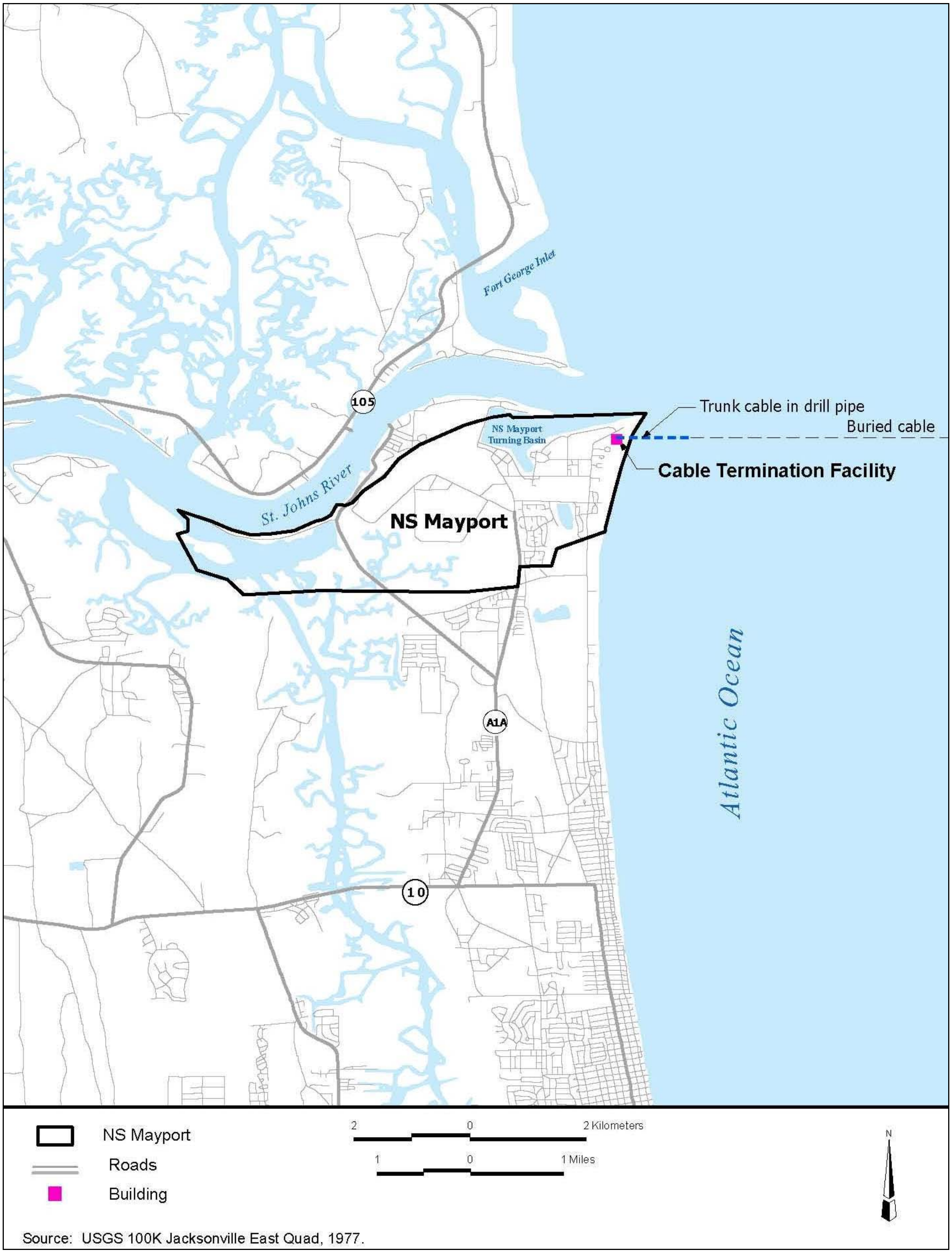


Figure 1-4. Representation of a tethered sensor node without protective structure. Source: DoN (2007a)



Source: USGS 100K Jacksonville East Quad, 1977.

Figure 1-5. Location map of the Site A cable installation and cable termination facility. Sources: USGS (1977); DoN (2007a)

The trunk cable would be buried within the coastal zone and terminate in a small building known as the CTF (**Figure 1-6**). From there, information gathered on the USWTR would be transmitted via either an existing military data link or existing commercial data links to the Fleet Area Control and Surveillance Facilities Virginia Capes and Jacksonville (FACSFAC VACAPES/FACSFAC JAX).

The design of the in-water system is structured to achieve a long operating life, in the case of USWTR a goal of 20 years (yr), with a minimum need for maintenance and repair. This is due to the high cost of performing at-sea repairs on transducer nodes or cables, the inherently long lead time to plan and conduct such repairs (often six months or more) and the loss of the training range in the interim until such repairs are made. The long-life performance is achieved by implementing multiple levels of redundancy in the system design, to include back up capacity to key electronic components, fault tolerance to the loss of individual sensors, and overlap in the detection areas for individual tracking sensors. The use of materials capable of withstanding long-term exposure to high water pressure and salt water-induced corrosion is also important. Cables may be periodically inspected by divers or undersea vehicles to ensure they remain buried.

The FACSFAC VACAPES would submit cable area coordinates to the National GeoSpatial-Intelligence Agency (NGA) and request that the USWTR area be noted on charts within the appropriate area. This area would be noted in the *U.S. Coast Pilot* as a military operating area, as are other areas on the east coast. The Department of the Navy (DoN) will promulgate a notice to mariners and a notice to airmen within 72 hours (hr) of the training activities, as appropriate. The DoN also will establish a local outreach program that could include such avenues of communication as a website; U.S. Coast Guard (USCG) radio; state programs to communicate with divers and commercial and recreational fishers; and regular communications with the community.

Construction is scheduled to be completed in one to three phases based on the manner in which funding is made available. If completed in three phases, the first phase would encompass a minimum of 686 km^2 (200 NM^2), followed by a second phase of 686 km^2 (200 NM^2), and a final phase of 343 km^2 (100 NM^2). A two-phase installation is also possible. If the range were built in phases, there would be an approximate three-year wait between the construction of each phase. Should the Navy determine that a single installation phase is appropriate, the Overseas Environmental Impact Statement (OEIS)/Environmental Impact Statement (EIS) reflects the anticipated effects of the entire operational capability. Construction would take approximately 6 to 12 months (mo) per phase. The preferred in-water construction period is spring through fall.

1.4 TRAINING RANGE USAGE

The principal type of exercise conducted on the USWTR would be ASW. A wide range of ships, submarines, aircraft, non-explosive exercise weapons, and other training-related devices are used for ASW training. Submarines, surface ships, and aircraft all conduct ASW and would be the principal users of the range. The requirements of threat realism on the USWTR necessitate training with a variety of sensors, non-explosive exercise weapons, target submarine simulators, and other associated hardware. Many of the materials used on the USWTR would be recovered after use; however, some would be left in place. All ordnance used would be non-explosive.

1.4.1 Anti-Submarine Warfare (ASW)

Either individually or as a coordinated force, submarines, surface ships, and aircraft conduct ASW against submarine targets. Submarine targets include both actual submarines and other mobile targets that simulate the operations and signature characteristics of an actual submarine. ASW exercises are complex and highly variable. These exercises have been grouped into the four representative scenarios described below in order to best characterize them for environmental impact analysis purposes. Additional details regarding the four training scenarios are summarized in **Table 1-1**. **Table 1-2** provides a list of the platforms, sensors, non-explosive exercise weapons, target submarine simulators, and other associated hardware typically employed in each scenario.

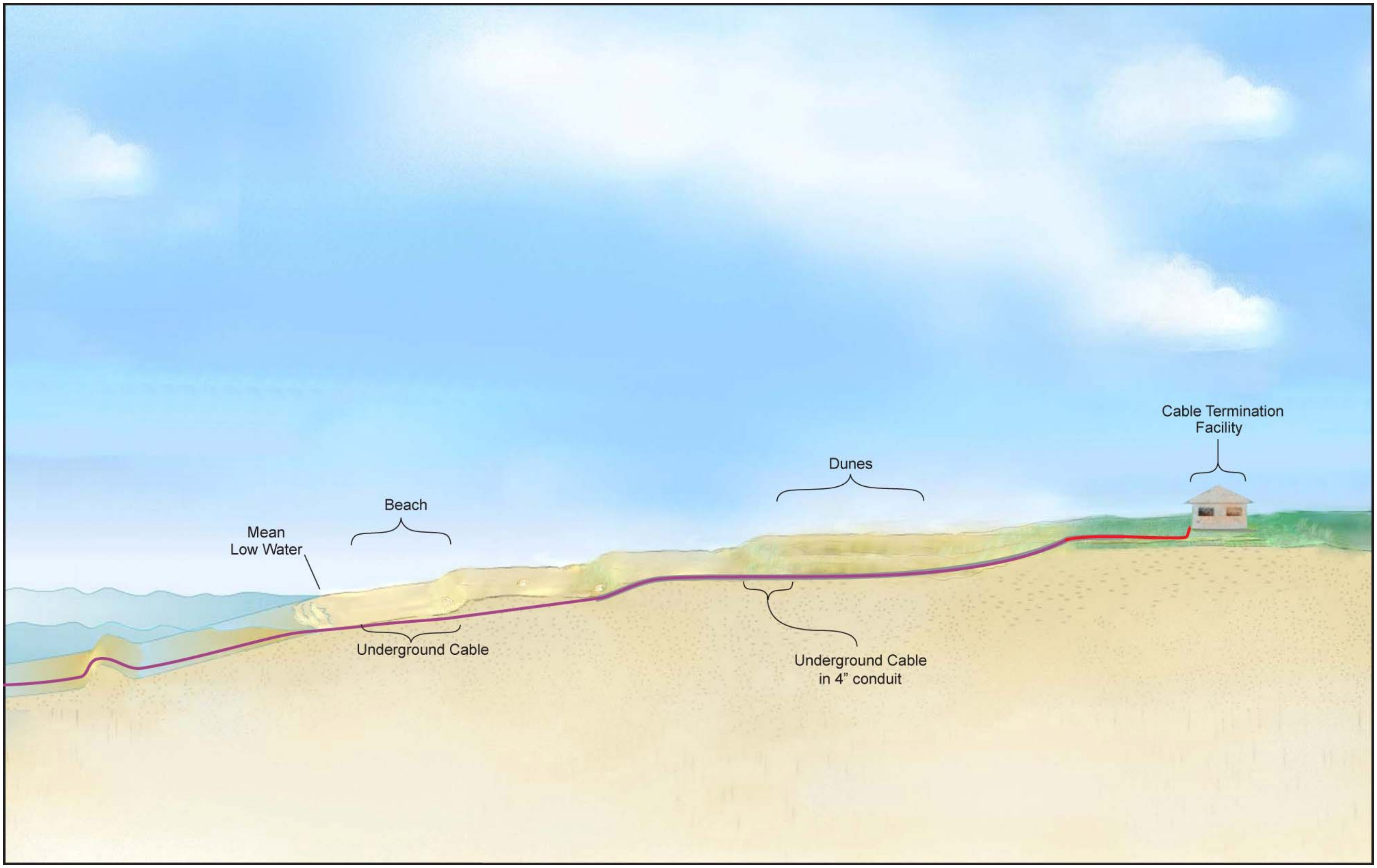


Figure 1-6. Depiction of the Site A landside cable installation, Wild Cow Island, Florida. Source: DoN (2007a)

Table 1-1
USWTR Scenarios

Component	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Exercise Participants	One fixed- or rotary-wing aircraft vs. one submarine target	One ship and one helicopter vs. submarine target	One submarine vs. one submarine target	Two surface ships and two helicopters vs. submarine target
Non-explosive Exercise Weapons Used	Lightweight exercise torpedoes (EXTORPs) and lightweight recoverable exercise torpedoes (REXTORPs)	Lightweight and heavyweight EXTORPs (and once per year, a vertical launch anti-submarine [VLA] rocket may be fired from a ship on range) and REXTORPs	Heavyweight EXTORPs	Lightweight and heavyweight EXTORPs (and once per year, a VLA may be fired from a ship on range) and REXTORPs
Active Sound Sensors/ Sources Used	Active sonobuoys, dipping sonar, range pingers, torpedo sonar, underwater communication devices, submarine acoustic countermeasures, and NIXIE	Ships' sonar, active sonobuoys, range pingers, dipping sonar, torpedo sonar, and underwater communication devices, submarine acoustic countermeasures, and NIXIE	Submarine sonar, range pingers, torpedo sonar, and underwater communication devices	Ships' sonar, active sonobuoys, range pingers, dipping sonar, torpedo sonar, and underwater communication devices, submarine acoustic countermeasures, and NIXIE
Other Devices Used	Passive sonobuoys, target simulators, submarine acoustic countermeasures, and expendable bathythermographs (XBTs)	Passive sonobuoys, target simulators, submarine acoustic countermeasures, and XBTs	Submarine acoustic countermeasures, submarine target simulators, and XBTs	Passive sonobuoys, target simulators, submarine acoustic countermeasures, and XBTs
Approximate Duration of Exercise	1.5 – 2.5 hr (helo) 4 – 5 hr (fixed wing)	3 – 4 hr	6 hr	3 – 4 hr
Frequency of Exercise	355 events per year	62 events per year	15 events per year	38 events per year
Comments	Submarine targets can be an actual submarine or submarine target.	Submarine targets can be an actual submarine or submarine target.	One submarine simulates a quiet diesel-electric submarine. The other attempts to detect, locate, and simulate attack.	Submarine targets can be an actual submarine or submarine target.
Exercise Participants	One fixed- or rotary-wing aircraft vs. one submarine target	One ship and one helicopter vs. submarine target	One submarine vs. one submarine target	Two surface ships and two helicopters vs. submarine target

Table 1-2
Typical Hardware Used on an USWTR

Hardware	Description	
PLATFORMS		
Surface Ships	East coast multi-mission surface combatants including destroyers, cruisers, and frigates are primarily homeported at Norfolk, Virginia, and Mayport, Florida.	Approx. 140
Submarines	Attack submarines are designed to seek and destroy enemy submarines and surface ships. Submarines primarily from east coast homeports of Norfolk, Virginia, Groton, Connecticut and Kings Bay, Georgia would use the range.	Approx. 150
Helicopters	For ASW, helicopters operate from 0 to 760 m (2,500 ft). The SH-60 Seahawk (SH-60B) is a twin-engine helicopter flown from cruisers, destroyers, and frigates. The SH-60F is essentially the same basic airframe with a different sensor suite and is flown from carriers. For ASW, the SH-60B uses magnetic anomaly detection, sonobuoys (monitored both onboard and on its host ship via link), radar, radar detection equipment (electronic support measures), and both aided (forward-looking infrared, low-light vision 'night vision,' or binoculars), and unaided visual search. The SH-60F's primary ASW sensor is a dipping active and passive sonar that is employed from a hover. It can use sonobuoys. The SH-60F does not have magnetic anomaly detection gear, radar, or sophisticated electronic support measures. The homeport for both helicopters is Jacksonville Florida. The SH-60F is at NAS Jacksonville and the SH-60B is nearby at Naval Air Station (NAS) Mayport. The MH-60R is the replacement for both the SH-60B and the SH-60F and will also be based in Jacksonville. It will have a dipping sonar plus elaborate radar, electroptics, and electronic support measures.	Approx. 320
Fixed-Wing Aircraft	Maritime patrol aircraft from Jacksonville, Florida, operate from near the ocean surface to 3,050 m (10,000 ft). They carry advanced submarine detection sensors such as active and passive aircraft launched sonobuoys and magnetic anomaly detection gear. Maritime patrol aircraft have the longest on-station time of any ASW aircraft. All Atlantic coast fixed wing ASW aircraft will be based in Jacksonville.	Approx. 180
Range Support Craft	Range support craft are approximately 61-m-long (200-ft-long) range support boats. They are used for launching and recovering targets and for recovering EXTORPs and REXTORPs. On some days, the range boat participating in training exercises would retrieve multiple pieces of equipment.	Approx. 220
TARGETS		
MK 30 ASW Target Simulator	The MK 30, an electrically propelled target, is the current standard US Navy submarine target simulator. The target is 54 cm (21 in.) in diameter, 6.2 m (20 ft) long, and weighs 1,220 kilograms (kg) (2,700 pounds [lb]). It can be launched from a surface craft or dropped by a helicopter, and may be recovered by either surface craft or helicopter. The MK 30 can tow a 92-m (300-ft) array consisting of a hydrophone, a projector (to simulate submarine signatures), and a magnetic source (to trigger magnetic anomaly detection gear). It either runs a preprogrammed trajectory or is controlled by signals transmitted from the range. The MK 30 can run for about six hours (depending on the speed selected) and is fully recovered at the end of each run. It is reconditioned and reused.	Approx. 180

Table 1-2 (*Continued*)
Typical Hardware Used on an USWTR

Hardware	Description	
TARGETS		
MK 39 Expendable Mobile Acoustic Torpedo Target	The MK 39 expendable mobile acoustic torpedo target is an electrically propelled air- or ship-launched submarine simulator. It is 12.4 by 91.4 cm (4.9 by 36 in) and weighs 9.6 kg (21 lbs). The MK 39 target acts as an echo repeater for active sonars and an acoustic target for passive detection. It can also deploy a 30.5-m (100-ft) wire to produce a recognizable magnetic anomaly detection signature. The MK 39 contains lithium batteries. If launched from an aircraft, the MK 39 separates from its parachute assembly. The parachute (38 cm [15 in.] in diameter) is jettisoned and sinks away from the unit. When the MK 39 enters the water following the launch, it typically travels 9 m (30 ft) downward, then activates itself and begins its preprogrammed run for several hours. The target typically runs for 6 hr, but has the capability to run up to 11 hr. At the completion of the run, the MK 39 scuttles and sinks to the ocean bottom.	Approx. 160
EXERCISE WEAPONS		
MK 46 and MK 54 Lightweight EXTORPs, and REXTORPs	MK 46 and MK 54 are high-speed lightweight torpedoes that are launched from helicopters, fixed-wing aircraft, and surface ships. The MK 46 and MK 54 have an OTTO II fuel propulsion system and primarily use acoustic homing. An exercise torpedo that actually “runs” is referred to as an “EXTORP.” Only about 10 percent (%) of the lightweight shots would be “runners.” The remaining shots are non-running “dummy” torpedo shapes called “REXTORPs.” REXTORPs do not have fuel sources. All torpedoes would be recovered. A parachute assembly for aircraft-launched torpedoes is jettisoned and sinks. The parachutes range from 0.37 to 0.84 square meters (m^2) (4 to 9 square feet [ft^2]) in diameter.	Approx. 330 (Approx. 300 “non-runners,” 30 “runners”)
MK 48 Advanced Capability Heavyweight EXTORPs	MK 48 is the current standard U.S. Navy heavyweight torpedo for use by submarines and has an OTTO II fuel propulsion system. Over it’s service life the MK48 has been extensively modified to remain current with the threat. The MK 48 advanced capability (ADCAP) is an extensively modified version of the MK 48 torpedo, capable of greater speed and endurance. The torpedo uses passive and active acoustic homing modes, and also can operate via wire guidance from the submarine. The guidance wire is generally 28 km (15 NM) long and 0.11 cm (0.043 in.) in diameter. The maximum tensile breaking strength of the wire is 19 kg (42 lb). All MK 48 exercise shots would be EXTORPs. All torpedoes would be recovered.	Approx. 50
Vertical Launch Antisubmarine Rocket	The vertical launch antisubmarine rocket provides naval surface ships with a rapid-response all-weather ASW and standoff weapon capability to offset the advantages that enemy submarines enjoy by virtue of being submerged and acoustically silent. A MK 46 or MK 54 EXTORP is mounted on one of these rockets, which is launched from a surface ship. During flight, the torpedo separates from the rocket airframe and parachutes into the sea. The torpedo would be recovered.	Approx. 10

Table 1-2 (*Continued*)
Typical Hardware Used on an USWTR

Hardware	Description	
SENSORS		
Sonobuoys	A sonobuoy is an expendable device used for the detection of underwater radiated or reflected sound energy from a target submarine and for conducting vertical water column temperature measurements. There are three basic types of sonobuoys: passive, active, and XBTs (see below). Sonobuoys are launched from aircraft and ships. Following deployment, sonobuoys' sensors descend to specified depths. A float containing a wire antenna is inflated and goes to the surface from the depth at which the buoy is deployed (generally about 27 to 122 m [90 to 400 ft]). Data measurements are transmitted to the surface unit via an electrical cable and the information is then radioed back to an aircraft or ship. Sonobuoys are cylindrical devices about 12.5 cm (4.9 in.) in diameter and 91 cm (36 in.) in length. They weigh between 6 and 18 kg (14 and 39 lb). At water impact, a seawater battery activates and deployment initiates. The parachute assembly (aircraft launched only) is jettisoned and sinks away from the unit, while a float containing an antenna is inflated. The parachute canopies are generally 20 to 30 cm (8 to 12 in.) in diameter. The subsurface assembly descends to a selected depth. There, the sonobuoy case falls away and sea anchors deploy to stabilize the hydrophone (underwater microphone). The operating life of the seawater battery is programmable up to eight hours, after which the sonobuoy scuttles itself and sinks to the ocean bottom.	Approx. 2,000
Expendable Bathythermograph (XBT)	XBTs are launched from aircraft, ships, and submarines. An XBT system consists of an expendable probe, a data processing/recording system, and a launcher. An XBT is a device for obtaining a record of temperature as a function of depth. The XBT probe has a single, fine copper wire that spools out at the launch end. A return signal is received via a sea water return consisting of a wire whose end is in contact with the sea water. Eventually, the wire runs out and breaks and the XBT sinks to the ocean floor. Airborne versions are also used; these use radio frequencies to transmit the data to the aircraft during deployment. Data are recorded as the probe falls. ASW operators use temperature profiles data obtained by the XBT to identify the impact of temperature on sonar propagation and acoustic range prediction (http://www.sippican.com accessed 28 November 2007).	Approx. 470
Ship and Submarine Sonars	Surface ships and submarines are equipped with both active and passive sonar to search for, detect, localize, classify, and track submarines and surface ships. Passive systems do not emit any energy and therefore are not a subject of this OEIS/EIS. The primary active sonar systems for surface ships are the 53 and 56 class sonar systems. The primary submarine active sonar is the BQQ – 5. Submarines are also equipped with several types of auxiliary sonar systems for ice and mine avoidance, for top and bottom sounders to determine the submarine's distance from the surface and the bottom in the water column, and for acoustic communications.	Per ship and submarine usage as listed above.
Dipping Sonars	Dipping sonars are active or passive sonar systems that are lowered on cable by helicopters to detect or maintain contact with underwater targets. Although not all of the current inventory of rotary wing ASW aircraft are equipped with dipping sonar (SH-60B is not so equipped, SH-60F is equipped), the MH-60R, which is replacing both the SH-60B and SH-60F, will have dipping sonar. The usage number to the right reflects the assumption that eventual usage of the range will be exclusively by the MH-60R.	Approx. 320

Table 1-2 (*Continued*)
Typical Hardware Used on an USWTR

Hardware	Description	
COUNTERMEASURES		
Acoustic Device Countermeasures	Submarines launch acoustic device countermeasures to foil opponents' sensors and weapons. They are sound-producing decoys, typically cylinder-shaped. They are 8 to 15 cm (3 to 6 in.) in diameter, 102 to 280 cm (40 to 110 in.) long, and weigh between 3 and 57 kg (7 and 125 lb).	Approx. 40
Anti-torpedo Decoy (NIXIE)	Surface ships sometimes trail an anti-torpedo decoy called a NIXIE when faced with a possible torpedo attack. The NIXIE is a small cylindrical sound-producing decoy at the end of an approximately 2.5-cm (1-in.) thick smooth cable, which is towed approximately 100 m (330 ft) astern of the ship. The NIXIE generates sounds to create a false target for the torpedo. Both the device and cable are smooth and slick to prevent any unwanted sounds from entering the water. The device is not typically used for long periods as it restricts ships movements.	Est. fewer than 20

Scenario 1: One Aircraft vs. One Submarine (see **Figure 1-7**). The Range Operations Center (ROC) gives an aircraft the approximate, or "last known," location of the submarine. An aircraft flies over the range area and the crew conducts a localized search for a target submarine using available sensors. After the crew detects the submarine, it simulates an attack. Each exercise period typically involves the firing of one exercise torpedo (EXTORP); additional attack phases are conducted with simulated torpedo firings.

Scenario 2: One Ship with Helicopter vs. One Submarine (see **Figure 1-8**). A ship, with a helicopter on board, approaches the range area and launches its helicopter to conduct a "stand-off" localization and attack. In some exercises, the ship conducts its own "close in" attack simulation (i.e., where the ship gets close enough to track the submarine using its own hull-mounted sonar). Each exercise period typically involves the firing of one EXTORP by the ship or helicopter or, in some cases, by both. Some ships carry two helicopters, but only one participates in the exercise at any one time. While the ship is searching for the submarine, the submarine may practice simulated attacks against the target and on average would launch EXTORPs during 50 percent (%) of the exercises.

Scenario 3: One Submarine vs. Another Submarine (see **Figure 1-9**). Two submarines on the range practice locating and attacking each other. If only one submarine is available for the exercise, it practices attacks against a target simulator or a range support boat, or it practices shallow water maneuvers without any attack simulation.

Scenario 4: Two Ships and Two Helicopters vs. One Submarine (see **Figure 1-10**). This scenario involves the same action as Scenario 2, but with two ships and two aircraft – helicopters or marine patrol aircraft – searching for, locating, and attacking one submarine. Typically, one ship and one aircraft are actively prosecuting while the other ship and the other aircraft are repositioning. While the ships are searching for the submarine, the submarine may practice simulated attacks against the ships and on average would launch torpedoes during 50% of the exercises. Multiple sources may be active at one time. Scenario 4 is operationally the busiest event on the range.

1.4.2 Active Acoustic Devices

Tactical ASW sonars are designed to search for, detect, localize, classify, and track submarines. There are two types of sonars, passive and active.

Passive sonars only listen to incoming sounds and, since they do not emit sound energy in the water, lack the potential to acoustically affect the environment.

Active sonars emit sounds that bounce off an underwater object to determine information about the object. Active sonars are the most effective detection systems against modern, ultra-quiet submarines in shallow water.

Modern sonar technology has developed a multitude of sonar sensor and processing systems. In concept, the simplest active sonars emit omnidirectional pulses (pings) and time the arrival of the reflected echoes from the target object to determine range. More sophisticated active sonar emits an omnidirectional ping and then rapidly scans a steered receiving beam to provide both directional and range information. More advanced sonars use multiple preformed beams, listening to echoes from several directions simultaneously and providing efficient detection of both direction and range.

The military sonars to be deployed in the USWTR are designed to detect submarines in tactical operational scenarios. This task requires the use of passive sonars across a broad spectrum and active sonars in the mid-frequency range (1 to 10 kilohertz [kHz]) predominantly.

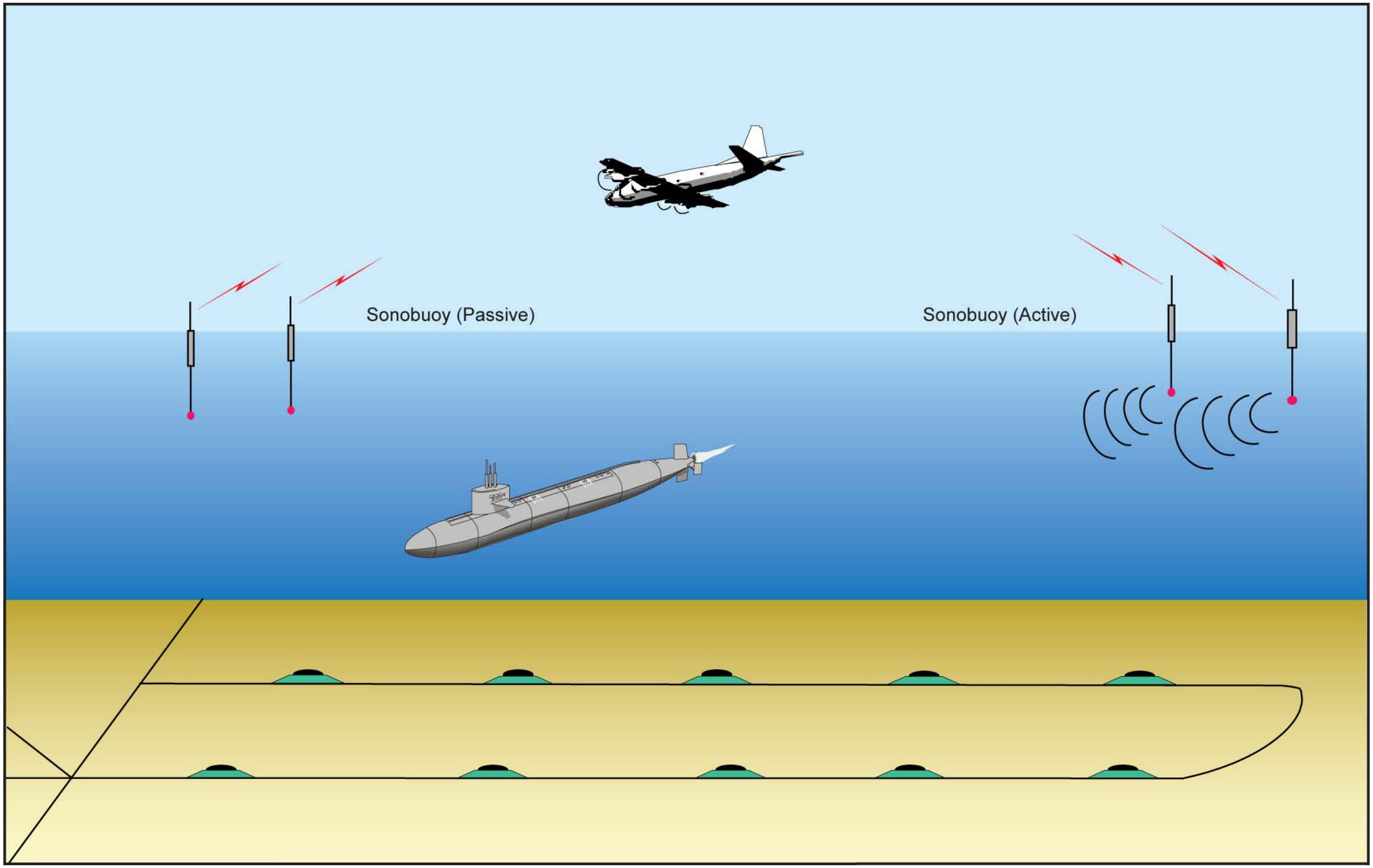


Figure 1-7. Depiction of the range use Scenario 1: One aircraft versus one submarine. Source: DoN (2007a)

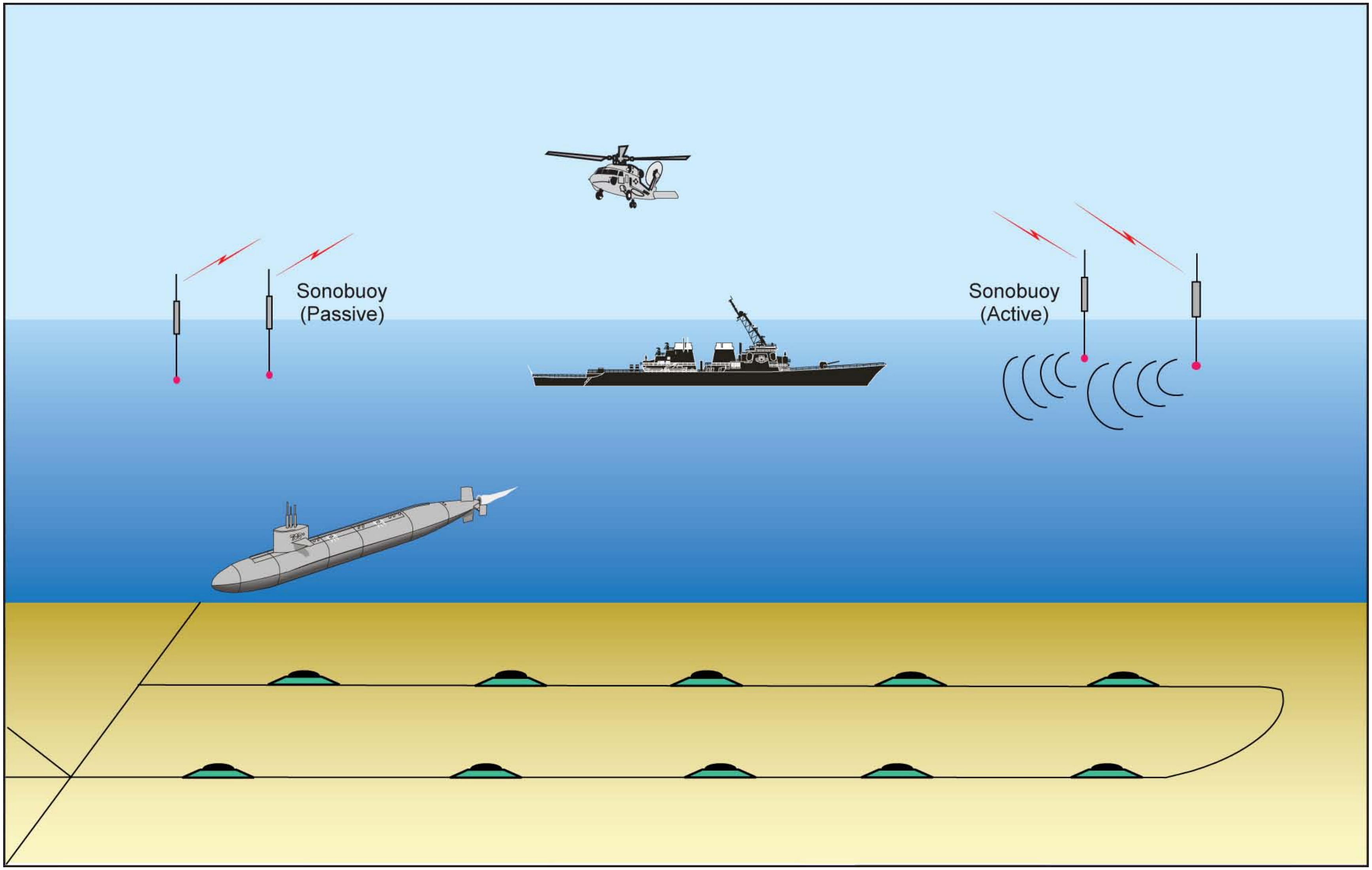


Figure 1-8. Depiction of the range use Scenario 2: One ship with helicopter versus one submarine. Source: DoN (2007a)

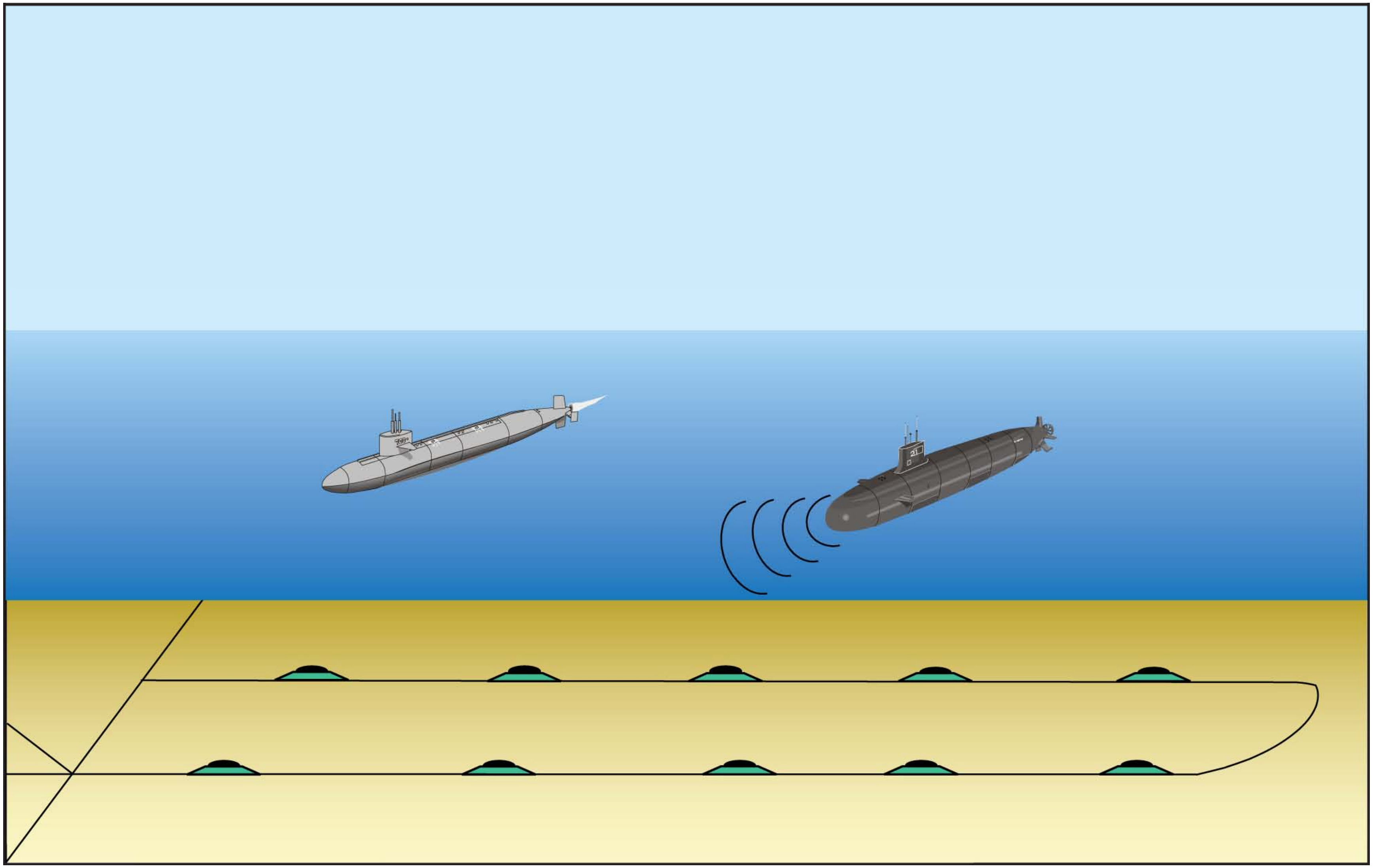


Figure 1-9. Depiction of the range use Scenario 3: One submarine versus another submarine. Source: DoN (2007a)

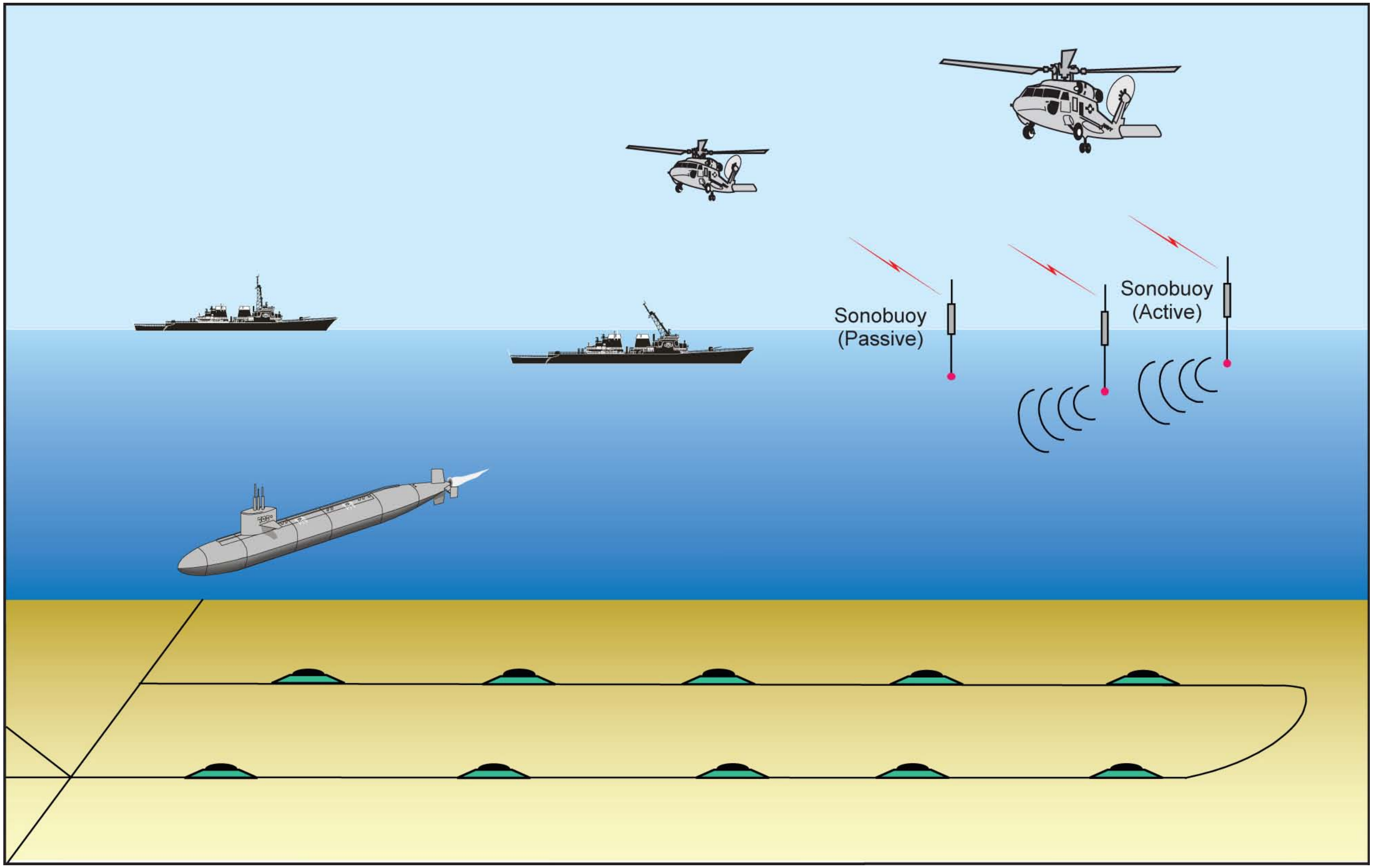


Figure 1-10. Depiction of the range use Scenario 4: Two ships and two helicopters versus one submarine. Source: DoN (2007a)

The types of tactical acoustic sources that would be used in training exercises on the range include:

Surface Ship Sonars. Although most (greater than 60%) surface ships do not have any mid-frequency active (MFA) sonar (i.e., aircraft carriers, amphibious ships, and support ships), some surface ships would operate MFA sonar in the USWTR, including guided missile cruisers (CG), guided missile destroyers (DDG) and frigates (FFG).

Submarine Sonars. Tactical military submarine sonars are used to detect and target enemy submarines and surface ships. Use of these active sonars is minimized to prevent detection by enemy submarines and surface ships. Submarines are also equipped with several types of auxiliary sonar systems for ice and mine avoidance, to determine the submarine's depth (distance to the surface or underside of ice) and the submarine's height from the bottom. Submarines are also equipped with underwater communications devices.

Aircraft Sonar Systems. Aircraft sonar systems that would operate on the USWTR include sonobuoys and dipping sonars.

Torpedoes. Torpedoes are the primary ASW weapon used by surface ships, aircraft, and submarines. The guidance systems of these weapons can be autonomous or, if launched by a submarine, electronically controlled from the launching platform through an attached wire. The autonomous guidance systems use onboard sonars. They operate either passively, exploiting the emitted sound energy by the target, or actively, homing on the received echoes. All torpedoes to be used at the USWTR would be non-explosive and recovered after use.

Acoustic Device Countermeasures (ADCs). ADCs are submarine simulators and act as decoys to avert localization and/or torpedo attacks.

Training Targets. ASW training targets are used to simulate target submarines. They are equipped with one or a combination of the following devices: (1) acoustic projectors emanating sounds to simulate submarine acoustic signatures; (2) echo repeaters to simulate the characteristics of the echo of a particular sonar signal reflected from a specific type of submarine; (3) magnetic sources to trigger magnetic detectors. Both expendable and recoverable training targets would be used on the USWTR.

Range Sources. Range pingers are active sound-producing devices that allow each of the in-water platforms on the range (e.g., ships, submarines, target simulators, and EXTORPs) to be tracked by the range transducer nodes. In addition to passively tracking the pinger signal from each range participant, the range transducer nodes are also capable of transmitting signals for a limited set of functions. These functions include submarine warning signals, signalized commands to submarine target simulators, and occasional voice or data communications (received by participating ships and submarines on range).

1.5 RANGE LOGISTICS SUPPORT

In general, the USWTR would take advantage of existing logistics support for range operations. However, some logistical support arrangements must be made for the delivery and recovery of targets and torpedoes.

1.5.1 Target Support

Recoverable targets (i.e., MK 30s) may be used on the USWTR approximately 175 times a year. These targets are distinct from the expendable MK 39 acoustic torpedo and are fully recovered. A range support boat provides the range with the targets for the training exercises. One range craft would be on site whenever a MK 30 is in use.

Range users would deploy expendable targets as needed. Range support craft are not needed for expendable targets.

1.5.2 Exercise Torpedo Support

Either recoverable EXTORPs (REXTORPs) or EXTORPs may be launched in an attack on the range by ships and aircraft (both marine patrol aircraft and helicopters). An EXTPORP is an actual torpedo without a high-explosive warhead and configured for exercise use. A REXTORP is a torpedo-shaped dummy without propulsion, seeker assembly, or warhead. At the end of the torpedo run, specially designed and equipped range torpedo recovery boats typically recover EXTORPs; however, if a torpedo recovery boat is not available, all surface combatants are trained and equipped to recover torpedoes.

When an EXTORP is recovered, the fuel tank is full of liquid composed of seawater and fuel. The EXTORP is returned to a range support facility (which could be portable) where this liquid is removed and stored for later processing under existing procedures. The unit is then flushed with a non-corrosive preservative and is transported to an intermediate maintenance facility for rebuild. Typically, individual torpedoes are reused approximately 20 times.

Helicopters working from ships would not require shore support, and maritime patrol aircraft would be supported by their home base. Helicopters not operating from ships would require a minimal staging area to onload/offload and, potentially, to store torpedoes, depending on how often the torpedoes are used on the range. Squadron personnel would have to be brought into the staging area on a temporary basis to assemble and onload/offload the torpedoes.

The staging area would be located at an existing airfield located within 148 km (80 NM) of the training range. The 148-km (80-NM) distance is based on the limitations of the recovery helicopters. Standard operating procedures also dictate that helicopters should avoid overflights of populated civilian land areas when carrying suspended loads.

1.6 DATES AND DURATION OF ACTIVITIES

The four scenarios would be run an estimated 480 times each year (**Table 1-3**). Often, multiple scenarios will be conducted sequentially within one day, so that this does not equate to training every day during the year. The Navy plans to train throughout the year to meet the requirements and schedules associated with the Fleet Response Training Plan (FRTP) and the potential for immediate deployment of forces (see **Section 1.1**).

In their large east coast OPAREAs, the Navy also conducts broader-scale exercises called joint task force exercises (JTFEX) and composite training unit exercises (COMPTUEX). In the case of these larger exercises, some units may break off and conduct operations on the USWTR, following one of the described exercise scenarios. The totals in **Table 1-3** include these additional training exercises. On any given day, the training scenario used may vary in some measure from one of the four scenarios described here, or more than one scenario may occur simultaneously on the range, but the total of all these scenario runs would represent the typical annual spectrum of training activities on the range. Any such variations would be within the range of analyzed impacts.

Table 1-3
Annual Tally of ASW Training Scenarios

Scenario	Approximate # Stand-Alone Events	Approximate # Events During JTFEX and COMPTUEX	Approximate Annual Total Events
1	320	40	360
2	60	0	60
3	20	0	20
4	10	30	40
Total Annual Events on Range			**480**
Note: JTFEX and COMPTUEX are multi-unit exercises. When their participants work on the USWTR, their numbers are represented above.			

2.0 MARINE MAMMAL SPECIES AND NUMBERS OCCURRING IN THE ACTION AREA

Most of the resource information presented for the Action Area is compiled in the Marine Resources Assessment (MRA) Update for the Charleston (CHASN)/JAX OPAREAs (DoN, 2007b) and this chapter relies heavily on the data gathered in the MRAs. The Navy MRA Program was implemented by the Commander, Fleet Forces Command, to initiate collection of data and information concerning the protected and commercial marine resources found in the Navy's OPAREAs. Specifically, the goal of the MRA program is to describe and document the marine resources present in each of the Navy's OPAREAs. The MRA for the CHASN/JAX OPAREA was recently updated in 2007 (DoN, 2007b).

Thirty-five marine mammal species have confirmed or potential records in the proposed Action Area. These include 32 cetacean, 2 pinniped, and 1 sirenian species (DoN, 2007b). Although these 35 marine mammal species may have recorded sightings or stranding in or near the study area, only 15 of those species are considered to occur regularly in the region. A number of the other species are considered extralimital indicating that there are one or more records of an animal's presence in the study area, but it is considered beyond the normal range of the species. Extralimital species, including all pinniped species, will not be analyzed further in this study. **Table 2-1** lists the species analyzed in this application. Some cetacean species are resident in the area year-round (e.g., bottlenose dolphins), while others (e.g., North Atlantic right and humpback whales) occur seasonally as they migrate through the area.

Marine mammals are found throughout the Action Area, with large numbers of sightings occurring on the continental shelf, particularly along the coast, and near the continental shelf break. Many toothed whale species, such as the pilot whale and Risso's dolphin, frequent waters near the shelf break, where concentrations of their preferred prey (squid) occur. The bottlenose dolphin, Atlantic spotted dolphin, humpback whale, and North Atlantic right whale are the most likely species to be sighted on the shelf. Some baleen whales, such as the humpback whale and the North Atlantic right whale, migrate through the nearshore waters of the Action Area. Critical habitat for the North Atlantic right whale occurs in the Action Area (for more information, see the right whale discussion). Due to the highly endangered status of this species, dedicated aerial surveys were conducted during fall and winter (November through March) to obtain information on the occurrence of this species on its winter calving ground in the coastal waters of Georgia and northern Florida. As a result, there were concentrated survey efforts in a confined region when North Atlantic right whale mothers with their calves occur in the Action Area. Other than these dedicated aerial survey efforts, there is comparatively little effort conducted in other portions of the Action Area, particularly deep waters seaward of the continental shelf break. Information on the occurrence of offshore cetacean species is limited.

The endangered West Indian manatee (*Trichechus manatus*) is considered rare in the Action Area; this species normally occurs in extremely nearshore waters. However, manatees occasionally move further offshore (Reid et al., 1991). Manatees may be found in nearshore waters of the Action Area but are not likely to occur further offshore in the Action Area.

Cuvier's (*Ziphius cavirostris*), Gervais' (*Mesoplodon europaeus*), and Blainville's (*Mesoplodon densirostris*) beaked whales are the only beaked whale species expected regularly in the Action Area with possible rare occurrences of True's beaked whales (*Mesoplodon mirus*). Sowerby's beaked whales (*Mesoplodon bidens*) are considered extralimital in the Action Area (DoN, 2007b). It is very unlikely that proposed actions would impact the Sowerby's beaked whale; therefore, these this species is not discussed further in this application.

Marine Mammal Occurrence

The MRA data were used to provide a regional context for each species. The MRA represents a compilation and synthesis of available scientific literature (for example [e.g.], journals, periodicals, theses, dissertations, project reports, and other technical reports published by government agencies, private businesses, or consulting firms), and National Marine Fisheries Service (NMFS) reports including stock assessment reports (SARs), recovery plans, and survey reports.

The Navy has requested NMFS initiate Endangered Species Act (ESA) consultation in support of this Letter of Authorization (LOA) request.

Estimated Marine Mammal Densities

The density estimates that were used in previous Navy environmental documents have been recently updated to provide a compilation of the most recent data and information on the occurrence, distribution, and density of marine mammals. The updated density estimates presented in this assessment are derived from the *Navy OPAREA Density Estimates (NODE) for the Southeast OPAREAs* report (DoN, 2007b). Quantification of marine mammal density and abundance was primarily accomplished by evaluating line-transect survey data which was collected by the NMFS Northeast and Southeast Fisheries Science Centers (NEFSC and SEFSC). The NEFSC and SEFSC are the technical centers within NMFS that are responsible to collecting and analyzing data to assess marine mammal stocks in the U.S. Atlantic Exclusive Economic Zone (EEZ). These data sets were analyzed and evaluated in conjunction with regional subject matter experts, NMFS technical staff, and scientists with the University of St. Andrews, Scotland, Centre for Environmental and Ecological Modelling (CREEM). Methods and results are detailed in NODE reports covering all U.S. Atlantic coast OPAREAS as well as the Gulf of Mexico (GOMEX).

Density estimates for cetaceans were derived in one of three ways, in order of preference: 1) through spatial models using line-transect survey data provided by the NMFS (as discussed below); 2) using abundance estimates from Mullin and Fulling (2003); 3) or. based on the cetacean abundance estimates found in the National Oceanic and Atmospheric Administration (NOAA) SARs (Waring et al., 2007). The following lists how density estimates were derived for each species:

Model-Derived Density Estimates

- Fin whale (*Balaenoptera physalus*)
- Sperm whale (*Physeter macrocephalus*)
- Beaked whales (Family Ziphiidae)
- Bottlenose dolphin (*Tursiops truncatus*)
- Atlantic spotted dolphin (*Stenella frontalis*)
- Striped dolphin (*Stenella coeruleoalba*)
- Common dolphin (*Delphinus delphis*)
- Risso's dolphin (*Grampus griseus*)
- Pilot whales (*Globicephala* spp.)

SAR or Literature-Derived Density Estimates

- North Atlantic right whale (*Eubalaena glacialis*)[1]
- Humpback whale (*Megaptera novaeangliae*)[1]
- Minke whale (*Balaenoptera acutorostrata*)[2]
- *Kogia* spp.[2]
- Rough-toothed dolphin (*Steno bredanensis*)[2]
- Pantropical spotted dolphin (*Stenella attenuata*)[2]
- Clymene dolphin (*Stenella clymene*)[2]

Species for Which Density Estimates Are Not Available[3]

- Blue whale (*Balaenoptera musculus*)
- Sei whale (*Balaenoptera borealis*)
- Bryde's whale (*Balaenoptera brydei/edeni*)
- Killer whale (*Orcinus orca*)
- Pygmy killer whale (*Feresa attenuata*)
- False killer whale (*Pseudorca crassidens*)
- Melon-headed Whale (*Peponocephala electra*)
- Spinner dolphin (*Stenella longirostris*)
- Fraser's dolphin (*Lagenodelphis hosei*)
- Harbor porpoise (*Phocoena phocoena*)

[1] Abundance estimates were geographically and seasonally partitioned
[2] Abundance estimates were uniformly distributed geographically and seasonally
[3] See DoN (2007d) for additional discussion
Source: DoN (2007d)

Spatial modeling using Program DISTANCE (RUWPA[1]), a program based on Buckland et al. (2001, 2004), is the primary method of density estimation used to produce the updated NODE reports. Together with appropriate line-transect survey data, this method provides the most accurate/up-to-date density information for marine mammals in U.S. Navy OPAREAs. The density estimates in this document were calculated by a team of experts using survey data collected and provided by the NMFS and with expert modeling support provided by CREEM. Researchers at CREEM are recognized as the international authority on density estimation and have been at the forefront in development of new techniques and analysis methods for animal density including spatial modeling techniques. Spatial modeling techniques have an advantage over traditional line-transect/distance sampling techniques in that they can provide relatively fine scale estimates for areas with limited or no available survey effort by creating models based on habitat parameters associated with observations from other surveys with similar spatial or temporal characteristics. Analysis of line-transect data in this manner allows for finer-scale spatial and/or temporal resolution of density estimates, providing indications of regions within the study area where higher and lower concentrations of marine mammals may occur rather then the traditional approach of generating a single estimate covering a broad spatial strata. These generic spatial strata tend to mask the finer scale habitat associations suggested by the specific ecology of an individual species.

For the model-based approach, density estimates were calculated for each species within areas containing survey effort. A relationship between these density estimates and the associated environmental parameters such as depth, slope, distance from the shelf break, sea surface temperature (SST), and chlorophyll *a* (chl *a*) concentration was formulated using generalized additive models (GAMs). This relationship was then used to generate a two-dimensional density surface for the region by predicting densities in areas where no survey data exist. For the Southeast, all analyses for cetaceans were based on sighting data collected through shipboard surveys conducted by the NMFS NEFSC and SEFSC between 1998 and 2005. Species-specific density estimates derived through spatial modeling were compared with abundance estimates found in the SAR (Waring et al., 2007) to ensure consistency and all spatial models and density estimates were reviewed by NMFS technical staff. For a more detailed description of the methodology involved in calculating the density estimates, please refer to the NODE report for the Southeast OPAREAs (DoN, 2007d).

Table 2-1
Occurrence of marine mammal species in the Study Area and their status under the ESA. Naming convention matches that used in the NOAA SARs.

	Scientific Name	Status
Order Cetacea		
Suborder Mysticeti (baleen whales)		
Family Balaenidae (bowhead and right whales)		
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Family Balaenopteridae (rorquals)		
Humpback whale	*Megaptera novaeangliae*	Endangered
Minke whale	*Balaenoptera acutorostrata*	
Bryde's whale	*Balaenoptera edeni/brydei**	
Sei whale	*Balaenoptera borealis*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Blue whale	*Balaenoptera musculus*	Endangered
Suborder Odontoceti (toothed whales)		
Family Physeteridae (sperm whale)		
Sperm whale	*Physeter macrocephalus*	Endangered
Family Kogiidae (pygmy sperm whales)		
Pygmy sperm whale	*Kogia breviceps*	
Dwarf sperm whale	*Kogia sima*	
Family Ziphiidae (beaked whales)		
Cuvier's beaked whale	*Ziphius cavirostris*	
True's beaked whale	*Mesoplodon mirus*	
Gervais' beaked whale	*Mesoplodon europaeus*	
Blainville's beaked whale	*Mesoplodon densirostris*	
Family Delphinidae (dolphins)		
Rough-toothed dolphin	*Steno bredanensi*s	
Bottlenose dolphin	*Tursiops truncatus*	
Pantropical spotted dolphin	*Stenella attenuata*	
Atlantic spotted dolphin	*Stenella frontalis*	
Spinner dolphin	*Stenella longirostris*	
Striped dolphin	*Stenella coeruleoalba*	
Clymene dolphin	*Stenella clymene*	
Short-beaked common dolphin	*Delphinus delphis*	
Fraser's dolphin	*Lagenodelphis hosei*	
Risso's dolphin	*Grampus griseus*	
Melon-headed whale	*Peponocephala electra*	
Pygmy killer whale	*Feresa attenuata*	
False killer whale	*Pseudorca crassidens*	
Killer whale	*Orcinus orca*	
Short-finned pilot whale	*Globicephala macrorhynchus*	
Order Sirenia		
Family Trichechidae (manatees)		
West Indian manatee	*Trichechus manatus*	Endangered

* Includes more than one species, but nomenclature is still unsettled

3.0 AFFECTED SPECIES STATUS AND DISTRIBUTION

Marine mammal distribution is affected by demographic, evolutionary, ecological, habitat-related, and anthropogenic factors (Bjørge, 2002; Bowen et al., 2002; Forcada, 2002; Stevick et al., 2002). Movement of individuals is generally associated with feeding or breeding activity (Stevick et al., 2002). Some baleen whale species, such as the humpback whale, make extensive annual migrations to low-latitude mating and calving grounds in the winter and to high-latitude feeding grounds in the summer (Corkeron and Connor, 1999). Migrations undoubtedly occur during these seasons due to the presence of highly productive waters and associated cetacean prey species at high latitudes and of warm water temperatures at low latitudes (Corkeron and Connor, 1999; Stern, 2002); however, not all baleen whales migrate. Some individual fin, Bryde's, minke, and blue whales may stay in a specific area year-round.

Cetacean movements can also reflect the distribution and abundance of prey (Gaskin, 1982; Payne et al., 1986; Kenney et al., 1996). Cetacean movements have been linked to indirect indicators of prey, such as temperature variations, sea-surface chl *a* concentrations, and features such as bottom depth (Fiedler, 2002). Oceanographic features, such as eddies associated with the Gulf Stream, are important factors determining cetacean distribution since their prey are attracted to the increased primary productivity associated with some of these features (Biggs et al., 2000; Wormuth et al., 2000; Davis et al., 2002). The warm Gulf Stream moves rapidly through the Florida Straits and extends northeast along the continental shelf. The Gulf Stream is closest to the coast in the South Atlantic Bight (SAB) where the Action Area is located. This current is the single most-influential oceanographic feature of the region and influences water temperature, salinity, and nutrient availability. These factors, in turn, are important in regulating primary productivity associated with phytoplankton growth in the region and the subsequent secondary productivity of zooplankton and other animal life that provide prey for marine mammals. During fall, winter, and spring, phytoplankton abundances coincide with outer shelf upwelling, while in summer phytoplankton growth also occurs over the inner and middle shelf along the SAB (Atkinson et al., 1984).

There is also an association between cetaceans and cold-core and warm-core rings (Griffin, 1999; Biggs et al., 2000; Waring et al., 2001). Both ring types are eddies that detach from the Gulf Stream and increase the likelihood of higher cetacean presence for the duration of these mesoscale hydrographic features. It is likely that the upwelling associated with cold-core rings permits greater feeding efficiency by cetaceans on mesopelagic squids and fishes. Disturbances, such as hurricanes, atmospheric frontal systems, and shifts in current patterns can also increase the before-mentioned oceanographic conditions to enhance local productivity. For example, increased sediment and nutrient loads are present in freshwater systems following heavy and prolonged rainfall, similarly enhancing primary productivity along the continental shelf near the system's effluence.

3.1 THREATENED OR ENDANGERED MARINE MAMMAL SPECIES

Seven marine mammal species that occur in the Action Area and may be affected by the proposed activities are listed as endangered under the ESA. These include five baleen whale species (blue, fin, humpback, North Atlantic right, and sei), one toothed whale species (sperm whale), and one sirenian species (West Indian manatee).

3.1.1 North Atlantic Right Whale

- **General Description**—Adults are robust and may reach 18 m in length (Jefferson et al., 1993). North Atlantic right whales feed on zooplankton, particularly large calanoid copepods such as *Calanus* (Kenney et al., 1985; Beardsley et al., 1996; Baumgartner et al., 2007).

- **Status**—The North Atlantic right whale is one of the world's most endangered large whale species (Clapham et al., 1999; Perry et al., 1999; IWC, 2001).

  According to the North Atlantic right whale report card released annually by the North Atlantic Right Whale Consortium, approximately 393 individuals are thought to occur in the western North Atlantic (NARWC, 2007). The most recent NOAA SAR states that in a review of the photo-id recapture database for June 2006, 313 individually recognized whales were known to be alive during 2001 (Waring et al., 2008). This is considered the minimum population size. The North Atlantic right whale is under the jurisdiction of the NMFS. The recovery plan for the North Atlantic right whale was published in 2005 (NMFS, 2005a).

This species is presently declining in number (Caswell et al., 1999; Kraus et al., 2005). Kraus et al. (2005) noted that the recent increases in birth rate were insufficient to counter the observed spike in human-caused mortality that has recently occurred.

In an effort to reduce ship collisions with critically endangered North Atlantic right whales, the Early Warning System (EWS) (Right Whale Sighting Advisory System) was instigated in 1994 for the calving region along the southeastern U.S. coast. This system was extended in 1996 to the feeding areas off New England (MMC, 2003).

In 1999, a Mandatory Ship Reporting System was implemented by the USCG (USCG, 1999; USCG, 2001). This reporting system requires specified vessels (Navy ships are exempt) to report their location while in the nursery and feeding areas of the right whale (Ward-Geiger et al., 2005). At the same time, ships receive information on locations of North Atlantic right whale sightings in order to avoid whale collisions. Reporting takes place in the southeastern U.S. from 15 November through 15 April. In the northeastern U.S., the reporting system is year-round and the geographical boundaries include the waters of Cape Cod Bay, Massachusetts Bay, and the Great South Channel east and southeast of Massachusetts.

Proposed regulations include a speed restriction of 10 knots (kt) or less during certain times of the year along the U.S. east coast; these restrictions would only apply to vessels greater than 20 m in length and modification of key shipping routes into Boston (NMFS, 2006c; NOAA, 2006)

- **Diving Behavior**—Dives of 5 to 15 minutes (min) or longer have been reported (CETAP, 1982; Baumgartner and Mate, 2003), but can be much shorter when feeding (Winn et al., 1995). Foraging dives in the known feeding high-use areas are frequently near the bottom of the water column (Goodyear, 1993; Mate et al., 1997; Baumgartner et al., 2003). Baumgartner and Mate (2003) found that the average depth of a right whale dive was strongly correlated with both the average depth of peak copepod abundance and the average depth of the mixed layer’s upper surface. Right whale feeding dives are characterized by a rapid descent from the surface to a particular depth between 80 and 175 m (262 to 574 ft), remarkable fidelity to that depth for 5 to 14 min, and then rapid ascent back to the surface (Baumgartner and Mate, 2003). Longer surface intervals have been observed for reproductively active females and their calves (Baumgartner and Mate, 2003). The longest tracking of a right whale is of an adult female which migrated 1,928 km (1,040 NM) in 23 days (mean was 3.5 km/hr [1.9 NM/hr) from 40 km (22 NM) west of Browns Bank (Bay of Fundy) to Georgia (Mate and Baumgartner, 2001).

- **Acoustics and Hearing**—Northern right whales produce a variety of sounds, including moans, screams, gunshots, blows, upcalls, downcalls, and warbles that are often linked to specific behaviors (Matthews et al., 2001; Laurinolli et al., 2003; Vanderlaan et al., 2003; Parks et al., 2005; Parks and Tyack, 2005). Sounds can be divided into three main categories: (1) blow sounds; (2) broadband impulsive sounds; and (3) tonal call types (Parks and Clark, 2007). Blow sounds are those coinciding with an exhalation; it is not known whether these are intentional communication signals or just produced incidentally (Parks and Clark, 2007). Broadband sounds include non-vocal slaps (when the whale strikes the surface of the water with parts of its body) and the “gunshot” sound; data suggests that the latter serves a communicative purpose (Parks and Clark, 2007). Tonal calls can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated (FM), higher-frequency calls (Parks and Clark, 2007). Most of these sounds range in frequency from 0.02 to 15 kHz (dominant frequency range from 0.02 to less than 2 kHz; durations typically range from 0.01 to multiple seconds) with some sounds having multiple harmonics (Parks and Tyack, 2005). Source levels for some of these sounds have been measured as ranging from 137 to 192 decibels at the reference level of one micropascal at 1 m (dB re 1 μPa-m) root mean square (rms) (Parks et al., 2005; Parks and Tyack, 2005). In certain regions (i.e., northeast Atlantic), preliminary results indicate that right whales vocalize more from dusk to dawn than during the daytime (Leaper and Gillespie, 2006).

Recent morphometric analyses of northern right whale inner ears estimates a hearing range of approximately 0.01 to 22 kHz based on established marine mammal models (Parks et al., 2004; Parks and Tyack, 2005; Parks et al., 2007). In addition, Parks et al. (2007) estimated the functional hearing range for right whales to be 15 Hz to 18 kHz. Nowacek et al. (2004) observed that exposure to short tones and down sweeps, ranging in frequency from 0.5 to 4.5 kHz, induced an alteration in behavior (received levels of 133 to 148 dB re 1 μPa-m), but exposure to sounds produced by vessels (dominant frequency range of 0.05 to 0.5 kHz) did not produce any behavioral response (received levels of 132 to 142 dB re 1 μPa-m).

- **Habitat**—North Atlantic right whales on the winter calving grounds are most often found in very shallow, nearshore regions within cooler SSTs inshore of a mid-shelf front (Kraus et al., 1993; Ward, 1999). High whale densities can extend more northerly than the current defined boundary of the calving critical habitat in response to interannual variability in regional SST distribution (Garrison, 2007). Warm Gulf Stream waters appear to represent a thermal limit (both southward and eastward) for right whales (Keller et al., 2006).

  The feeding areas are characterized by bottom topography, water column structure, currents, and tides that combine to physically concentrate zooplankton into extremely dense patches (Wishner et al., 1988; Murison and Gaskin, 1989; Macaulay et al., 1995; Beardsley et al., 1996; Baumgartner et al., 2003).

- **General Distribution**—Right whales occur in sub-polar to temperate waters. The North Atlantic right whale was historically widely distributed, ranging from latitudes of 60 degrees (°) North (N) to 20°N prior to serious declines in abundance due to intensive whaling (e.g., NMFS, 2006b; Reeves et al., 2007). North Atlantic right whales are found primarily in continental shelf waters between Florida and Nova Scotia (Winn et al., 1986). Most sightings are concentrated within five high-use areas: coastal waters of the southeastern U.S. (Georgia and Florida), Cape Cod and Massachusetts Bays, the Great South Channel, the Bay of Fundy, and the Nova Scotian Shelf (Winn et al., 1986; NMFS, 2005). Of these, one calving and two feeding areas in U.S. waters are designated as critical habitat for North Atlantic right whales under the ESA (NMFS, 1994; NMFS, 2005a) (**Figure 3-1**). The critical habitat designated waters off Georgia and northern Florida are the only known calving ground for western North Atlantic right whales, with use concentrated in the winter (as early as November and through March) (Winn et al., 1986). The feeding grounds of Cape Cod Bay which have concentrated use in February through April (Winn et al., 1986; Hamilton and Mayo, 1990) and the Great South Channel east of Cape Cod with concentrated use in April through June (Winn et al., 1986; Kenney et al., 1995) have also been designated as critical habitat for the North Atlantic right whale (**Figure 3-1**).

  Most North Atlantic right whale sightings follow a well-defined seasonal migratory pattern through several consistently utilized habitats (Winn et al., 1986). It should be noted, however, that some individuals may be sighted in these habitats outside the typical time of year and that migration routes are poorly known (Winn et al., 1986). Right whales typically migrate within 65 km of shore, but individuals have been observed farther offshore (Knowlton, 1997). In fact, trans-Atlantic migrations of North Atlantic right whales between the eastern U.S. coast and Norway have been documented (Jacobsen et al., 2004) which suggests a possible offshore migration path.

  During the spring through early summer, North Atlantic right whales are found on feeding grounds off the northeastern U.S. and Canada. During the winter (as early as November and through March), North Atlantic right whales may be found in coastal waters off North Carolina, Georgia, and northern Florida (Winn et al., 1986).

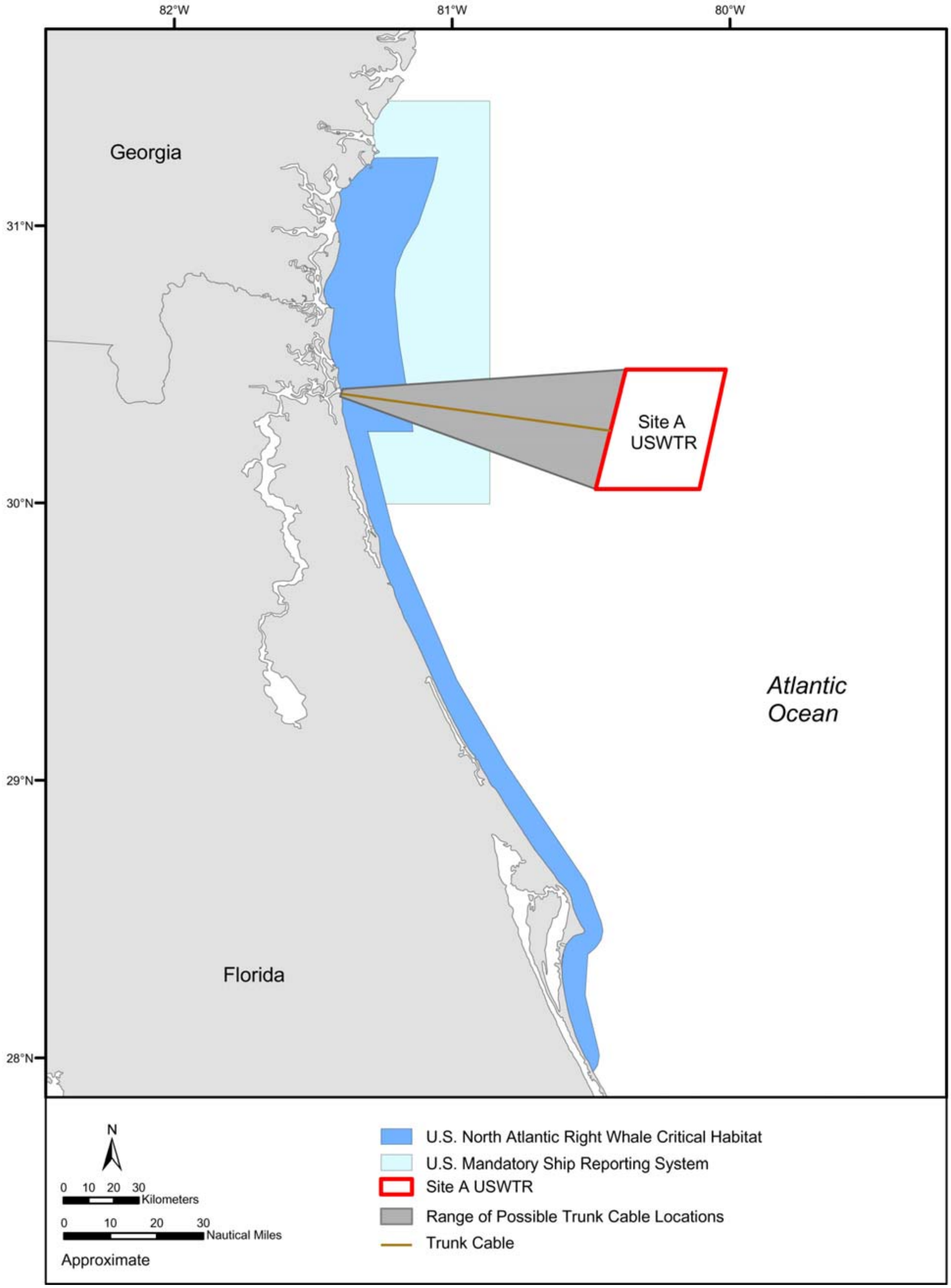


Figure 3-1. Critical habitat for the North Atlantic right whale in the Action Area.

Occurrence in the Action Area—North Atlantic right whales migrate to the coastal waters of the southeastern U.S. to calve during the winter months (November through March). The coastal waters off Georgia and northern Florida are the only known calving ground for the North Atlantic right whale. During the summer, North Atlantic right whales should occur further north on their feeding grounds; however, North Atlantic right whales might be seen anywhere off the Atlantic U.S. throughout the year (Gaskin, 1982). As noted by Kraus et al. (1993), North Atlantic right whale sightings have been opportunistically reported off the southeastern U.S. as early as September and as late as June in some years. Recently, a mother and calf pair was sighted off of northeastern Florida in July (NOAA, 2007). The North Atlantic right whale is anticipated year-round from the shore to the continental shelf break in the Action Area, with a peak concentration during November through March.

Critical Habitat—One calving area and two feeding areas in U.S. waters are designated as critical habitat for North Atlantic right whales under the ESA (**Figure 3-1**) (NMFS, 1994; NMFS, 2005a). The critical habitat designated waters off Georgia and northern Florida are the only known calving ground for western North Atlantic right whales, with use concentrated in the winter (as early as November and through March) (Winn et al., 1986). The feeding grounds of Cape Cod Bay which has individuals in February through April (Winn et al., 1986; Hamilton and Mayo, 1990) and the Great South Channel east of Cape Cod with use in April through June (Winn et al., 1986; Kenney et al., 1995) have also been designated as critical habitat for the North Atlantic right whale. Critical habitat designations affect federal agency actions or federally-funded or permitted activities.

3.1.2 Humpback Whale

- **General Description**—Adult humpback whales are 11 to 16 m in length and are more robust than other rorquals. The body is black or dark gray, with very long (about one-third of the body length) flippers that are usually at least partially white (Jefferson et al., 1993; Clapham and Mead, 1999). Humpback whales feed on a wide variety of invertebrates and small schooling fishes, including euphausiids (krill); the most common fish prey are herring, mackerel, sand lance, sardines, anchovies, and capelin (Clapham and Mead, 1999).

- **Status**—An estimated 11,570 humpback whales occur in the entire North Atlantic (Stevick et al., 2003a). Humpback whales in the North Atlantic are thought to belong to five different stocks based on feeding locations (Katona and Beard, 1990; Waring et al., 2008): Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland. There appears to be very little exchange between these separate feeding stocks (Katona and Beard, 1990). The best estimate of abundance for the Gulf of Maine Stock is 847 individuals (Waring et al., 2008) based on a 2006 aerial survey. The humpback whale is listed as endangered under the ESA and management of the species is under the jurisdiction of the NMFS. The recovery plan for the humpback whale was issued in 1991 (NMFS, 1991).

- **Diving Behavior**—Humpback whale diving behavior depends on the time of year (Clapham and Mead, 1999). In summer, most dives last less than 5 min; those exceeding 10 min are atypical. In winter (December through March), dives average 10 to 15 min; dives of greater than 30 min have been recorded (Clapham and Mead, 1999). Although humpback whales have been recorded to dive as deep as 500 m (1,640 ft) (Dietz et al., 2002), on the feeding grounds they spend the majority of their time in the upper 120 m (394 ft) of the water column (Dolphin, 1987; Dietz et al., 2002). Recent D-tag work revealed that humpbacks are usually only a few meters below the water's surface while foraging (Ware et al., 2006). On wintering grounds, Baird et al. (2000) recorded dives deeper than 100 m (328 ft).

- **Acoustics and Hearing**—Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) sounds made within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson, 1995).

The best-known types of sounds produced by humpback whales are songs, which are thought to be breeding displays used only by adult males (Helweg et al., 1992). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard outside breeding areas and out of season (Mattila et al., 1987; Gabriele et al., 2001; Gabriele and Frankel, 2002; Clark and Clapham, 2004). Humpback song is an incredibly elaborate series of patterned vocalizations, which are hierarchical in nature (Payne and McVay, 1971). There is geographical variation in humpback whale song, with different populations singing different songs, and all members of a population using the same basic song; however, the song evolves over the course of a breeding season, but remains nearly unchanged from the end of one season to the start of the next (Payne et al., 1983).

Social calls are from 50 hertz (Hz) to over 10 kHz, with dominant frequencies below 3 kHz (Silber, 1986). Female vocalizations appear to be simple; Simão and Moreira (2005) noted little complexity. The male song, however, is complex and changes between seasons. Components of the song range from under 20 Hz to 4 kHz and occasionally 8 kHz, with source levels measured between 151 and 189 dB re 1 μPa-m and high-frequency harmonics extending beyond 24 kHz (Au et al., 2001; Au et al., 2006). Songs have also been recorded on feeding grounds (Mattila et al., 1987; Clark and Clapham, 2004). The main energy lies between 0.2 and 3.0 kHz, with frequency peaks at 4.7 kHz. "Feeding" calls, unlike song and social sounds, are highly stereotyped series of narrow-band trumpeting calls. They are 20 Hz to 2 kHz, less than 1 second (s) in duration, and have source levels of 162 to 192 dB re 1 μPa-m. The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al., 1985; Thompson et al., 1986).

- **Habitat**—Although humpback whales typically travel over deep, oceanic waters during migration, their feeding and breeding habitats are mostly in shallow, coastal waters over continental shelves (Clapham and Mead, 1999). Shallow banks or ledges with high sea-floor relief characterize feeding grounds (Payne et al., 1990; Hamazaki, 2002). The habitat requirements of wintering humpbacks appear to be determined by the conditions necessary for calving. Optimal calving conditions are warm waters (24° to 28° Celsius [C]) and relatively shallow, low-relief ocean bottom in protected areas (i.e., behind reefs) (Sanders et al., 2005). Females with calves occur in significantly shallower waters than other groups of humpback whales, and breeding adults use deeper, more offshore waters (Smultea, 1994; Ersts and Rosenbaum, 2003).

- **General Distribution**—Humpback whales are globally distributed in all major oceans and most seas. They are generally 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 water during migration (Clapham and Mattila, 1990; Calambokidis et al., 2001).

  In the North Atlantic Ocean, humpbacks are found from spring through fall on feeding grounds that are located from south of New England to northern Norway (NMFS, 1991). During the winter, most of the North Atlantic population of humpback whales is believed to migrate south to calving grounds in the West Indies region (Whitehead and Moore, 1982; Smith et al., 1999; Stevick et al., 2003b).

  There has been an increasing occurrence of humpbacks, which appear to be primarily juveniles, during the winter along the U.S. Atlantic coast from Florida north to Virginia (Clapham et al., 1993; Swingle et al., 1993; Wiley et al., 1995; Laerm et al., 1997). It has recently been proposed that the mid-Atlantic region primarily represents a supplemental winter feeding ground, which is also an area of mixing of humpback whales from different feeding stocks (Barco et al., 2002).

<u>Occurrence in the Action Area</u>—Humpback whales are expected to occur throughout the Action Area during fall, winter, and spring during migrations between calving grounds in the Caribbean and feeding grounds off the northeastern U.S. Humpback whales are not expected in the Action Area during summer, since they should occur further north on their feeding grounds.

3.1.3 Sei Whale

- **General Description**—Adult sei whales are up to 18 m in length and are mostly dark gray in color with a lighter belly, often with mottling on the back (Jefferson et al., 1993). In the North Atlantic Ocean, the major prey species are copepods and krill (Kenney et al., 1985).

- **Status**—The International Whaling Commission (IWC) recognizes three sei whale stocks in the North Atlantic: Nova Scotia, Iceland-Denmark Strait, and Northeast Atlantic (Perry et al., 1999). The Nova Scotia Stock occurs in U.S. Atlantic waters (Waring et al., 2008). The best abundance estimate for sei whales in the western North Atlantic is 207; however this is considered conservative due to uncertainties in population movements and structure (Waring et al., 2008). The sei whale is under the jurisdiction of the NMFS. A draft recovery plan for fin and sei whales was released in 1998 (NMFS, 1998b). It has since been determined that the two species should have separate recovery plans. The independent recovery plan for the sei whale has not yet been issued; however, the species is listed as endangered under the ESA.

- **Diving Behavior**—There are no reported diving depths or durations for sei whales.

- **Acoustics and Hearing**—Sei whale vocalizations have been recorded only on a few occasions. Recordings from the North Atlantic consisted of paired sequences (0.5 to 0.8 s, separated by 0.4 to 1.0 s) of 10 to 20 short (4 milliseconds [ms]) FM sweeps between 1.5 and 3.5 kHz; source level was not known (Thomson and Richardson, 1995). These mid-frequency calls are distinctly different from low-frequency tonal and frequency swept calls recently recorded in the Antarctic; the average duration of the tonal calls was 0.45 ± 0.3 s, with an average frequency of 433 ± 192 Hz and a maximum source level of 156 ± 3.6 dB re 1 μPa-m (McDonald et al., 2005). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- **Habitat**—Sei whales are most often found in deep, oceanic waters of the cool temperate zone. Sei whales appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges (Kenney and Winn, 1987; Schilling et al., 1992; Gregr and Trites, 2001; Best and Lockyer, 2002). These areas are often the location of persistent hydrographic features, which may be important factors in concentrating prey, especially copepods. On the feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood, 1987). Characteristics of preferred breeding grounds are unknown. Horwood (1987) noted that sei whales prefer oceanic waters and are rarely found in marginal seas; historical whaling catches were usually from deepwater, and land station catches were usually taken from along or just off the edges of the continental shelf.

- **General Distribution**—Sei whales have a worldwide distribution but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood, 1987). Sei whales spend the summer months feeding in the subpolar higher latitudes and return to the lower latitudes to calve in the winter. For the most part, the location of winter breeding areas remains a mystery (Rice, 1998; Perry et al., 1999).

  In the western North Atlantic Ocean, the Nova Scotia Stock of the sei whale occurs primarily from Georges Bank north to Davis Strait (northeast Canada, between Greenland and Baffin Island; Perry et al., 1999). Peak abundance in U.S. waters occurs from winter through spring (mid-March through mid-June), primarily around the edges of Georges Bank (CETAP, 1982; Stimpert et al., 2003). The distribution of the Nova Scotia stock might extend along the U.S. coast at least to North Carolina (NMFS, 1998b).

  The hypothesis is that the Nova Scotia stock moves from spring feeding grounds on or near Georges Bank, to the Scotian Shelf in June and July, eastward to perhaps Newfoundland and the Grand Banks in late summer, then back to the Scotian Shelf in fall, and offshore and south in winter (Mitchell and Chapman, 1977).

Occurrence in the Action Area—Sei whales are found predominantly in deep water (NMFS, 1998b). Sei whales are not expected to occur in the Action Area during the summer, since they should be on feeding grounds around the eastern Scotian Shelf or Grand Banks (Mitchell, 1975; Mitchell and Chapman, 1977). During fall, winter, and spring, sei whale may occur in the Action Area; however occurrences are more anticipated in deeper waters to the east of the Action Area.

3.1.4 Fin Whale

- **General Description**—The fin whale is the second-largest whale species, with adults reaching 24 m in length (Jefferson et al., 1993). Fin whales feed by "gulping" upon a wide variety of small, schooling prey (especially herring, capelin, and sand lance) including squid and crustaceans (krill and copepods) (Kenney et al., 1985; NMFS, 2006a).

- **Status**—The NOAA SAR estimates that there are 2,269 individual fin whales in the U.S. Atlantic waters (Waring et al., 2008); this is probably an underestimate, however, as survey coverage of known and potential fini whale habitat was incomplete. The fin whale is listed as endangered under the ESA and is managed under jurisdiction of the NMFS. The draft recovery plan for the fin whale was released in June 2006 (NMFS, 2006a). NMFS recently initiated a 5-yr review for the fin whale under the ESA (NMFS, 2007a).

- **Diving Behavior**—Fin whale dives are typically 5 to 15 min long and separated by sequences of four to five blows at 10- to 20-s intervals (CETAP, 1982; Stone et al., 1992; Lafortuna et al., 2003). Kopelman and Sadove (1995) found significant differences in blow intervals, dive times, and blows per hour between surface-feeding and non-surface-feeding fin whales. Croll et al. (2001) determined that fin whales off the Pacific coast dived to a mean of 97.9 m (321.2 ft) (standard deviation [S.D.] of ± 32.6 m [106.9 ft]) with a duration of 6.3 min (S.D. of 1.53 min) when foraging and to 59.3 m (194.6 ft) (S.D. of ± 29.67 m [97.34 ft]) with a duration of 4.2 min (S.D. of ± 1.67 min) when not foraging. Panigada et al. (1999) reported fin whale dives exceeding 150 m (492 ft) and coinciding with the diel migration of krill.

- **Acoustics and Hearing**—Fin and blue whales produce calls with the lowest frequency and highest source levels of all cetaceans. Infrasonic, pattern sounds have been documented for fin whales (Watkins et al., 1987; Clark and Fristrup, 1997; McDonald and Fox, 1999). Fin whales produce a variety of sounds with a frequency range up to 750 Hz. The long, patterned 15 to 30 Hz vocal sequence is most typically recorded; only males are known to produce these (Croll et al., 2002). The most typical fin whale sound is a 20 Hz infrasonic pulse (actually an FM sweep from about 23 to 18 Hz) with durations of about 1 s and can reach source levels of 184 to 186 dB re 1 µPa-m (maximum up to 200; Watkins et al., 1987; Thomson and Richardson, 1995; Charif et al., 2002). Croll et al. (2002) recently suggested that these long, patterned vocalizations might function as male breeding displays, much like those that male humpback whales sing. The source depth, or depth of calling fin whales, has been reported to be about 50 m (164 ft) (Watkins et al., 1987). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- **Habitat**—The fin whale is found in continental shelf, slope, and oceanic waters. Off the U.S. east coast, the fin whale appears to be scarce in slope and Gulf Stream waters (CETAP, 1982; Waring et al., 1992). Waring et al. (1992) reported sighting fin whales along the edge of a warm core eddy and a remnant near Wilmington Canyon, along the northern wall of the Gulf Stream. Globally, this species tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually (Payne et al., 1986; 1990; Kenney et al., 1997; Notarbartolo-di-Sciara et al., 2003). Clark and Gagnon (2004) determined that vocalizing fin whales show strong preferences for shelf breaks, seamounts, or other areas where food resources are known to occur, even during summer months.

- **General Distribution**—Fin whales are broadly distributed throughout the world's oceans, including temperate, tropical, and polar regions (Jefferson et al., 2008). The overall range of fin whales in the North Atlantic extends from the Gulf of Mexico/Caribbean Sea and Mediterranean Sea north to Greenland, Iceland, and Norway (Gambell, 1985; NMFS, 1998b). In the western North Atlantic, the fin whale is the most commonly sighted large whale in continental shelf waters from the mid-Atlantic coast of the U.S. to eastern Canada (CETAP, 1982; Hain et al., 1992).

  Relatively consistent sighting locations for fin whales off the U.S. Atlantic coast include the banks on the Nova Scotian Shelf, Georges Bank, Jeffreys Ledge, Cashes Ledge, Stellwagen Bank, Grand Manan Bank, Newfoundland Grand Banks, the Great South Channel, the Gulf of St. Lawrence, off Long Island and Block Island, Rhode Island, and along the shelf break of the northeastern U.S. (CETAP, 1982; Hain et al., 1992; Waring et al., 2004). Hain et al. (1992) reported that the single most important habitat in their study was a region of the western Gulf of Maine, to Jeffreys Ledge, Cape Ann, Stellwagen Bank, and to the Great South Channel, in approximately 50 m of water. This was an area of high prey (sand lance) density during the 1970s and early 1980s (Kenney and Winn, 1986). Secondary areas of important fin whale habitat included the mid- to outer shelf from the northeast area of Georges Bank through the mid-Atlantic Bight.

  Based on passive acoustic detection using Navy Sound Surveillance System (SOSUS) hydrophones in the western North Atlantic (Clark, 1995), fin whales are believed to move southward in the fall and northward in spring. The location and extent of the wintering grounds are poorly known (Aguilar, 2002). Fin whales have been seen feeding as far south as the coast of Virginia (Hain et al., 1992).

  Fin whales are not completely absent from northeastern U.S. continental shelf waters in winter, indicating that not all members of the population conduct a full seasonal migration. Perhaps a fifth to a quarter of the spring/summer peak population remains in this area year-round (CETAP, 1982; Hain et al., 1992).

  Peak calving is in October through January (Hain et al., 1992); however location of breeding grounds is unknown.

Occurrence in the Action Area—Fin whales may occur in the Action Area in the winter, spring, and fall from the shore to the 2,500-m isobath (DoN, 2007b). During the summer, fin whales should be on their feeding grounds at higher latitudes off the northeastern U.S. and are not expected to occur in the Action Area.

3.1.5 Blue Whale

- **General Description**—Blue whales are the largest-living animals. Adult blue whales in the Northern Hemisphere reach 22.9 to 28 m in length (Jefferson et al., 1993). Blue whales, like other rorquals, feed by "gulping" (Pivorunas, 1979) almost exclusively on krill (Nemoto and Kawamura, 1977).

- **Status**—The endangered blue whale was severely depleted by commercial whaling in the twentieth century (NMFS, 1998a). At least two discrete populations are found in the North Atlantic. One ranges from West Greenland to New England and is centered in eastern Canadian waters; the other is centered in Icelandic waters and extends south to northwest Africa (Sears et al., 2005). There are no current estimates of abundance for the North Atlantic blue whale (Waring et al., 2008); however, the 308 photo-identified individuals from the Gulf of St. Lawrence area are considered to be a minimum population estimate for the western North Atlantic stock (Sears et al., 1987; Waring et al., 2008). The blue whale is under the jurisdiction of the NMFS. The recovery plan for the blue whale was issued in 1998 (NMFS, 1998a).

- **Diving Behavior**—Fin whale dives are typically 5 to 15 min long and separated by sequences of four to five blows at 10- to 20-s intervals (CETAP, 1982; Stone et al., 1992; Lafortuna et al., 2003). Kopelman and Sadove (1995) found significant differences in blow intervals, dive times, and blows per hour between surface-feeding and non-surface-feeding fin whales. Croll et al. (2001) determined that fin whales off the Pacific coast dived to a mean of 97.9 m (321.2 ft) (S.D. of ± 32.6 m [106.9 ft]) with a duration of 6.3 min (S.D. of 1.53 min) when foraging and to 59.3 m (194.6 ft) (S.D. of ± 29.67 m [97.34 ft]) with a duration of 4.2 min (S.D.of ± 1.67 min) when not foraging. Panigada et al. (1999) reported fin whale dives exceeding 150 m (492 ft) and coinciding with the diel migration of krill.

- **Acoustics and Hearing**—Fin and blue whales produce calls with the lowest frequency and highest source levels of all cetaceans. Infrasonic, pattern sounds have been documented for fin whales (Watkins et al., 1987; Clark and Fristrup, 1997; McDonald and Fox, 1999). Fin whales produce a variety of sounds with a frequency range up to 750 Hz. The long, patterned 15 to 30 Hz vocal sequence is most typically recorded; only males are known to produce these (Croll et al., 2002). The most typical fin whale sound is a 20-Hz infrasonic pulse (actually an FM sweep from about 23 to 18 Hz) with durations of about 1 s and can reach source levels of 184 to 186 dB re 1 μPa-m (maximum up to 200; Watkins et al., 1987; Thomson and Richardson, 1995; Charif et al., 2002). Croll et al. (2002) recently suggested that these long, patterned vocalizations might function as male breeding displays, much like those that male humpback whales sing. The source depth, or depth of calling fin whales, has been reported to be about 50 m (164 ft) (Watkins et al., 1987). While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- **Habitat**—Blue whales inhabit both coastal and oceanic waters in temperate and tropical areas (Yochem and Leatherwood, 1985). Blue whales in the Atlantic are primarily found in deeper, offshore waters and are rare in shallow, shelf waters (Wenzel et al., 1988). Important foraging areas for this species include the edges of continental shelves and upwelling regions (Reilly and Thayer, 1990; Schoenherr, 1991). Based on acoustic and tagging data from the North Pacific, relatively cold, productive waters and fronts attract feeding blue whales (e.g., Moore et al., 2002). In the Gulf of St. Lawrence, blue whales show strong preferences for the nearshore regions where strong tidal and current mixing leads to high productivity and rich prey resources (Sears et al., 1990). Clark and Gagnon (2004) determined that vocalizing blue whales show strong preferences for shelf breaks, sea mounts, or other areas where food resources are known to occur, even during summer months.

- **General Distribution**—Blue whales are distributed from the ice edge to the tropics and subtropics in both hemispheres (Jefferson et al., 1993). Stranding and sighting data suggest that the blue whale’s original range in the Atlantic extended south to Florida, the Gulf of Mexico, however the southern limit of this species’ range is unknown (Yochem and Leatherwood, 1985). Blue whales rarely occur in the U.S. Atlantic EEZ and the Gulf of Maine from August to October, which may represent the limits of their feeding range (CETAP, 1982; Wenzel et al., 1988). Researchers using Navy Integrated Undersea Surveillance System (IUSS) resources have more recently been able to detect blue whales throughout the open Atlantic south to at least The Bahamas (Clark, 1995; Clark and Gagnon, 2004) suggesting that all North Atlantic blue whales may comprise a single stock (NMFS, 1998a).

  Calving occurs primarily during the winter (Yochem and Leatherwood, 1985; Jefferson et al., 2008). Breeding grounds are thought to be located in tropical/subtropical waters; however exact locations are unknown (Jefferson et al., 2008).

Occurrence in the Action Area—Blue whales may occur in the Action Area; however they are generally expected to be found in waters farther east, seaward of the 2,000-m isobath during fall, winter, and spring (DoN, 2007b). Blue whales are not expected to occur in the Action Area during summer when they should occur further north in their feeding ranges.

3.1.6 Sperm Whale

- **General Description**—The sperm whale is the largest toothed whale species. Adult females can reach 12 m in length, while adult males measure as much as 18 m in length (Jefferson et al., 1993). Sperm whales prey on mesopelagic squids and other cephalopods, as well as demersal fishes and benthic invertebrates (Rice, 1989; Clarke, 1996).

- **Status**—Sperm whales are classified as endangered under the ESA (NMFS, 2006d), although they are globally not in any immediate danger of extinction. The current combined best estimate of sperm whale abundance from Florida to the Bay of Fundy in the western North Atlantic Ocean is 4,804 individuals (Waring et al., 2008). Stock structure for sperm whales in the North Atlantic is unknown (Dufault et al., 1999). The sperm whale is under the jurisdiction of the NMFS. The draft recovery plan for the sperm whale was released in June 2006 for public comment (NMFS, 2006d). In January 2007, NMFS initiated a 5-yr review for the sperm whale under the ESA (NMFS, 2007a).

- **Diving Behavior**—Sperm whales forage during deep dives that routinely exceed a depth of 400 m (1,312 ft) and a duration of 30 min (Watkins et al., 2002). They are capable of diving to depths of over 2,000 m (6,562 ft) with durations of over 60 min (Watkins et al., 1993). Sperm whales spend up to 83% of daylight hours underwater (Jaquet et al., 2000; Amano and Yoshioka, 2003). Males do not spend extensive periods of time at the surface (Jaquet et al., 2000). In contrast, females spend prolonged periods of time at the surface (1 to 5 hr daily) without foraging (Whitehead and Weilgart, 1991; Amano and Yoshioka, 2003). An average dive cycle consists of about a 45-min dive with a 9-min surface interval (Watwood et al., 2006). The average swimming speed is estimated to be 2.5 km/hr (1.3 NM/hr) (Watkins et al., 2002). Dive descents for tagged individuals average 11 min at a rate of 1.52 m/s (2.95 kt), and ascents average 11.8 min at a rate of 5.5 km/hr (3 NM/hr) (Watkins et al., 2002).

- **Acoustics and Hearing**—Sperm whales typically produce short-duration (less than 30 ms), repetitive broadband clicks used for communication and echolocation. These clicks range in frequency from 0.1 to 30 kHz, with dominant frequencies between the 2 to 4 kHz and 10 to 16 kHz ranges (Thomson and Richardson, 1995). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill, 1977). Codas are shared between individuals of a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead, 1997; Rendell and Whitehead, 2004). Recent research in the South Pacific suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al., 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects, similar to those of killer whales (Weilgart and Whitehead, 1997; Pavan et al., 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean and those in the Pacific (Weilgart and Whitehead, 1997). Furthermore, the clicks of neonatal sperm whales are very different from those of adults. Neonatal clicks are of low-directionality, long-duration (2 to 12 ms), low-frequency (dominant frequencies around 0.5 kHz) with estimated source levels between 140 and 162 dB re 1 μPa-m rms, and are hypothesized to function in communication with adults (Madsen et al., 2003). Source levels from adult sperm whales' highly directional (possible echolocation), short (100 microseconds [μs]) clicks have been estimated up to 236 dB re 1 μPa-m rms (Møhl et al., 2003). Creaks (rapid sets of clicks) are heard most-frequently when sperm whales are engaged in foraging behavior in the deepest portion of their dives with intervals between clicks and source levels being altered during these behaviors (Miller et al., 2004; Laplanche et al., 2005). It has been shown that sperm whales may produce clicks during 81% of their dive period, specifically 64% of the time during their descent phases (Watwood et al., 2006). In addition to producing clicks, sperm whales in some regions like Sri Lanka and the Mediterranean Sea have been recorded making what are called trumpets at the beginning of dives just before commencing click production (Teloni, 2005). The estimated source level of one of these low intensity sounds (trumpets) was estimated to be 172 dB_{pp} re 1 μPa-m (Teloni et al., 2005).

The anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic frequency sounds. They may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten, 1992). The auditory brainstem response (ABR) technique used on a stranded neonatal sperm whale indicated it could hear sounds from 2.5 to 60 kHz with best sensitivity to frequencies between 5 and 20 kHz (Ridgway and Carder, 2001).

- **Habitat**—Sperm whale distribution can be variable, but is generally associated with waters over the continental shelf edge, continental slope, and offshore (CETAP, 1982; Hain et al., 1985; Smith et al., 1996; Waring et al., 2001; Davis et al., 2002). Rice (1989) noted a strong offshore preference by sperm whales.

  In some areas, sperm whale densities have been correlated with high secondary productivity and steep underwater topography (Jaquet and Whitehead, 1996). Data from the Gulf of Mexico suggest that sperm whales adjust their movements to stay in or near cold-core rings (Davis et al., 2000; 2002), which demonstrate that sperm whales can shift their movements in response to prey density.

  Off the eastern U.S., sperm whales are found in regions of pronounced horizontal temperature gradients, such as along the edges of the Gulf Stream and within warm-core rings (Waring et al., 1993; Jaquet et al., 1996; Griffin, 1999). Fritts et al. (1983) reported sighting sperm whales associated with the Gulf Stream. Waring et al. (2003) conducted a deepwater survey south of Georges Bank in 2002 and examined fine-scale habitat use by sperm whales. Sperm whales were located in waters characterized by sea-surface temperatures of 23.2° to 24.9°C and bottom depths of 325 to 2,300 m (Waring et al., 2003).

- **General Distribution**—Sperm whales are found from tropical to polar waters in all oceans of the world between approximately 70°N and 70° South (S) (Rice, 1998). Females are normally restricted to areas with SST greater than approximately 15°C, whereas males, and especially the largest males, can be found in waters as far poleward as the pack ice with temperatures close to 0° (Rice, 1989). The thermal limits of female distribution correspond approximately to the 40° parallels (50° in the North Pacific) (Whitehead, 2003).

  Sperm whales are the most-frequently sighted whale seaward of the continental shelf off the eastern U.S. (CETAP, 1982; Kenney and Winn, 1987; Waring et al., 1993; Waring et al., 2007). In Atlantic EEZ waters, sperm whales appear to have a distinctly seasonal distribution (CETAP, 1982; Scott and Sadove, 1997; Waring et al., 2007). Although concentrations shift depending on the season, sperm whales are generally distributed in Atlantic EEZ waters year-round.

  Mating may occur December through August, with the peak breeding season falling in the spring (NMFS, 2006d); however location of specific breeding grounds is unknown.

Occurrence in the Action Area—Worldwide, sperm whales exhibit a strong affinity for deep waters beyond the continental shelf break (Rice, 1989). Sperm whales are expected to occur seaward of the shelf break throughout the Action Area in all seasons.

3.1.7 West Indian Manatee

- **General Description**—The West Indian manatee is a rotund, slow-moving animal, which reaches a maximum length of 3.9 m (Jefferson et al., 1993). Two important aspects of the West Indian manatee's physiology influence behavior: nutrition and metabolism. West Indian manatees have an unusually low metabolic rate and a high thermal conductance that lead to energetic stress in winter (Bossart et al., 2002). West Indian manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation, but they also ingest invertebrates (USFWS, 2001; Courbis and Worthy, 2003; Reich and Worthy, 2006).

- **Status and Management**—West Indian manatee numbers are assessed by aerial surveys during the winter months when manatees are concentrated in warm-water refuges. Aerial surveys conducted in 2007 produced a preliminary abundance estimate 2,812 manatees in Florida (FMRI, 2007). Along Florida's Gulf Coast, observers counted 1,400 West Indian manatees, while observers on the Atlantic coast counted 1,412 (FMRI, 2007).

  The manatee is under the jurisdiction of the USFWS. In the most recent revision of the West Indian manatee recovery plan, it was concluded that, based upon movement patterns, West Indian manatees around Florida should be divided into four relatively discrete management units or subpopulations, each representing a significant portion of the species' range (USFWS, 2001). Manatees found along the Atlantic U.S. coast make up two subpopulations: the Atlantic Region and the Upper St. Johns River Region (USFWS, 2001). Manatees from the western coast of Florida make up the other two subpopulations: the Northwest Region and the Southwest Region (USFWS, 2001).

  In 1976, critical habitat was designated for the West Indian manatee in Florida (USFWS, 1976; **Figure 3-2**). There are two types of manatee protection areas in the state of Florida: manatee sanctuaries and manatee refuges (USFWS, 2001; USFWS, 2002b; USFWS, 2002a). Manatee sanctuaries are areas where all waterborne activities are prohibited while manatee refuges are areas where activities are permitted but certain waterborne activities may be regulated (USFWS, 2001; USFWS, 2002b; USFWS, 2002a).

- **Diving Behavior**—Manatees are shallow divers. The distribution of preferred seagrasses is mostly limited to areas of high light; therefore, manatees are fairly restricted to shallower nearshore waters (Wells et al., 1999). It is unlikely that manatees descend much deeper than 20 m (66 ft), and don't usually remain submerged for longer than 2 to 3 min; however, when bottom resting, manatees have been known to stay submerged for up to 24 min (Wells et al., 1999).

- **Acoustics and Hearing**—West Indian manatees produce a variety of squeak-like sounds that have a typical frequency range of 0.6 to 12 kHz (dominant frequency range from 2 to 5 kHz), and last 0.25 to 0.5 s (Steel and Morris, 1982; Thomson and Richardson, 1995; Niezrecki et al., 2003). Recently, vocalizations below 0.1 kHz have also been recorded (Frisch and Frisch, 2003; Frisch, 2006). Overall, West Indian manatee vocalizations are considered relatively stereotypic, with little variation between isolated populations examined (i.e., Florida and Belize; Nowacek et al., 2003); however, vocalizations have been newly shown to possess nonlinear dynamic characteristics (e.g., subharmonics or abrupt, unpredictable transitions between frequencies), which could aid in individual recognition and mother-calf communication (Mann et al., 2006). Average source levels for vocalizations have been calculated to range from 90 to 138 decibels referenced to 1 micropascal (dB re 1 μPa) (average: 100 to 112 dB re 1 μPa) (Nowacek et al., 2003; Phillips et al., 2004). Behavioral data on two animals indicate an underwater hearing range of approximately 0.4 to 46 kHz, with best sensitivity between 16 and 18 kHz (Gerstein et al., 1999), while earlier electrophysiological studies indicated best sensitivity from 1 to 1.5 kHz (Bullock et al., 1982).

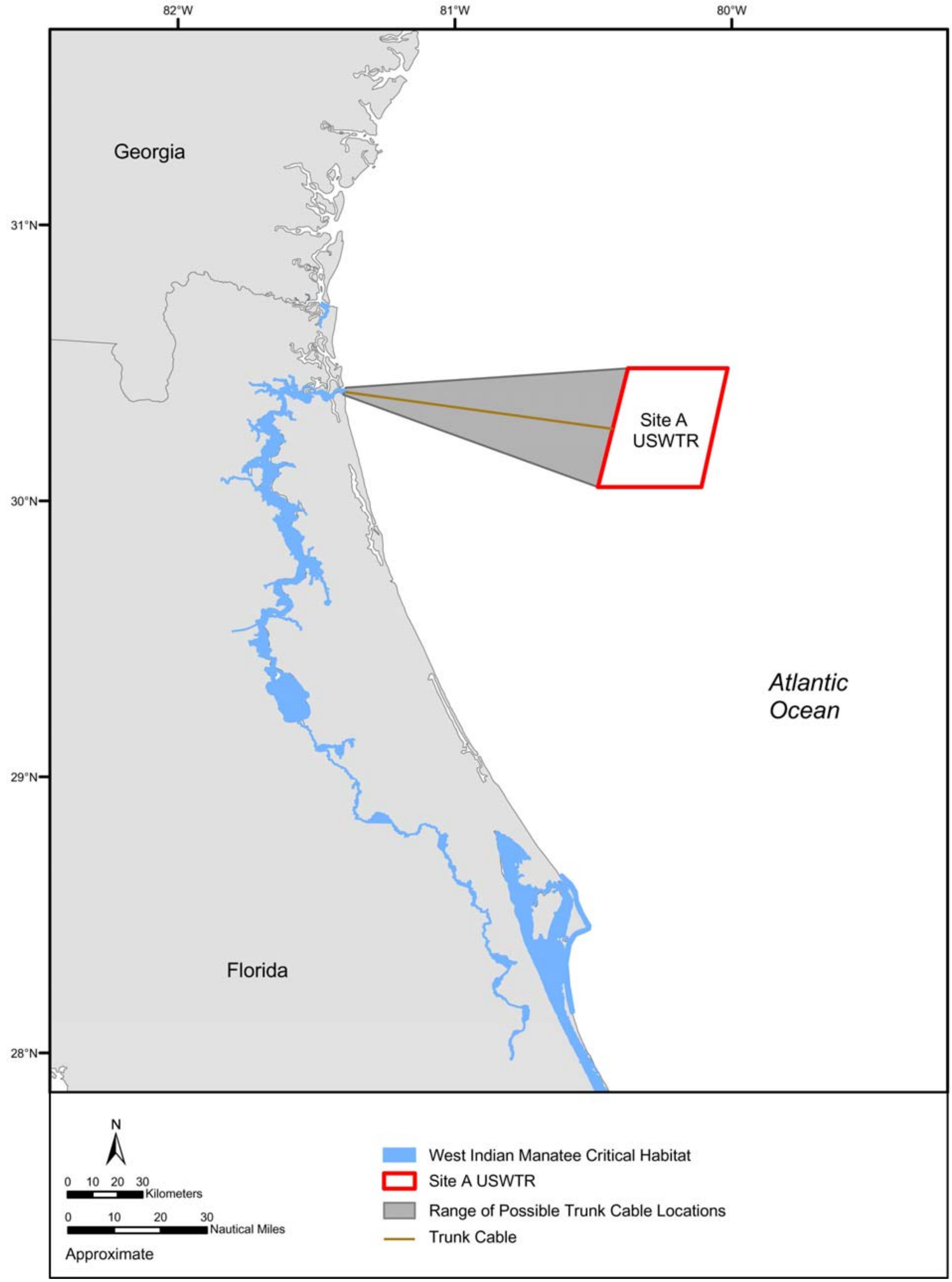


Figure 3-2. Critical habitat of the West Indian manatee in the Study Area.

- **Habitat**—Sightings of manatees are restricted to warm freshwater, estuarine, and extremely nearshore coastal waters. Manatees occur in very shallow waters of 2 to 4 m in depth (7 to 13 ft) generally close to shore (approximately less than 1 km) (Beck et al., 2004). Shallow seagrass beds close to deep channels are preferred feeding areas in coastal and riverine habitats (Lefebvre et al., 2000; USFWS, 2001). West Indian manatees are frequently located in secluded canals, creeks, embayments, and lagoons near the mouths of coastal rivers and sloughs. These areas serve as locations of feeding, resting, mating, and calving (USFWS, 2001). Estuarine and brackish waters with access to natural and artificial freshwater sources are typical West Indian manatee habitat (USFWS, 2001). When ambient water temperatures drop below about 20°C in fall and winter, migration to natural or anthropogenic warm-water sources takes place (Irvine, 1983). Effluents from sewage treatment plants are important sources of freshwater for West Indian manatees in the Caribbean Sea (Rathbun et al., 1985). Manatees are also observed drinking fresh water that flows out of the mouths of rivers (Lefebvre et al., 2001) and out of offered hoses at harbors (Fertl et al., 2005).

- **General Distribution**—The West Indian manatee occurs in warm, subtropical, and tropical waters of the western North Atlantic Ocean, from the southeastern U.S. to Central America, northern South America, and the West Indies (Lefebvre et al., 2001). West Indian manatees occur along both the Atlantic and Gulf coasts of Florida. West Indian manatees are sometimes reported in the Florida Keys; these sightings are typically in the upper Florida Keys, with some reports as far south as Key West (Moore, 1951b, 1951a; Beck, 2006). During winter months, the West Indian manatee population confines itself to inshore and inner shelf waters of the southern half of peninsular Florida and to springs and warm water outfalls (e.g., power plant cooling water outfalls) just beyond northeastern Florida. As water temperatures rise in spring, West Indian manatees disperse from winter aggregation areas.

  Several patterns of seasonal movement are known along the Atlantic coast ranging from year-round residence to long-distance migration (Deutsch et al., 2003). Individuals may be highly consistent in seasonal movement patterns and show strong fidelity to warm and winter ranges, both within and across years (Deutsch et al., 2003).

Occurrence in the Action Area—Manatees are expected in the freshwater, estuarine, and nearshore coastal waters in or near the Cable Range portion Action Area throughout the year. They are not expected in the offshore portions of the Action Area.

Critical Habitat—Critical habitat for the West Indian manatee was designated under 41 Federal Register (FR) 41914 in 1976 with an augmentation and correction in 1977 (USFWS, 1976). The habitat extends throughout the state of Florida and encompasses the St Johns River and Lake George in and near the vicinity of the Action Area. The designated area includes all of the West Indian manatee's known range at the time of designation (including waterways throughout about one-third to one-half of Florida) (Laist, 2002). This critical habitat designation has been infrequently used or referenced since it is broad in description, treats all waterways the same, and does not highlight any particular areas (Laist, 2002).

3.2 NON-THREATENED OR ENDANGERED MARINE MAMMAL SPECIES

Twenty-five non-threatened/non-endangered marine mammal species may be affected by the proposed activities in the Action Area. These include 2 baleen whale species and 23 toothed whale species.

3.2.1 Minke Whale

- **General Description**—Minke whales are small rorquals; adults reach lengths of just over 9 m (Jefferson et al., 1993). In the western North Atlantic, minke whales feed primarily on schooling fish, such as sand lance, capelin, herring, and mackerel (Kenney et al., 1985), as well as copepods and krill (Horwood, 1990).

- **Status**—There are four recognized populations in the North Atlantic Ocean: Canadian East Coast, West Greenland, Central North Atlantic, and Northeastern North Atlantic (Donovan, 1991). Minke whales off the eastern U.S. are considered to be part of the Canadian East Coast stock which inhabits the area from the eastern half of the Davis Strait to 45° West (W) and south to the Gulf of Mexico (Waring et al., 2008). The best estimate of abundance for the Canadian East Coast stock is 3,312 individuals (Waring et al., 2008). The minke whale is under the jurisdiction of NMFS.

- **Diving Behavior**—Diel and seasonal variation in surfacing rates are documented for this species; this is probably due to changes in feeding patterns (Stockin et al., 2001). Dive durations of 7 to 380 s are recorded in the eastern North Pacific and the eastern North Atlantic (Lydersen and Øritsland, 1990; Stern, 1992; Stockin et al., 2001). Mean time at the surface averages 3.4 s (S.D. was ± 0.3 s) (Lydersen and Øritsland, 1990). Stern (1992) described a general surfacing pattern of minke whales consisting of about four surfacings interspersed by short-duration dives averaging 38 s. After the fourth surfacing, there was a longer duration dive ranging from approximately 2 to 6 min.

- **Acoustics and Hearing**—Recordings of minke whale sounds indicate the production of both high- and low-frequency sounds (range of 0.06 to 20 kHz) (Beamish and Mitchell, 1973; Winn and Perkins, 1976; Thomson and Richardson, 1995; Mellinger et al., 2000). Minke whale sounds have a dominant frequency range of 0.06 to greater than 12 kHz, depending on sound type (Thomson and Richardson, 1995; Edds-Walton, 2000). Mellinger et al. (2000) described two basic forms of pulse trains: a “speed-up” pulse train (dominant frequency range: 0.2 to 0.4 kHz) with individual pulses lasting 40 to 60 ms, and a less common “slow-down” pulse train (dominant frequency range: 50 to 0.35 kHz) lasting for 70 to 140 ms. Source levels for this species have been estimated to range from 151 to 175 dB re 1 µPa-m (Ketten, 1998). Gedamke et al. (2001) recorded a complex and stereotyped sound sequence (“star-wars vocalization”) in the Southern Hemisphere that spanned a frequency range of 50 Hz to 9.4 kHz. Broadband source levels between 150 and 165 dB re 1 µPa-m were calculated for this star-wars vocalization. “Boings” recorded in the North Pacific have many striking similarities to the star-wars vocalization in both structure and acoustic behavior. “Boings” are produced by minke whales and are suggested to be a breeding display, consisting of a brief pulse at 1.3 kHz followed by an amplitude-modulated call with greatest energy at 1.4 kHz, with slight frequency modulation over a duration of 2.5 s (Rankin and Barlow, 2005).

  While no empirical data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes are most adapted to hear low to infrasonic frequencies.

- **Habitat**—Off eastern North America, minke whales generally remain in waters over the continental shelf, including inshore bays and estuaries (Mitchell and Kozicki, 1975; Murphy, 1995; Mignucci-Giannoni, 1998). However, based on whaling catches and global surveys, there is an offshore component to minke whale distribution (Slijper et al., 1964; Horwood, 1990; Mitchell, 1991).

- **General Distribution**—Minke whales are distributed in polar, temperate, and tropical waters (Jefferson et al., 1993); they are less common in the tropics than in cooler waters. This species is more abundant in New England waters than in the mid-Atlantic (Hamazaki, 2002; Waring et al., 2006). The southernmost sighting in recent NMFS shipboard surveys was of one individual offshore of the mouth of Chesapeake Bay, in waters with a bottom depth of 3,475 m (Mullin and Fulling, 2003). Minke whales off the U.S. Atlantic coast apparently migrate offshore and southward in winter (Mitchell, 1991). Minke whales are known to occur during the winter months (November through March) in the western North Atlantic from Bermuda to the West Indies (Winn and Perkins, 1976; Mitchell, 1991; Mellinger et al., 2000).

Mating is thought to occur in October to March but has never been observed (Stewart and Leatherwood, 1985); however location of specific breeding grounds is unknown though it is thought to be in areas of low latitude (Jefferson et al., 2008).

Occurrence in the Action Area—Minke whales generally occupy the continental shelf and are widely scattered in the mid-Atlantic region (CETAP, 1982). Minke whale sightings have been recorded in the vicinity of the Action Area during the winter (DoN, 2007b). The winter range of some rorquals (and often extrapolated to the minke whale) is thought to be in deep, offshore waters particularly at lower latitudes (Kellogg, 1928; Gaskin, 1982), and minke whale sightings have been reported in deep waters during this time of year (Slijper et al., 1964; Mitchell, 1991). Minke whales are expected to occur in the Action Area just inshore of the shelf break and seaward throughout most of the year. During the summer, minke whales are expected to occur at higher latitudes on their feeding grounds and are not expected in the Action Area.

3.2.2 Bryde's Whale

- **General Description**—Bryde's whales usually have three prominent ridges on the rostrum (other rorquals generally have only one) (Jefferson et al., 1993). Adults can be up to 15.5 m in length (Jefferson et al., 1993). Bryde's whales can be easily confused with sei whales. Bryde's whales are lunge-feeders, feeding on schooling fish and krill (Nemoto and Kawamura, 1977; Siciliano et al., 2004; Anderson, 2005).

- **Status**—No abundance information is currently available for Bryde's whales in the western North Atlantic (Waring et al., 2008). Bryde's whales are under the jurisdiction of NMFS.

- **Diving Behavior**—Bryde's whales are lunge-feeders, feeding on schooling fish and krill (Nemoto and Kawamura, 1977; Siciliano et al., 2004; Anderson, 2005). Cummings (1985) reported that Bryde's whales may dive as long as 20 min.

- **Acoustics and Hearing**—Bryde's whales produce low frequency tonal and swept calls similar to those of other rorquals (Oleson et al., 2003). Calls vary regionally, yet all but one of the call types have a fundamental frequency below 60 Hz. They last from one-quarter of a second to several seconds and are produced in extended sequences (Oleson et al., 2003). Heimlich et al. (2005) recently described five tone types. While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

- **Habitat**—Bryde's whales are found both offshore and near the coasts in many regions. The Bryde's whale appears to have a preference for water temperatures between approximately 15° and 20°C (Yoshida and Kato, 1999). Bryde's whales are more restricted to tropical and subtropical waters than other rorquals.

- **General Distribution**—Bryde's whales are found in subtropical and tropical waters and generally do not range north of 40° in the northern hemisphere or south of 40° in the southern hemisphere (Jefferson et al., 1993).

  The Bryde's whale does not have a well-defined breeding season in most areas and locations of specific breeding areas are unknown.

Occurrence in the Action Area—There is a general lack of knowledge of this species, particularly in the North Atlantic, although records support a tropical occurrence for the species here (Mead, 1977). This species has been known to strand on the coasts of Georgia and eastern Florida (Schmidly, 1981). It is possible some of the sightings of unidentified rorquals recorded in the region may be of Bryde's whales. Bryde's whales may occur seaward of the shoreline in the Action Area year-round based on occurrences both in coastal and offshore waters in other locales.

3.2.3 Pygmy and Dwarf Sperm Whales

- **General Description**—Dwarf and pygmy sperm whales are difficult for the inexperienced observer to distinguish from one another at sea, and sightings of either species are often categorized as *Kogia* spp. The difficulty in identifying pygmy and dwarf sperm whales is exacerbated by their avoidance reaction towards ships and change in behavior towards approaching survey aircraft (Würsig et al., 1998). Pygmy and dwarf sperm whales reach body lengths of around 3 and 2.5 m, respectively (Plön and Bernard, 1999). *Kogia* spp. feed on cephalopods and, less often, on deep-sea fish and shrimp (Caldwell and Caldwell, 1989; McAlpine et al., 1997; Willis and Baird, 1998; Santos et al., 2006).

- **Status**—There is currently no information to differentiate Atlantic stock(s) (Waring et al., 2008). The best estimate of abundance for both species combined in the western North Atlantic is 395 individuals (Waring et al., 2008). Species-level abundance estimates cannot be calculated due to uncertainty of species identification at sea (Waring et al., 2008). Pygmy and dwarf sperm whales are under the jurisdiction of NMFS.

- **Diving Behavior**—Willis and Baird (1998) reported that whales of the genus *Kogia* make dives of up to 25 min. Dive times ranging from 15 to 30 min (with 2 min surface intervals) have been recorded for a dwarf sperm whale in the Gulf of California (Breese and Tershy, 1993). Median dive times of around 11 min are documented for *Kogia* (Barlow, 1999). A satellite-tagged pygmy sperm whale released off Florida was found to make long nighttime dives, presumably indicating foraging on squid in the deep scattering layer (DSL) (Scott et al., 2001). Most sightings of *Kogia* are brief; these whales are often difficult to approach and they sometimes actively avoid aircraft and vessels (Würsig et al., 1998).

- **Acoustics and Hearing**—There is little published information on sounds produced by *Kogia* spp, although they are categorized as non-whistling smaller toothed whales. Recently, free-ranging dwarf sperm whales off La Martinique (Lesser Antilles) were recorded producing clicks at 13 to 33 kHz with durations of 0.3 to 0.5 s (Jérémie et al., 2006). The only sound recordings for the pygmy sperm whale are from two stranded individuals. A stranded individual being prepared for release in the western North Atlantic emitted clicks of narrowband pulses with a mean duration of 119 μs, interclick intervals between 40 and 70 ms, centroid frequency of 129 kHz, peak frequency of 130 kHz, and apparent source level of up to 175 dB re 1 μPa-m (Madsen et al., 2005). Another individual found stranded in Monterey Bay produced echolocation clicks ranging from 60 to 200 kHz, with a dominant frequency of 120 to 130 kHz (Ridgway and Carder, 2001).

  No information on sound production or hearing is available for the dwarf sperm whale. An ABR study completed on a stranded pygmy sperm whale indicated a hearing range of 90 to 150 kHz (Ridgway and Carder, 2001).

- **Habitat**—*Kogia* spp. occur in waters along the continental shelf break and over the continental slope (e.g., Baumgartner et al., 2001; McAlpine, 2002). Data from the Gulf of Mexico suggest that *Kogia* spp. may associate with frontal regions along the continental shelf break and upper continental slope, where higher epipelagic zooplankton biomass may enhance the densities of squids, their primary prey (Baumgartner et al., 2001).

- **General Distribution**—Both *Kogia* species apparently have a worldwide distribution in tropical and temperate waters (Jefferson et al., 1993). In the western Atlantic Ocean, stranding records have documented the pygmy sperm whale as far north as the northern Gulf of St. Lawrence, New Brunswick and parts of eastern Canada (Piers, 1923, Measures et al., 2004; McAlpine et. al., 1997; Baird et al., 1996) and as far south as Colombia and around to Brazil (in the southern Atlantic) (de Carvalho, 1967; Geise and Borobia, 1987; Muñoz-Hincapié et al., 1998). Pygmy sperm whales are also found in the Gulf of Mexico (Hysmith, 1976; Gunter et. al., 1955; Baumgartner et al., 2001) and in the Caribbean (MacLeod and Hauser, 2002).

The northern range of the dwarf sperm whale is largely unknown; however, multiple stranding records exist on the eastern coast of the U.S. as far north as North Carolina (Hohn et al., 2006) and Virginia (Morgan et al., 2002; Potter, 1979). Records of strandings and incidental captures indicate the dwarf sperm whale may range as far south as the Northern Antilles in the northern Atlantic (Muñoz-Hincapié et al., 1998); although records continue south along Brazil in the southern Atlantic (Muñoz-Hincapié et al., 1998). Dwarf sperm whales occur in the Caribbean (Caldwell et. al., 1973; Cardona-Maldonado and Mignucci-Giannoni, 1999) and the Gulf of Mexico (Davis et. al., 2002; Jefferson and Schiro, 1997).

Births have been recorded between December and March for dwarf sperm whales in South Africa (Plön, 2004), however, the breeding season and specific locations in the northwest Atlantic are unknown. Seasonality and location of pygmy sperm whale breeding is unknown.

<u>Occurrence in the Action Area</u>—*Kogia* spp. generally occur along the continental shelf break and over the continental slope (e.g., Baumgartner et al., 2001; McAlpine, 2002). Few sightings are recorded in the Action Area which is likely due to incomplete survey coverage throughout most of the deep waters of this region (especially during winter and fall) as well as their avoidance reactions towards ships. Strandings are recorded near the Action Area during all seasons and support the likelihood of *Kogia* spp. occurrence in the region year-round (DoN, 2007b). *Kogia* spp. are expected to occur seaward of the shelf break throughout the Action Area year-round.

3.2.4 Beaked Whales

Based upon available data, the following five beaked whale species may be affected by the proposed activities in the JAX Range Complex: Cuvier's beaked whales and four members of the genus *Mesoplodon* (True’s, Gervais', Blainville's, and Sowerby's beaked whales).

- **General Description**—Cuvier's beaked whales are relatively robust compared to other beaked whale species. Male and female Cuvier's beaked whales may reach 7.5 and 7.0 m in length, respectively (Jefferson et al., 1993). *Mesoplodon* species have maximum reported adult lengths of 6.2 m (Mead, 1989). Stomach content analyses of captured and stranded individuals suggest beaked whales are deep divers that feed by suction on mesopelagic fishes, squids, and deepwater benthic invertebrates (Heyning, 1989; Heyning and Mead, 1996; Santos et al., 2001; MacLeod et al., 2003). Stomach contents of Cuvier’s beaked whales rarely contain fishes, while stomach contents of *Mesoplodon* species frequently do (MacLeod et al., 2003).

- **Status**—The best estimate of *Mesoplodon* spp. and Cuvier’s beaked whale abundance combined in the western North Atlantic is 3,513 individuals (Waring et al., 2008). A recent study of global phylogeographic structure of Cuvier’s beaked whales suggested that some regions show a high level of differentiation (Dalebout et al., 2005); however, Dalebout et al., (2005) could not discern finer-scale population differences within the North Atlantic. Beaked whales are under the jurisdiction of NMFS.

- **Diving Behavior**—Dives range from those near the surface where the animals are still visible to long, deep dives. Dive durations for *Mesoplodon* spp. are typically over 20 min (Barlow, 1999; Baird et al., 2005). Tagged northern bottlenose whales off Nova Scotia were found to dive approximately every 80 min to over 800 m (2,625 ft), with a maximum dive depth of 1,453 m (4,764 ft) for as long as 70 min (Hooker and Baird, 1999). Northern bottlenose whale dives fall into two discrete categories: short-duration (mean of 11.7 min), shallow dives and long-duration (mean of 36.98 min), deep dives (Hooker and Baird, 1999). Tagged Cuvier’s beaked whale dive durations as long as 87 min and dive depths of up to 1,990 m (6,529 ft) have been recorded (Baird et al., 2004; Baird et al., 2005). Tagged Blainville’s beaked whale dives have been recorded to 1,408 m (4,619 ft) and lasting as long as 54 min (Baird et al., 2005). Baird et al. (2005) reported that several aspects of diving were similar between Cuvier’s and Blainville’s beaked whales: 1) both dove for 48 to 68 min to depths greater than 800 m (2,625 ft), with one long dive occurring on average every 2 hr; 2) ascent rates for long/deep dives were substantially slower than descent rates, while during shorter dives there were no consistent differences; and 3) both spent prolonged periods of time (66 to 155 min) in the upper 50 m (164 ft) of the water column. Both species make a series of shallow dives after a deep foraging dive to recover from oxygen debt; average intervals between foraging dives have been recorded as 63 min for Cuvier's beaked whales and 92 min for Blainville's beaked whales (Tyack et al., 2006).

- **Acoustics and Hearing**—Sounds recorded from beaked whales are divided into two categories: whistles and pulsed sounds (clicks); whistles likely serve a communicative function and pulsed sounds are important in foraging and/or navigation (Johnson et al., 2004; Madsen et al., 2005) (MacLeod and D'Amico, 2006; Tyack et al., 2006). Whistle frequencies are about 2 to 12 kHz, while pulsed sounds range in frequency from 300 Hz to 135 kHz; however, as noted by MacLeod and D'Amico (2006), higher frequencies may not be recorded due to equipment limitations. Whistles recorded from free-ranging Cuvier's beaked whales off Greece ranged in frequency from 8 to 12 kHz, with an upsweep of about 1 s (Manghi et al., 1999), while pulsed sounds had a narrow peak frequency of 13 to 17 kHz, lasting 15 to 44 s in duration (Frantzis et al., 2002). Short whistles and chirps from a stranded subadult Blainville's beaked whale ranged in frequency from slightly less than 1 to almost 6 kHz (Caldwell and Caldwell, 1971).

  Northern bottlenose whale sounds recorded by Hooker and Whitehead (2002) were predominantly clicks, with two major types of click series. Loud clicks were produced by whales socializing at the surface and were rapid with short and variable interclick intervals. The frequency spectra were often multimodal, and peak frequencies ranged between 2 and 22 kHz (mean of 11 kHz). Clicks received at low amplitude (produced by distant whales, presumably foraging at depth) were generally a unimodal frequency spectra with a mean peak frequency of 24 kHz and a 3 decibels (dB) bandwidth of 4 kHz. Winn et al. (1970) recorded sounds from northern bottlenose whales that were not only comprised of clicks but also whistles that they attributed to northern bottlenose whales. Hooker and Whitehead (2002) noted that it was more likely that long-finned pilot whales (*Globicephala melas*) had produced the whistles, although they also noted that more recordings from this species while no other animals are around are needed to confirm whether or not the species actually produces whistles or not.

  Recent studies incorporating D-tags (miniature sound and orientation recording tag) attached to Blainville's beaked whales in the Canary Islands and Cuvier's beaked whales in the Ligurian Sea recorded high-frequency echolocation clicks (duration: 175 μs for Blainville's and 200 to 250 μs for Cuvier's) with dominant frequency ranges from about 20 to over 40 kHz (limit of recording system was 48 kHz) and only at depths greater than 200 m (656 ft) (Johnson et al., 2004; Madsen et al., 2005; Zimmer et al., 2005; Tyack et al., 2006). The source level of the Blainville's beaked whales' clicks were estimated to range from 200 to 220 dB re 1 μPa-m peak-to-peak (Johnson et al., 2004), while they were 214 dB re 1 μPa-m peak-to-peak for the Cuvier's beaked whale (Zimmer et al., 2005).

  From anatomical examination of their ears, it is presumed that beaked whales are predominantly adapted to best hear ultrasonic frequencies (MacLeod, 1999; Ketten, 2000). Beaked whales have well-developed semi-circular canals (typically for vestibular function but may function differently in beaked whales) compared to other cetacean species, and they may be more sensitive than other cetaceans to low-frequency sounds (MacLeod, 1999; Ketten, 2000). Ketten (2000) remarked on how beaked whale ears (computerized tomography [CT] scans of Cuvier's, Blainville's, Sowerby's, and Gervais' beaked whale heads) have anomalously well-developed vestibular elements and heavily reinforced (large bore, strutted) Eustachian tubes and noted that they may impart special resonances and acoustic sensitivities. The only direct measure of beaked whale hearing is from a stranded juvenile Gervais' beaked whale using auditory evoked potential techniques (Cook et al., 2006). The hearing range was 5 to 80 kHz, with greatest sensitivity at 40 and 80 kHz (Cook et al., 2006).

- **Habitat**—World-wide, beaked whales normally inhabit continental slope and deep oceanic waters (>200 m) (Waring et al., 2001; Cañadas et al., 2002; Pitman, 2002; MacLeod et al., 2004;

Ferguson et al., 2006; MacLeod and Mitchell, 2006). Beaked whales are only occasionally reported in waters over the continental shelf (Pitman, 2002). Distribution of *Mesoplodon* spp. in the North Atlantic may relate to water temperature (MacLeod, 2000b). The Blainville's and Gervais' beaked whales occur in warmer southern waters, in contrast to Sowerby's and True's beaked whales that are more northern (MacLeod, 2000a). Beaked whale abundance off the eastern U.S. may be highest in association with the Gulf Stream and the warm-core rings it develops (Waring et al., 1992). In summer, the continental shelf break off the northeastern U.S. is primary habitat (Waring et al., 2001).

- **General Distribution**—Cuvier's beaked whales are the most widely-distributed of the beaked whales and are present in most regions of all major oceans (Heyning, 1989; MacLeod et al., 2006). This species occupies almost all temperate, subtropical, and tropical waters, as well as subpolar and even polar waters in some areas (MacLeod et al., 2006). Blainville's beaked whales are thought to have a continuous distribution throughout tropical, subtropical, and warm-temperate waters of the world's oceans; they occasionally occur in cold-temperate areas (MacLeod et al., 2006). The Gervais' beaked whale is restricted to warm-temperate and tropical Atlantic waters with records throughout the Caribbean Sea (MacLeod et al., 2006). The Sowerby's beaked whale is endemic to the North Atlantic; this is considered to be more of a temperate species (MacLeod et al., 2006). In the western North Atlantic, confirmed strandings of True's beaked whales are recorded from Nova Scotia to Florida and also in Bermuda (MacLeod et al., 2006). There is also a sighting made southeast of Hatteras Inlet, North Carolina (note that the latitude provided by Tove is incorrect) (Tove, 1995).

  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).

  Beaked whale life histories are poorly known, reproductive biology is generally undescribed, and the locations of specific breeding grounds are unknown.

<u>Occurrence in the Action Area</u>—Cuvier's, True's, Gervais', and Blainville's beaked whales are the only beaked whale species expected to occur regularly in the Action Area, with possible extralimital occurrences of the Sowerby's beaked whale. Expected beaked whale occurrence is seaward of the continental shelf break year-round. Beaked whale sightings in the western North Atlantic Ocean appear to be concentrated in waters between the 200-m isobath and those just beyond the 2,000-m isobath (DoN, 2007e; DoN, 2007f).

3.2.5 Rough-toothed Dolphin

- **General Description**—The rough-toothed dolphin is relatively robust with a cone-shaped head with no demarcation between the melon and beak (Jefferson et al., 1993). Rough-toothed dolphins reach 2.8 m in length (Jefferson et al., 1993). They feed on cephalopods and fish, including large fish such as dorado (Miyazaki and Perrin, 1994; Reeves et al., 1999; Pitman and Stinchcomb, 2002).

- **Status**—No abundance estimate is available for rough-toothed dolphins in the western North Atlantic (Waring et al., 2008). The rough-toothed dolphin is under the jurisdiction of NMFS.

- **Diving Behavior**—Rough-toothed dolphins may stay submerged for up to 15 min (Miyazaki and Perrin, 1994) and are known to dive as deep as 150 m (492 ft) (Manire and Wells, 2005).

- **Acoustics and Hearing**—The rough-toothed dolphin produces a variety of sounds, including broadband echolocation clicks and whistles. Echolocation clicks (duration less than 250 μs) typically have a frequency range of 0.1 to 200 kHz, with a dominant frequency of 25 kHz (Miyazaki and Perrin, 1994; Yu et al., 2003; Chou, 2005). Whistles (duration less than 1 s) have a wide frequency range of 0.3 to greater than 24 kHz but dominate in the 2 to 14 kHz range (Miyazaki and Perrin, 1994; Yu et al., 2003).

- **Habitat**—The rough-toothed dolphin is regarded as an offshore species that prefers deep waters; however, it can occur in shallower waters as well (e.g., Gannier and West, 2005). Tagging data for this species from the Gulf of Mexico and western North Atlantic provide important information on habitat preferences. Three dolphins with satellite-linked transmitters released in 1998 off the Gulf Coast of Florida were tracked off the Florida panhandle in average water depths of 195 m (Wells et al., 1999). Dolphins released in March of 2005 after a mass stranding were tagged with satellite-linked transmitters and released southeast of Fort Pierce moved within the Gulf Stream and parallel to the continental shelf off Florida, Georgia, and South Carolina, in waters with a depth of 400 to 800 m. (Manire and Wells, 2005). They later moved northeast into waters with a depth greater than 4,000 m (Manire and Wells, 2005). Another tagged dolphin from released after the 2005 mass stranding moved north as far as Charleston, South Carolina, before returning to the Miami area, remaining in relatively shallow waters (Wells, 2007). During May 2005, seven more rough-toothed dolphins (stranded in the Florida Keys in March 2005 and rehabilitated) were tagged and released by the Marine Mammal Conservancy in the Florida Keys (Wells, 2007). During an initial period of apparent disorientation in the shallow waters west of Andros Island, they continued to the east, then moved north through Crooked Island Passage, and paralleled the West Indies (Wells, 2007). The last signal placed them northeast of the Lesser Antilles (Wells, 2007). During September 2005, two more individuals (from the same mass stranding) were satellite-tagged and released east of the Florida Keys and proceeded south to a deep trench close to the north coast of Cuba (Wells, 2007).

- **General Distribution**—Rough-toothed dolphins are found in tropical to warm-temperate waters globally, rarely ranging north of 40°N or south of 35°S (Miyazaki and Perrin, 1994). This species is not a commonly encountered species in the areas where it is known to occur (Jefferson, 2002). Not many records for this species exist from the western North Atlantic, but they indicate that this species occurs from Virginia south to Florida, the Gulf of Mexico, the West Indies, and along the northeastern coast of South America (Leatherwood et al., 1976; Jefferson et al., 2008).

  Seasonality and location of rough-toothed dolphin breeding is unknown.

<u>Occurrence in the Action Area</u>—Occurrence is expected seaward of the shelf break throughout the Action Area based on this species' preference for deep waters.

3.2.6 Bottlenose Dolphin

- **General Description**—Bottlenose dolphins are large and robust with striking regional variations in body size; adult body lengths range from 1.9 to 3.8 m (Jefferson et al., 1993). Bottlenose dolphins are opportunistic feeders that utilize numerous feeding strategies to prey upon a variety of fish, cephalopods, and shrimp (Shane, 1990; Wells and Scott, 1999).

- **Status—**Two forms of bottlenose dolphins are recognized in the western North Atlantic Ocean: nearshore (coastal) and offshore (Waring et al., 2008). The best estimate for the western North Atlantic coastal stock of bottlenose dolphins is 15,620 (Waring et al., 2008). Currently, a single western North Atlantic offshore stock is recognized seaward of 34 km from the U.S. coastline (Waring et al., 2008). The best population estimate for this stock is 81,588 individuals (Waring et al., 2008).

- **Diving Behavior**—Dive durations as long as 15 min are recorded for trained individuals (Ridgway et al., 1969). Typical dives, however, are more shallow and of a much shorter duration. Mean dive durations of Atlantic bottlenose dolphins typically range from 20 to 40 s at shallow depths (Mate et al., 1995) and can last longer than 5 min during deep offshore dives (Klatsky et al., 2005). Offshore bottlenose dolphins regularly dive to 450 m (1,476 ft) and possibly as deep as 700 m (2,297 ft) (Klatsky et al., 2005). Bottlenose dolphin dive behavior may correlate with diel cycles (Mate et al., 1995; Klatsky et al., 2005); this may be especially true for offshore stocks, which have dive deeper and more frequently at night to feed upon the deep scattering layer (Klatsky et al., 2005).

- **Acoustics and Hearing**—Sounds emitted by bottlenose dolphins have been classified into two broad categories: pulsed sounds (including clicks and burst-pulses) and narrow-band continuous sounds (whistles), which usually are frequency modulated. Clicks and whistles have a dominant frequency range of 110 to 130 kHz and a source level of 218 to 228 dB re 1 μPa-m peak-to-peak (Au, 1993) and 3.4 to 14.5 kHz and 125 to 173 dB re 1 μPa-m peak-to-peak, respectively (Ketten, 1998). Whistles are primarily associated with communication and can serve to identify specific individuals (i.e., signature whistles) (Caldwell and Caldwell, 1965; Janik et al., 2006). Up to 52% of whistles produced by bottlenose dolphin groups with mother-calf pairs can be classified as signature whistles (Cook et al., 2004). Sound production is also influenced by group type (single or multiple individuals), habitat, and behavior (Nowacek, 2005). Bray calls (low-frequency vocalizations; majority of energy below 4 kHz), for example, are used when capturing fishes, specifically sea trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*), in some regions (i.e., Moray Firth, Scotland) (Janik, 2000). Additionally, whistle production has been observed to increase while feeding (Acevedo-Gutiérrez and Stienessen, 2004; Cook et al., 2004). Furthermore, both whistles and clicks have been demonstrated to vary geographically in terms of overall vocal activity, group size, and specific context (e.g., feeding, milling, traveling, and socializing) (Jones and Sayigh, 2002; Zaretsky et al., 2005; Baron, 2006). For example, preliminary research indicates that characteristics of whistles from populations in the northern Gulf of Mexico significantly differ (i.e., in frequency and duration) from those in the western north Atlantic (Zaretsky et al., 2005; Baron, 2006).

  Bottlenose dolphins can typically hear within a broad frequency range of 0.04 to 160 kHz (Au, 1993; Turl, 1993). Electrophysiological experiments suggest that the bottlenose dolphin brain has a dual analysis system: one specialized for ultrasonic clicks and another for lower-frequency sounds, such as whistles (Ridgway, 2000). Scientists have reported a range of highest sensitivity between 25 and 70 kHz, with peaks in sensitivity at 25 and 50 kHz (Nachtigall et al., 2000). Recent research on the same individuals indicates that auditory thresholds obtained by electrophysiological methods correlate well with those obtained in behavior studies, except at the some lower (10 kHz) and higher (80 and 100 kHz) frequencies (Finneran and Houser, 2006).

  Temporary threshold shifts (TTS) in hearing have been experimentally induced in captive bottlenose dolphins using a variety of noises (i.e., broad-band, pulses) (Ridgway et al., 1997; Schlundt et al., 2000; Nachtigall et al., 2003; Finneran et al., 2005; Mooney et al., 2005; Mooney, 2006). For example, TTS has been induced with exposure to a 3 kHz, 1-s pulse with sound exposure level (SEL) of 195 dB referenced to 1 micropascal squared second (dB re 1 μPa^2-s) (Finneran et al., 2005), one-second pulses from 3 to 20 kHz at 192 to 201 dB re 1μPa-m (Schlundt et al., 2000), and octave band noise (4 to 11 kHz) for 50 min at 179 dB re 1 μPa-m (Nachtigall et al., 2003). Preliminary research indicates that TTS and recovery after noise exposure are frequency dependent and that an inverse relationship exists between exposure time and sound pressure level associated with exposure (Mooney et al., 2005; Mooney, 2006). Observed changes in behavior were induced with an exposure to a 75 kHz one-second pulse at 178 dB re 1 μPa-m (Ridgway et al., 1997; Schlundt et al., 2000). Finneran et al. (2005) concluded that a SEL of 195 dB re 1 μPa^2-s is a reasonable threshold for the onset of TTS in bottlenose dolphins exposed to mid-frequency tones.

- **Habitat**—Coastal bottlenose dolphins occur in coastal embayments and estuaries as well as in waters over the continental shelf; individuals may exhibit either resident or migratory patterns in coastal areas (Kenney, 1990) Read et al. (2003) found the dolphins occurring in North Carolina bays, sounds, and estuaries to contribute substantially to the coastal bottlenose dolphin population in the area. Bays, sounds, and estuaries are high-use habitats for bottlenose dolphins due to their importance as nursery and feeding areas (Read et al., 2003).

Coastal bottlenose dolphins show a temperature-limited distribution, occurring in significantly warmer waters than the offshore stock, and having a distinct northern boundary (Kenney, 1990). A study of the Chesapeake Bay/Virginia coast area showed a much greater probability of sightings with SSTs of 16° to 28°C (Armstrong et al., 2005). SST may significantly influence seasonal movements of migrating coastal dolphins along the western Atlantic coast (Barco et al., 1999); these seasonal movements are likely also influenced by movements of prey resources.

The nearshore waters of the Outer Banks serve as winter habitat for coastal bottlenose dolphins (Read et al., 2003). Cape Hatteras represents important habitat for bottlenose dolphins, particularly in winter, as evidenced from concentrations of bottlenose dolphins during recent aerial surveys (Torres et al., 2005).

In the western North Atlantic, the greatest concentrations of the offshore stock are along the continental shelf break (Kenney, 1990). Evidence suggests that there is a distinct spatial separation pf the coastal and offshore stocks during the summer; however the morphotypes overlap in the winter (Garrison et al., 2003; Torres et. al., 2003). During Cetacean and Turtle Assessment Program (CETAP) surveys, offshore bottlenose dolphins generally were distributed between the 200 and 2,000-m isobaths in waters with a mean bottom depth of 846 m from Cape Hatteras to the eastern end of Georges Bank. Geography and temperature also influence the distribution of offshore bottlenose dolphins (Kenney, 1990).

- **General Distribution**—In the western North Atlantic, bottlenose dolphins occur as far north as Nova Scotia but are most common in coastal waters from New England to Florida, the Gulf of Mexico, the Caribbean, and southward to Venezuela and Brazil (Würsig et al., 2000). Bottlenose dolphins occur seasonally in estuaries and coastal embayments as far north as Delaware Bay (Kenney, 1990) and in waters over the outer continental shelf and inner slope, as far north as Georges Bank (CETAP, 1982; Kenney, 1990).

  In North Carolina, there is significant overlap between distributions of coastal and offshore dolphins during the summer. North of Cape Lookout, there is a separation of the two stocks by bottom depth; the coastal form occurs in nearshore waters (<20 m deep) while the offshore form is in deeper waters (>40 m deep) (Garrison and Hoggard, 2003); however, south of Cape Lookout to northern Florida, there is significant spatial overlap between the two stocks. In this region, coastal dolphins may be found in waters as deep as 31 m and 75 km from shore while offshore dolphins may occur in waters as shallow as 13 m (Garrison et al., 2003). Additional aerial surveys and genetic sampling are required to better understand the distribution of the two stocks throughout the year.

  Populations exhibit seasonal migrations regulated by temperature and prey availability (Torres et al., 2005), traveling as far north as New Jersey in summer and as far south as central Florida in winter (Urian et al., 1999) .

  Coastal bottlenose dolphins along the western Atlantic coast may exhibit either resident or migratory patterns (Waring et.al., 2008). Photo-identification studies support evidence of year-round resident bottlenose dolphin populations in Beaufort and Wilmington, North Carolina (Koster et al., 2000); these are the northernmost documented sites of year-round residency for bottlenose dolphins in the western North Atlantic (Koster et al., 2000). Migratory dolphins may enter these areas seasonally as well, as evidenced by a bottlenose dolphin tagged in 2001 in Virginia Beach who overwintered in waters between Cape Hatteras and Cape Lookout (NMFS-SEFSC, 2001).

  Bottlenose dolphins are flexible in their timing of reproduction. Seasons of birth for bottlenose dolphin populations are likely responses to seasonal patterns of availability of local resources (Urian et al., 1996). There are no specific breeding locations for this species.

<u>Occurrence in the Action Area</u>—Bottlenose dolphins are abundant in continental shelf and inner slope waters throughout the western North Atlantic (CETAP, 1982; Kenney, 1990; Waring et al., 2008). The

greatest concentrations of offshore animals are along the continental shelf break and between the 200- and 2,000-m isobaths (Kenney, 1990; Waring et.al, 2008); however, tagging data suggest that the range of offshore bottlenose dolphins may actually extend further offshore into much deeper waters (Wells et al., 1999). Bottlenose dolphins are expected to occur throughout the Action Area year-round.

3.2.7 Atlantic Spotted Dolphin

- **General Description**—Atlantic spotted dolphin adults are up to 2.3 m long and can weigh as much as 143 kilograms (kg) (Jefferson et al., 1993). Atlantic spotted dolphins are born spotless and develop spots as they age (Perrin et al., 1994c; Herzing, 1997). There is marked regional variation in the adult body size of the Atlantic spotted dolphin (Perrin et al., 1987). There are two forms: a robust, heavily spotted form that inhabits the continental shelf, usually found within 250 to 350 km of the coast and a smaller, less-spotted form that inhabits offshore waters (Perrin et al., 1994c). Atlantic spotted dolphins feed on small cephalopods, fish, and benthic invertebrates (Perrin et al., 1994c).

- **Status**—The best estimate of Atlantic spotted dolphin abundance in the western North Atlantic is 50,978 individuals (Waring et al., 2008). Recent genetic evidence suggests that there are at least two populations in the western North Atlantic (Adams and Rosel, 2006), as well as possible continental shelf and offshore segregations. Atlantic populations are divided along a latitudinal boundary corresponding roughly to Cape Hatteras (Adams and Rosel, 2006). The Atlantic spotted dolphin is under the jurisdiction of NMFS.

- **Diving Behavior**—The only information on diving depth for this species is from a satellite-tagged individual in the Gulf of Mexico (Davis et al., 1996). This individual made short, shallow dives to less than 10 m (33 ft) and as deep as 60 m (197 ft), while in waters over the continental shelf on 76% of dives.

- **Acoustics and Hearing**—A variety of sounds including whistles, echolocation clicks, squawks, barks, growls, and chirps have been recorded for the Atlantic spotted dolphin (Thomson and Richardson, 1995). Whistles have dominant frequencies below 20 kHz (range: 7.1 to 14.5 kHz) but multiple harmonics extend above 100 kHz, while burst pulses consist of frequencies above 20 kHz (dominant frequency of approximately 40 kHz) (Lammers et al., 2003). Other sounds, such as squawks, barks, growls, and chirps, typically range in frequency from 0.1 to 8 kHz (Thomson and Richardson, 1995). Recently recorded echolocation clicks have two dominant frequency ranges at 40 to 50 kHz and 110 to 130 kHz, depending on source level (i.e., lower source levels typically correspond to lower frequencies and higher frequencies to higher source levels (Au and Herzing, 2003). Echolocation click source levels as high as 210 dB re 1 µPa-m peak-to-peak have been recorded (Au and Herzing, 2003). Spotted dolphins in The Bahamas were frequently recorded during agonistic/aggressive interactions with bottlenose dolphins (and their own species) to produce squawks (0.2 to 12 kHz broad band burst pulses; males and females), screams (5.8 to 9.4 kHz whistles; males only), barks (0.2 to 20 kHz burst pulses; males only), and synchronized squawks (0.1-15 kHz burst pulses; males only in a coordinated group) (Herzing, 1996).

  There has been no data collected on Atlantic spotted dolphin hearing ability; however, odontocetes are generally adapted to hear high-frequencies (Ketten, 1997).

- **Habitat**—Atlantic spotted dolphins occupy both continental shelf and offshore habitats. The large, heavily-spotted coastal form typically occurs over the continental shelf within or near the 185 m isobath, 8 to 20 km from shore (Perrin et al., 1994c; Davis et al., 1998; Perrin, 2002a). There are also frequent sightings beyond the continental shelf break in the Caribbean Sea, Gulf of Mexico, and off the U.S. Atlantic Coast (Mills and Rademacher, 1996; Roden and Mullin, 2000; Fulling et al., 2003; Mullin and Fulling, 2003; Mullin et al., 2004). Atlantic spotted dolphins are found commonly in inshore waters south of Chesapeake Bay as well as over continental shelf break and slope waters north of this region (Payne et al., 1984; Mullin and Fulling, 2003). Sightings have also been made along the northern wall of the Gulf Stream and its associated warm-core ring features (Waring et al., 1992).

- **General Distribution**—Atlantic spotted dolphins are distributed in warm-temperate and tropical Atlantic waters from approximately 45°N to 35°S; in the western North Atlantic, this translates to waters from northern New England to Venezuela, including the Gulf of Mexico and the Caribbean Sea (Perrin et al., 1987).

  Peak calving periods in the Bahamas are early spring and late fall (Herzing, 1997); however in the western Atlantic breeding times and locations are largely unknown.

<u>Occurrence in the Action Area</u>— Atlantic spotted dolphins may occur in both continental shelf and offshore waters of the Action Area year-round. The Gulf Stream and its associated warm-core ring features likely influence occurrence of this species in this region.

3.2.8 Pantropical Spotted Dolphin

- **General Description**—The pantropical spotted dolphin is a rather slender dolphin. Adults may reach 2.6 m in length (Jefferson et al., 1993). Pantropical spotted dolphins are born spotless and develop spots as they age although the degree of spotting varies geographically (Perrin and Hohn, 1994). North and offshore of Cape Hatteras, adults may bear only a few small, dark, ventral spots whereas individuals over the continental shelf become so heavily spotted that they appear nearly white (Perrin and Hohn, 1994). Pantropical spotted dolphins prey on epipelagic fish, squid, and crustaceans (Perrin and Hohn, 1994; Robertson and Chivers, 1997; Wang et al., 2003).

- **Status**—The best estimate of abundance of the western North Atlantic stock of pantropical spotted dolphins is 4,439 individuals (Waring et al., 2008). There is no information on stock differentiation for pantropical spotted dolphins in the U.S. Atlantic (Waring et al., 2008). The pantropical spotted dolphin is under the jurisdiction of NMFS.

- **Diving Behavior**—Dives during the day generally are shorter and shallower than dives at night; rates of descent and ascent are higher at night than during the day (Baird et al., 2001). Similar mean dive durations and depths have been obtained for tagged pantropical spotted dolphins in the eastern tropical Pacific and off Hawaii (Baird et al., 2001).

- **Acoustics and Hearing**—Pantropical spotted dolphin whistles have a frequency range of 3.1 to 21.4 kHz (Thomson and Richardson, 1995). Clicks typically have two frequency peaks (bimodal) at 40 to 60 kHz and 120 to 140 kHz with estimated source levels up to 220 dB re 1 μPa peak-to-peak (Schotten et al., 2004). No direct measures of hearing ability are available for pantropical spotted dolphins, but ear anatomy has been studied and indicates that this species should be adapted to hear the lower range of ultrasonic frequencies (less than 100 kHz) (Ketten, 1992;, 1997).

- **Habitat**—Pantropical spotted dolphins tend to associate with bathymetric relief and oceanographic interfaces. Pantropical spotted dolphins may rarely be sighted in shallower waters (e.g., Peddemors, 1999; Gannier, 2002; Mignucci-Giannoni et al., 2003; Waring et al., 2007). Along the northeastern U.S., Waring et al. (1992) found that *Stenella* spp. were distributed along the Gulf Stream's northern wall. *Stenella* sightings also occurred within the Gulf Stream, which is consistent with the oceanic distribution of this genus and its preference for warm water (Waring et al., 1992; Mullin and Fulling, 2003).

- **General Distribution**—Pantropical spotted dolphins occur in subtropical and tropical waters worldwide (Perrin and Hohn, 1994).

In the eastern tropical Pacific, where this species has been best studied, there are two (possibly three) calving peaks: one in spring, (one possibly in summer), and one in fall (Perrin and Hohn, 1994). However, in the western Atlantic breeding times and locations are largely unknown.

Occurrence in the Action Area—Pantropical spotted dolphins have been sighted along the Florida shelf and slope waters and offshore in Gulf Stream waters southeast of Cape Hatteras (Waring et. al., 2008). In the Atlantic, this species is considered broadly sympatric with Atlantic spotted dolphins (Perrin and Hohn, 1994). The offshore form of the Atlantic spotted dolphin and the pantropical spotted dolphin can be difficult to differentiate at sea. Based on sighting data and known habitat preferences, pantropical spotted dolphins are expected to occur seaward of the shelf break throughout the Action Area year-round.

3.2.9 Spinner Dolphin

- **General Description**—The spinner dolphin generally has a dark eye-to-flipper stripe and dark lips and beak tip (Jefferson et al., 1993). This species typically has a three-part color pattern (dark gray cape, light gray sides, and white belly). Adults can reach 2.4 m in length (Jefferson et al., 1993). Spinner dolphins feed primarily on small mesopelagic fish, squid, and sergestid shrimp (Perrin and Gilpatrick, 1994).

- **Status**—No abundance estimates are currently available for the western North Atlantic stock of spinner dolphins (Waring et al., 2008). Stock structure in the western North Atlantic is unknown (Waring et al., 2008). The spinner dolphin is under the jurisdiction of NMFS.

- **Diving Behavior**—Spinner dolphins feed primarily on small mesopelagic fish, squid, and sergestid shrimp, and they dive to at least 200 to 300 m (656 to 984 ft) (Perrin and Gilpatrick, 1994). Foraging takes place primarily at night when the mesopelagic community migrates vertically towards the surface and also horizontally towards the shore at night (Benoit-Bird et al., 2001; Benoit-Bird and Au, 2004). Rather than foraging offshore for the entire night, spinner dolphins track the horizontal migration of their prey (Benoit-Bird and Au, 2003). This tracking of the prey allows spinner dolphins to maximize their foraging time while foraging on the prey at its highest densities (Benoit-Bird and Au, 2003; Benoit-Bird, 2004).

  Spinner dolphins are well known for their propensity to leap high into the air and spin before landing in the water; the purpose of this behavior is unknown. Norris and Dohl (1980) also described several other types of aerial behavior, including several other leap types, backslaps, headslaps, noseouts, tailslaps, and a behavior called “motorboating.” Undoubtedly, spinner dolphins are one of the most aerially active of all dolphin species.

- **Acoustics and Hearing**—Pulses, whistles, and clicks have been recorded from this species. Pulses and whistles have dominant frequency ranges of 5 to 60 kHz and 8 to 12 kHz, respectively (Ketten, 1998). Spinner dolphins consistently produce whistles with frequencies as high as 16.9 to 17.9 kHz with a maximum frequency for the fundamental component at 24.9 kHz (Bazúa-Durán and Au, 2002; Lammers et al., 2003). Clicks have a dominant frequency of 60 kHz (Ketten, 1998). The burst pulses are predominantly ultrasonic, often with little or no energy below 20 kHz (Lammers et al., 2003). Source levels between 195 and 222 dB re 1 μPa-m peak-to-peak have been recorded for spinner dolphin clicks (Schotten et al., 2004).

- **Habitat**—Spinner dolphins occur in both oceanic and coastal environments. Most sightings of this species have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick, 1994). Spinner dolphin distribution in the Gulf of Mexico and off the northeastern U.S. coast is primarily in offshore waters. Along the northeastern U.S. and Gulf of Mexico, they are distributed in waters with a bottom depth greater than 2,000 m (CETAP, 1982; Davis et al., 1998). Off the eastern U.S. coast, spinner dolphins were sighted within the Gulf Stream, which is consistent with the oceanic distribution and warm-water preference of this genus (Waring et al., 1992).

- **General Distribution**—Spinner dolphins are found in subtropical and tropical waters worldwide, with different geographical forms in various ocean basins. The range of this species extends to near 40° latitude (Jefferson et al., 1993). Distribution in the western North Atlantic is thought to extend from North Carolina south to Venezuela (Schmidly, 1981), including the Gulf of Mexico (Davis et al., 2002).

  Breeding occurs across all season with calving peaks that may range from late spring to fall for different populations (Jefferson et al., 2008); however location of breeding areas is unknown.

<u>Occurrence in the Action Area</u>—Occurrence is expected from the vicinity of the continental shelf break to eastward of the Action Area boundary based on the spinner dolphin's known preference for deep, warm waters, and the distribution of the few confirmed records for this species in the area (DoN, 2007b). No seasonal differences in occurrence are anticipated.

3.2.10 Clymene Dolphin

- **General Description**—Due to similarity in appearance, Clymene dolphins are easily confused with spinner and short-beaked common dolphins (Fertl et al., 2003). The Clymene dolphin, however, is smaller and more robust, with a much shorter and stockier beak. The Clymene dolphin can reach 2 m in length and weights of 85 kg (Jefferson et al., 1993). Clymene dolphins feed on small pelagic fish and squid (Perrin et al., 1981; Perrin and Mead, 1994; Fertl et al., 1997).

- **Status**—The population in the western North Atlantic is currently considered a separate stock for management purposes although there is not enough information to distinguish this stock from the Gulf of Mexico stock(s) (Waring et al., 2008). The best estimate of abundance for the western North Atlantic stock of Clymene dolphins is 6,086 individuals (Waring et al., 2008). The Clymene dolphin is under NMFS jurisdiction.

- **Diving Behavior**—There is no diving information available for this species.

- **Acoustics and Hearing**—The only data available for this species is a description of their whistles. Clymene dolphin whistle structure is similar to that of other stenellids, but it is generally higher in frequency (range of 6.3 to 19.2 kHz) (Mullin et al., 1994a).

  There is no empirical data on the hearing ability of Clymene dolphins; however, the most sensitive hearing range for odontocetes generally includes high frequencies (Ketten, 1997).

- **Habitat**—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). Biogeographically, the Clymene dolphin is found in the warmer waters of the North Atlantic from the North Equatorial Current, the Gulf Stream, and the Canary Current (Fertl et al., 2003). In the western North Atlantic, Clymene dolphins were identified 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 (Mullin and Fulling, 2003).

- **General Distribution**—In the western Atlantic Ocean, Clymene dolphins are distributed from New Jersey to Brazil, including the Gulf of Mexico and Caribbean Sea (Fertl et al., 2003; Moreno et al., 2005).

  Seasonality and location of Clymene dolphin breeding is unknown.

<u>Occurrence in the Action Area</u>—Clymene dolphins have been found stranded along the Atlantic coast of Florida adjacent to the Action Area and further south throughout the year (Caldwell and Caldwell, 1975b; Perrin et al., 1981; Fertl et al., 2001). Based on confirmed sightings and the preference of this

species for deep waters, Clymene dolphins are expected in waters seaward of the shelf break throughout the year.

3.2.11 Striped Dolphin

- **General Description**—The striped dolphin is uniquely marked with black lateral stripes from eye to flipper and eye to anus. There is also a light gray spinal blaze originating above and behind the eye and narrowing below and behind the dorsal fin (Jefferson et al., 2008).This species reaches 2.6 m in length. Small, mid-water fishes (in particular, myctophids or lanternfish) and squids are the dominant prey (Perrin et al., 1994a; Ringelstein et al., 2006).

- **Status**—The best estimate of striped dolphin abundance in the western North Atlantic is 94,462 individuals (Waring et al., 2008). The striped dolphin is under the jurisdiction of NMFS.

- **Diving Behavior**—Striped dolphins often feed in pelagic or benthopelagic zones along the continental slope or just beyond it in oceanic waters. A majority of their prey possesses luminescent organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 200 to 700 m (656 to 2,297 ft) to reach potential prey (Archer II and Perrin, 1999). Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements.

- **Acoustics and Hearing**—Striped dolphin whistles range from 6 to greater than 24 kHz, with dominant frequencies ranging from 8 to 12.5 kHz (Thomson and Richardson, 1995). A single striped dolphin's hearing range, determined by using standard psycho-acoustic techniques, was from 0.5 to 160 kHz with best sensitivity at 64 kHz (Kastelein et al., 2003).

- **Habitat**—Striped dolphins are usually found beyond the continental shelf, typically over the continental slope out to oceanic waters and are often associated with convergence zones and waters influenced by upwelling (Au and Perryman, 1985). This species also occurs in conjunction with the shelf edge in the northeastern U.S. (between Cape Hatteras and Georges Bank; Hain et al., 1985). Striped dolphins are known to associate with the Gulf Stream's northern wall and warm-core ring features (Waring et al., 1992).

- **General Distribution**—Striped dolphins are distributed worldwide in cool-temperate to tropical zones. In the western North Atlantic, this species occurs from Nova Scotia southward to the Caribbean Sea, Gulf of Mexico, and Brazil (Baird et al., 1993; Jefferson et al., 2008). Off the northeastern U.S., striped dolphins are distributed along the continental shelf break from Cape Hatteras to the southern margin of Georges Bank, as well as offshore over the continental slope and continental rise in the mid-Atlantic region (CETAP, 1982).

  Off Japan, where their biology has been best studied, there are two calving peaks: one in summer and one in winter (Perrin et al., 1994). However, in the western Atlantic breeding times and locations are largely unknown.

<u>Occurrence in the Action Area</u>— As noted earlier, the striped dolphin is a deepwater species that is generally distributed north of Cape Hatteras (CETAP, 1982). Based on sparse available data, striped dolphins may sporadically occur near and seaward of the shelf break throughout the Action Area year-round.

3.2.12 Common Dolphin

- **General Description**—Only the short-beaked common dolphin is expected to occur in the Action Area. The short-beaked common dolphin is a moderately-robust dolphin, with a moderate-length beak, and a tall, slightly falcate dorsal fin. Length ranges up to about 2.3 m (females) and 2.6 m (males); however, there is substantial geographic variation (Jefferson et al., 1993). Common dolphins feed on a wide variety of epipelagic and mesopelagic schooling fish and squid, such as the long-finned squid, Atlantic mackerel, herring, whiting, pilchard, and anchovy (Waring et al., 1990; Overholtz and Waring, 1991).

- **Status**—The best estimate of abundance for the Western North Atlantic *Delphinus* spp. stock is 120,743 individuals (Waring et al., 2008). There is no information available for western North Atlantic common dolphin stock structure (Waring et al., 2008). The common dolphin is under the jurisdiction of NMFS.

- **Diving Behavior**—Diel fluctuations in vocal activity of this species (more vocal activity during late evening and early morning) appear to be linked to feeding on the deep scattering layer as it rises (Goold, 2000). Foraging dives up to 200 m (656 ft) in depth have been recorded off southern California (Evans, 1994).

- **Acoustics and Hearing**—Recorded *Delphinus* spp. vocalizations include whistles, chirps, barks, and clicks (Ketten, 1998). Clicks range from 0.2 to 150 kHz with dominant frequencies between 23 and 67 kHz and estimated source levels of 170 dB re 1 μPa. Chirps and barks typically have a frequency range from less than 0.5 to 14 kHz, and whistles range in frequency from 2 to 18 kHz (Fish and Turl, 1976; Thomson and Richardson, 1995; Ketten, 1998; Oswald et al., 2003). Maximum source levels are approximately 180 dB re 1 μPa-m (Fish and Turl, 1976).

  This species' hearing range extends from 10 to 150 kHz; sensitivity is greatest from 60 to 70 kHz (Popov and Klishin, 1998).

- **Habitat**—Common dolphins occupy a variety of habitats, including shallow continental shelf waters, waters along the continental shelf break, and continental slope and oceanic areas. Along the U.S. Atlantic coast, common dolphins typically occur in temperate waters on the continental shelf between the 100 and 200 m isobaths, but can occur in association with the Gulf Stream (CETAP, 1982; Selzer and Payne, 1988; Waring and Palka, 2002).

- **General Distribution**—Common dolphins occur from southern Norway to West Africa in the eastern Atlantic and from Newfoundland to Florida in the western Atlantic (Perrin, 2002b), although this species more commonly occurs in temperate, cooler waters in the northwestern Atlantic (Waring and Palka, 2002). This species is abundant within a broad band paralleling the continental slope from 35°N to the northeast peak of Georges Bank (Selzer and Payne, 1988). Short-beaked common dolphin sightings are known to occur primarily along the continental shelf break south of 40°N in spring and north of this latitude in fall. During fall, this species is particularly abundant along the northern edge of Georges Bank (CETAP, 1982) but less common south of Cape Hatteras (Waring et al., 2008).

  Calving peaks differ between stocks, and have been reported in spring and autumn as well as in spring and summer (Jefferson et al., 1993); however locations of breeding areas are unknown.

Occurrence in the Action Area—Common dolphins primarily occur in a broad band along the shelf break from Cape Hatteras to Nova Scotia year-round (CETAP, 1982). This species is less common south of Cape Hatteras (NMFS, 2007b). Based on the cool water temperature preferences of this species and available sighting data, there is likely a very low possibility of encountering common dolphins only during the winter, spring, and fall throughout the Action Area (DoN, 2007b). While there are a number of historical stranding records for common dolphins during the summer, there have been no recent confirmed records for this species. Therefore, common dolphins are not expected to occur in the Action Area during the summer. Although the common dolphin is often found along the shelf-edge, there are sighting and bycatch records in shallower waters to the north, as well as sightings on the continental shelf in the JAX/CHASN OPAREA (DoN, 2007b).

3.2.13 Fraser's Dolphin

- **General Description**—The Fraser's dolphin reaches a maximum length of 2.7 m and is generally more robust than other small delphinids (Jefferson et al., 1993). They feed on mesopelagic fish, squid, and shrimp (Jefferson and Leatherwood, 1994; Perrin et al., 1994b).

- **Status**—No abundance estimate of Fraser's dolphins in the western North Atlantic is available (Waring et al., 2008). Fraser's dolphins are under the jurisdiction of NMFS.

- **Diving Behavior**—There is no information available on depths to which Fraser's dolphins may dive, but they are thought to be capable of deep diving.

- **Acoustics and Hearing**—Fraser's dolphin whistles have been recorded having a frequency range of 7.6 to 13.4 kHz in the Gulf of Mexico (duration less than 0.5 s) (Leatherwood et al., 1993).

  There are no empirical hearing data hearing data available for this species.

- **Habitat**—The Fraser's dolphin is an oceanic species, except in places where deepwater approaches a coastline (Dolar, 2002).

- **General Distribution**—Fraser's dolphins are found in subtropical and tropical waters around the world, typically between 30°N and 30°S (Jefferson et al., 1993). Few records are available from the Atlantic Ocean (Leatherwood et al., 1993; Watkins et al., 1994; Bolaños and Villarroel-Marin, 2003).

  Location of Fraser's dolphin breeding is unknown, and available data do not support calving seasonality.

<u>Occurrence in the Action Area</u>—Although there are no confirmed records of Fraser's dolphins in the Action Area, the most likely area of occurrence in the Action Area is in waters seaward of the continental shelf, and distribution is assumed to be similar year-round.

3.2.14 Risso's Dolphin

- **General Description**—Risso's dolphins are moderately large, robust animals reaching at least 3.8 m in length (Jefferson et al., 1993). Cephalopods are their primary prey (Clarke, 1996).

- **Status**—The best estimate of Risso's dolphin abundance in the western North Atlantic is 20,479 individuals (Waring et al., 2008). Risso's dolphins are under the jurisdiction of NMFS.

- **Diving Behavior**—Individuals may remain submerged on dives for up to 30 min and dive as deep as 600 m (1,967 ft) (DiGiovanni et al., 2005).

- **Acoustics and Hearing**—Risso's dolphin vocalizations include broadband clicks, barks, buzzes, grunts, chirps, whistles, and combined whistle and burst-pulse sounds that range in frequency from 0.4 to 22 kHz and in duration from less than a second to several seconds (Corkeron and Van Parijs, 2001). The combined whistle and burst pulse sound (2 to 22 kHz, mean duration of 8 s) appears to be unique to Risso's dolphin (Corkeron and Van Parijs, 2001). Risso's dolphins also produce echolocation clicks (40 to 70 μs duration) with a dominant frequency range of 50 to 65 kHz and estimated source levels up to 222 dB re 1 μPa-m peak-to-peak (Thomson and Richardson, 1995; Philips et al., 2003; Madsen et al., 2004).

  Baseline research on the hearing ability of this species was conducted by Nachtigall et al. (1995) in a natural setting (included natural background noise) using behavioral methods on one older individual. This individual could hear frequencies ranging from 1.6 to 100 kHz and was most sensitive between 8 and 64 kHz. Recently, the auditory brainstem response technique has been used to measure hearing in a stranded infant (Nachtigall et al., 2005). This individual could hear frequencies ranging from 4 to 150 kHz, with best sensitivity at 90 kHz. This study demonstrated that this species can hear higher frequencies than previously reported.

- **Habitat**—Several studies have noted that Risso's dolphins are found offshore, along the continental slope, and over the continental shelf (CETAP, 1982; Green et al., 1992; Baumgartner, 1997; Davis et al., 1998; Mignucci-Giannoni, 1998; Kruse et al., 1999). Baumgartner (1997) hypothesized that the fidelity of Risso's dolphins on the steeper portions of the upper continental slope in the Gulf of Mexico is most likely the result of cephalopod prey distribution in the same area.

- **General Distribution**—Risso's dolphins are distributed worldwide in cool-temperate to tropical waters from roughly 60°N to 60°S, where SSTs are generally greater than 10°C (Kruse et al., 1999). In the western North Atlantic, this species is found from Newfoundland (Jefferson et al., 2008) southward to the Gulf of Mexico (Baumgartner, 1997; Jefferson and Schiro, 1997), throughout the Caribbean, and around the equator (van Bree, 1975; Ward et al., 2001).

  Risso's dolphins are distributed along the continental shelf break and slope waters from Cape Hatteras north to Georges Bank in spring, summer, and fall (CETAP, 1982; Payne et al., 1984). In the winter the range shifts to mid-Atlantic Bight and offshore waters (Payne et al., 1984). Risso's dolphins may also occur in the waters from the mid-shelf to over the slope from Georges Bank south to, and including, the mid-Atlantic Bight, primarily in the summer and fall (Payne et al., 1984). Only rare occurrences are noted in the Gulf of Maine (Payne et al., 1984).

  In the North Atlantic, there appears to be a summer calving peak (Jefferson et al., 1993); however locations of breeding areas are unknown.

<u>Occurrence in the Action Area</u>—Risso's dolphins are expected just inshore of the shelf break and seaward of the shelf break throughout the Action Area year-round based on sighting data and the preference of this species for deep waters.

3.2.15 Melon-headed Whale

- **General Description**—Melon-headed whales at sea closely resemble pygmy killer whales; both species have blunt heads with little or no beak. Melon-headed whales have pointed (versus rounded) flippers and a more triangular head shape than pygmy killer whales (Jefferson et al., 1993). Melon-headed whales reach a maximum length of 2.75 m (Jefferson et al., 1993). Melon-headed whales prey on squid, pelagic fish, and occasionally crustaceans. Most fish and squid prey are mesopelagic in waters up to 1,500 m deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros, 1997).

- **Status**—There are no abundance estimates for melon-headed whales in the western North Atlantic (Waring et al., 2008). The melon-headed whale is under the jurisdiction of NMFS.

- **Diving Behavior**—Melon-headed whales prey on squids, pelagic fishes, and occasionally crustaceans. Most fish and squid prey are mesopelagic in waters up to 1,500 m deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros, 1997). There is no information on specific diving depths for melon-headed whales.

- **Acoustics and Hearing**—The only published acoustic information for melon-headed whales is from the southeastern Caribbean (Watkins et al., 1997). Sounds recorded included whistles and click sequences. Recorded whistles have dominant frequencies between 8 and 12 kHz; higher-level whistles were estimated at no more than 155 dB re 1 μPa-m (Watkins et al., 1997). Clicks had dominant frequencies of 20 to 40 kHz; higher-level click bursts were judged to be about 165 dB re 1 μPa-m (Watkins et al., 1997).

No empirical data on hearing ability for this species are available.

- **Habitat**—Melon-headed whales are most often found in offshore waters. Sightings off Cape Hatteras, North Carolina are reported in waters greater than 2,500 m (Waring et al., 2008), and most in the Gulf of Mexico have been well beyond the edge of the continental shelf break (Mullin et al., 1994; Davis and Fargion, 1996a; Davis et al., 2000) and out over the abyssal plain (Waring et al., 2004). Nearshore sightings are generally from areas where deep, oceanic waters approach the coast (Perryman, 2002).

- **General Distribution**—Melon-headed whales occur worldwide in subtropical and tropical waters. There are very few records for melon-headed whales in the North Atlantic (Ross and Leatherwood, 1994; Jefferson and Barros, 1997). Maryland is thought to represent the extreme of the northern distribution for this species in the northwest Atlantic (Perryman et al., 1994; Jefferson and Barros, 1997).

  Seasonality and location of melon-headed whale breeding are unknown.

<u>Occurrence in the Action Area</u>—The melon-headed whale is an oceanic species. Strandings have been recorded along the Florida coastline (DoN, 2007b). Based on the low number of confirmed sightings of this species along the Atlantic U.S. coast and the melon-headed whale's propensity for warmer and deeper waters, melon-headed whales might be encountered seaward of the shelf break in the Action Area.

3.2.16 Pygmy Killer Whale

- **General Description**—The pygmy killer whale is often confused with the melon-headed whale and less often with the false killer whale. Flipper shape is the best distinguishing characteristic; pygmy killer whales have rounded flipper tips (Jefferson et al., 1993). Pygmy killer whales reach lengths of up to 2.6 m (Jefferson et al., 1993). Pygmy killer whales eat predominantly fishes and squids, and sometimes take large fish. They are known to occasionally attack other dolphins (Perryman and Foster, 1980; Ross and Leatherwood, 1994).

- **Status**—There are no abundance estimates for pygmy killer whales in the western North Atlantic (Waring et al., 2008). Pygmy killer whales are under the jurisdiction of NMFS.

- **Diving Behavior**—There is no diving information available for this species.

- **Acoustics and Hearing**—The pygmy killer whale emits short duration, broadband signals similar to a large number of other delphinid species (Madsen et al., 2004). Clicks produced by pygmy killer whales have centroid frequencies between 70 and 85 kHz; there are bimodal peak frequencies between 45 and 117 kHz. The estimated source levels are between 197 and 223 dB re 1 μPa-m peak-to-peak (Madsen et al., 2004). These clicks possess characteristics of echolocation clicks (Madsen et al., 2004).

  There are no empirical hearing data available for this species.

- **Habitat**—Pygmy killer whales generally occupy offshore habitats. In the northern Gulf of Mexico, this species is found primarily in deeper waters off the continental shelf (Davis and Fargion, 1996b; Davis et al., 2000) out to waters over the abyssal plain (Jefferson, 2006). Pygmy killer whales were sighted in waters deeper than 1,500 m off Cape Hatteras (Hansen et al., 1994).

- **General Distribution**—Pygmy killer whales have a worldwide distribution in tropical and subtropical waters, generally not ranging north of 40°N or south of 35°S (Jefferson et al., 1993). There are few records of this species in the western North Atlantic (e.g., Caldwell and Caldwell, 1971; Ross and Leatherwood, 1994). Most records from outside the tropics are associated with unseasonable intrusions of warm water into higher latitudes (Ross and Leatherwood, 1994).

Seasonality and location of pygmy killer whale breeding are unknown.

Occurrence in the Action Area—A sighting of six individuals is confirmed in the vicinity of the Action Area (Hansen et al., 1994). There are also a few strandings to the south (Caldwell and Caldwell, 1975a; Schmidly, 1981). The pygmy killer whale is an oceanic species; occurrence is expected seaward of the shelf break year-round throughout the Action Area.

3.2.17 False Killer Whale

- **General Description**—The false killer whale has a long slender body, a rounded overhanging forehead, and little or no beak (Jefferson et al., 1993). Individuals reach maximum lengths of 6.1 m (Jefferson et al., 1993). The flippers have a characteristic hump on the S-shaped leading edge—this is perhaps the best characteristic for distinguishing this species from the other "blackfish" (an informal grouping that is often taken to include pygmy killer, melon-headed, and pilot whales; Jefferson et al., 1993). Deepwater cephalopods and fishes are their primary prey (Odell and McClune, 1999), but large pelagic species, such as dorado, have been taken. False killer whales are known to attack marine mammals such as other delphinids, (Perryman and Foster, 1980; Stacey and Baird, 1991), sperm whales (Palacios and Mate, 1996), and baleen whales (Hoyt, 1983; Jefferson, 2006).

- **Status**—There are no abundance estimates available for this species in the western North Atlantic (Waring et al., 2008). The false killer whale is under the jurisdiction of NMFS.

- **Diving Behavior**—Few diving data are available, although individuals are documented to dive as deep as 500 m (1,640 ft) (Odell and McClune, 1999). Shallower dive depths (maximum of 53 m [174 ft]; averaging from 8 to 12 m [26 to 39 ft]) have been recorded for false killer whales in Hawaiian waters.

- **Acoustics and Hearing**—Dominant frequencies of false killer whale whistles are from 4 to 9.5 kHz, and those of their echolocation clicks are from either 20 to 60 kHz or 100 to 130 kHz depending on ambient noise and target distance (Thomson and Richardson, 1995). Click source levels typically range from 200 to 228 dB re 1 µPa-m peak-to-peak (Ketten, 1998). Recently, false killer whales recorded in the Indian Ocean produced echolocation clicks with dominant frequencies of about 40 kHz and estimated source levels of 201-225 dB re 1 µPa-m peak-to-peak (Madsen et al., 2004).

- **Habitat**—False killer whales are primarily offshore animals, although they do come close to shore, particularly around oceanic islands (Baird, 2002). Inshore movements are occasionally associated with movements of prey and shoreward flooding of warm ocean currents (Stacey et al., 1994).

- **General Distribution**—False killer whales are found in tropical and temperate waters, generally between 50°S and 50°N latitude with a few records north of 50°N in the Pacific and the Atlantic (Baird et al., 1989; Odell and McClune, 1999).

  Seasonality and location of false killer whale breeding are unknown.

Occurrence in the Action Area—False killer whales occur in offshore, warm waters worldwide (Baird, 2002). The warm waters of the Gulf Stream likely influence occurrence in the Action Area. Occurrence is expected seaward of the shelf break throughout the Action Area year-round.

3.2.18 Killer Whale

- **General Description**—Killer whales are probably the most instantly recognizable of all the cetaceans. The black-and-white color pattern of the killer whale is striking, as is the tall, erect dorsal fin of the adult male (1.0 to 1.8 m in height). This is the largest member of the dolphin family. Females may reach 7.7 m in length and males 9.0 m (Dahlheim and Heyning, 1999). Killer whales feed on fish, cephalopods, seabirds, sea turtles, and other marine mammals (Katona et al., 1988; Jefferson et al., 1991; Jefferson et.al., 2008).

- **Status**—There are no estimates of abundance for killer whales in the western North Atlantic (Waring et al., 2008). Most cetacean taxonomists agree that multiple killer whale species or subspecies occur worldwide (Krahn et al., 2004; Waples and Clapham, 2004). However, at this time, further information is not available, particularly for the western North Atlantic. The killer whale is under the jurisdiction of NMFS.

- **Diving Behavior**—The maximum recorded depth for a free-ranging killer whale dive was 264 m (866 ft) off British Columbia (Baird et al., 2005a). A trained killer whale dove to 260 m (853 ft) (Dahlheim and Heyning, 1999). The longest duration of a recorded dive was 17 min (Dahlheim and Heyning, 1999); however, shallower dives were much more common for eight tagged individuals, where less than three percent of all dives examined were greater than 30 m (98 ft) in depth (Baird et al., 2003).

- **Acoustics and Hearing**—Killer whales produce a wide variety of clicks and whistles, but most of this species' social sounds are pulsed, with frequencies ranging from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz) (Thomson and Richardson, 1995). Echolocation clicks recorded for Canadian killer whales foraging on salmon have source levels ranging from 195 to 224 dB re 1 µPa-m peak-to-peak, a center frequency ranging from 45 to 80 kHz, and durations of 80 to 120 µs (Au et al., 2004). Echolocation clicks from Norwegian killer whales were considerably lower than the previously mentioned study and ranged from 173 to 202 re 1 µPa-m peak-to-peak. The clicks had a center frequency ranging from 22 to 49 kHz and durations of 31 to 203 µs (Simon et al., 2007). Source levels associated with social sounds have been calculated to range from 131 to 168 dB re 1 µPa-m and have been demonstrated to vary with vocalization type (e.g., whistles: average source level of 140.2 dB re 1 µPa-m, variable calls: average source level of 146.6 dB re 1 µPa-m, and stereotyped calls: average source level 152.6 dB re 1 µPa-m) (Veirs, 2004). Additionally, killer whales modify their vocalizations depending on social context or ecological function (i.e., short-range vocalizations [less than 10 km {5 NM} range] are typically associated with social and resting behaviors and long-range vocalizations [10 to 16 km {5 to 9 NM} range] are associated with travel and foraging) (Miller, 2006). Likewise, echolocation clicks are adapted to the type of fish prey (Simon et al., 2007).

  Acoustic studies of resident killer whales in British Columbia have found that they possess dialects, which are highly stereotyped, repetitive discrete calls that are group-specific and are shared by all group members (Ford, 2002). These dialects likely are used to maintain group identity and cohesion and may serve as indicators of relatedness that help in the avoidance of inbreeding between closely related whales (Ford, 1991;, 2002). Dialects have been documented in northern Norway (Ford, 2002) and southern Alaskan killer whales populations (Yurk et al., 2002) and are likely occur in other regions as well.

  Both behavioral and ABR techniques indicate killer whales can hear a frequency range of 1 to 100 kHz and are most sensitive at 20 kHz, which is one of the lowest maximum-sensitivity frequency known among toothed whales (Szymanski et al., 1999).

- **Habitat**—Killer whales have the most ubiquitous distribution of any species of marine mammal, and they have been observed in virtually every marine habitat from the tropics to the poles and from shallow, inshore waters (and even rivers) to deep, oceanic regions (Dahlheim and Heyning, 1999). In coastal areas, killer whales often enter shallow bays, estuaries, and river mouths (Leatherwood et al., 1976). Based on a review of historical sighting and whaling records, killer whales in the northwestern Atlantic are found most often along the shelf break and further offshore (Katona et al., 1988; Mitchell and Reeves, 1988). Killer whales in the Hatteras-Fundy region probably respond to the migration and seasonal distribution patterns of prey species, such as bluefin tuna, herring, and squids (Katona et al., 1988; Gormley, 1990).

- **General Distribution**—Killer whales are found throughout all oceans and contiguous seas, from equatorial regions to polar pack ice zones of both hemispheres. In the western North Atlantic, killer whales are known from the polar pack ice, off of Baffin Island, and in Labrador Sound southward to Florida, the Bahamas, and the Gulf of Mexico (Dahlheim and Heyning, 1999), where they have been sighted year-round (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997). A year-round killer whale population in the western North Atlantic may exist south of around 35°N (Katona et al., 1988).

  In the Atlantic, calving takes place in late fall to mid-winter (Jefferson et al., 2008); however location of killer whale breeding in the North Atlantic is unknown.

Occurrence in the Action Area—Killer whale sightings in the Action Area and its vicinity have been recorded close to shore (DoN, 2007b). However, just to the north of the Action Area, there are sightings in deep waters seaward of the continental shelf break. Occurrence in the Action Area is expected seaward of the shoreline year-round based on available sighting data and the diverse habitat preferences of this species.

3.2.19 Pilot Whales

- **General Description**—Pilot whales are among the largest dolphins, with long-finned pilot whales potentially reaching 5.7 m (females) and 6.7 m (males) in length. Short-finned pilot whales may reach 5.5 m (females) and 6.1 m (males) in length (Jefferson et al., 1993). The flippers of long-finned pilot whales are extremely long, sickle shaped, and slender, with pointed tips, and an angled leading edge that forms an "elbow". Long-finned pilot whale flippers range from 18 to 27% of length. Short-finned pilot whales have flippers that are somewhat shorter than long-finned pilot whale at 16 to 22% of the total body length (Jefferson et al., 1993). Both pilot whale species feed primarily on squid but also take fish (Bernard and Reilly, 1999).

- **Status**—The best estimate of pilot whale abundance (combined short-finned and long-finned) in the western North Atlantic is 31,139 individuals (Waring et al., 2008). Pilot whales are under the jurisdiction of NMFS.

- **Diving Behavior**—Pilot whales are deep divers, staying submerged for up to 27 min and routinely diving to 600 to 800 m (1,967 to 2,625 ft) (Baird et al., 2003; Aguilar de Soto et al., 2005). Mate (1989) described movements of a satellite-tagged, rehabilitated long-finned pilot whale released off Cape Cod that traveled roughly 7,600 km (4,101 NM) during the three months of the tag's operation. Daily movements of up to 234 km (126 NM) are documented. Deep diving occurred mainly at night, when prey within the deep scattering layer approached the surface. Tagged long-finned pilot whales in the Ligurian Sea were also found to make their deepest dives (up to 648 m [2,126 ft]) after dark (Baird et al., 2002). Two rehabilitated juvenile long-finned pilot whales released south of Montauk Point, New York made dives in excess of 26 min (Nawojchik et al., 2003). However, mean dive duration for a satellite tagged long-finned pilot whale in the Gulf of Maine ranged from 33 to 40 s, depending upon the month (July through September) (Mate et al., 2005).

- **Acoustics and Hearing**—Pilot whale sound production includes whistles and echolocation clicks. Short-finned pilot whale whistles and clicks have a dominant frequency range of 2 to 14 kHz and 30 to 60 kHz, respectively, at an estimated source level of 180 dB re 1 µPa-m peak-to-peak (Fish and Turl, 1976; Ketten, 1998).

  There are no hearing data available for either pilot whale species; however, the most sensitive hearing range for odontocetes generally includes high frequencies (Ketten, 1997).

- **Habitat**—Pilot whales occur along the continental shelf break, in continental slope waters, and in areas of high-topographic relief (Olson and Reilly, 2002). They also occur close to shore at oceanic islands where the shelf is narrow and deeper waters are nearby (Mignucci-Giannoni, 1998; Gannier, 2000; Anderson, 2005). While pilot whales are typically distributed along the continental shelf break, they are also commonly sighted on the continental shelf and inshore of the 100 m isobath, as well as seaward of the 2,000 m isobath north of Cape Hatteras (CETAP, 1982; Payne and Heinemann, 1993). Long-finned pilot whale sightings extend south to near Cape Hatteras (Abend and Smith, 1999) along the continental slope. Waring et al. (1992) sighted pilot whales principally along the northern wall of the Gulf Stream and along the shelf break at thermal fronts. A few of these sightings were also made in the mid-portion of the Gulf Stream near Cape Hatteras (Abend and Smith, 1999).

- **General Distribution**—Long-finned pilot whales are distributed in subpolar to temperate North Atlantic waters offshore and in some coastal waters. The short-finned pilot whale usually does not range north of 50°N or south of 40°S (Jefferson et al., 1993); however, short-finned pilot whales have stranded as far north as Rhode Island. Strandings of long-finned pilot whales have been recorded as far south as South Carolina (Waring et al., 2008). Short-finned pilot whales are common south of Cape Hatteras (Caldwell and Golley, 1965; Irvine et al., 1979). Long-finned pilot whales appear to concentrate during winter along the continental shelf break primarily between Cape Hatteras and Georges Bank (Waring et al., 1990). The apparent ranges of the two pilot whale species overlap in shelf/shelf-edge and slope waters of the northeastern U.S. between 35°N and 38° to 39°N (New Jersey to Cape Hatteras, North Carolina) (Payne and Heinemann, 1993); however, incidents of strandings of short-finned pilot whales as far north as Block Island, RI and Nova Scotia indicate that area of overlap may be larger than previously thought (Waring et. al., 2008).

  Pilot whales concentrate along the continental shelf break from during late winter and early spring north of Cape Hatteras (CETAP, 1982; Payne and Heinemann, 1993). This corresponds to a general movement northward and onto the continental shelf from continental slope waters (Payne and Heinemann, 1993). Short-finned pilot whales seem to move from offshore to continental shelf break waters and then northward to approximately 39°N, east of Delaware Bay during summer (Payne and Heinemann, 1993). Sightings coalesce into a patchy continuum and, by December, most short-finned pilot whales occur in the mid-Atlantic slope waters east of Cape Hatteras (Payne and Heinemann, 1993). Although pilot whales appear to be seasonally migratory, sightings indicate common year-round residents in some continental shelf areas, such as the southern margin of Georges Bank (CETAP, 1982; Abend and Smith, 1999).

  The calving peak for long-finned pilot whales is from July to September in the northern hemisphere (Bernard and Reilly, 1999). Short-finned pilot whale calving peaks in the northern hemisphere are in the fall and winter for the majority of populations (Jefferson et al., 2008). Locations of breeding areas are unknown.

<u>Occurrence in the Action Area</u>—The Action Area is located well south of the suggested overlap area for the two pilot whale species (Payne and Heinemann, 1993). Thus, the sightings of unidentified pilot whales in the Action Area vicinity are most likely of the short-finned pilot whale (DoN, 2007b). The majority of pilot whale strandings on beaches adjacent to the Action Area are of the short-finned pilot whale (Moore, 1953; Layne, 1965; Irvine et al., 1979; Winn et al., 1979; Schmidly, 1981). Schmidly (1981) reported on two possible long-finned pilot whale skulls from localities south of latitude 34°N (St. Catherine's Island, Georgia, was the southernmost record), but noted that their identification had not been verified. If those two records were proven to be of long-finned pilot whales, they would be the southernmost records for this species in the western North Atlantic. As deepwater species, pilot whales are expected seaward of the shelf break throughout the Action Area year-round. They may also occur between the shore and shelf break which is supported by opportunistic sightings and bycatch records inshore of the shelf break to the north of the Action Area (DoN, 2007f).

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4.0 TAKE AUTHORIZATION REQUESTED

The Navy requests a LOA pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act (MMPA) for the harassment of marine mammals incidental to USWTR usage. It is understood that an LOA is applicable for up 5 yr, and is appropriate where authorization for serious injury or mortality of marine mammals is requested. The request is for mid-frequency sonar and high-frequency sonar exercises and training events conducted within the USWTR Action Area (**Figure 1-1**). The request is for a 5-yr period beginning with initial operations on the USWTR in 2013.

The acoustic modeling approach taken in the USWTR EIS/OEIS and this LOA request attempts to quantify potential exposures to marine mammals resulting from operation of MFA and high-frequency active (HFA) sonar or sonobuoys that involve the use of explosive sources. Results from this conservative modeling approach are presented without consideration of mitigation measures employed per Navy standard operating procedures. For example, securing or turning off an active sonar system when an animal approaches closer than a specified distance reduces potential exposure since the sonar is no longer transmitting.

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5.0 NUMBER AND SPECIES EXPOSED

5.1 NON-ACOUSTIC EFFECTS

Vessel Strikes

Navy Vessels

Collisions with commercial and Navy ships can result in serious injury and may occasionally cause fatalities to cetaceans and manatees. Although the most vulnerable marine mammals may be assumed to be slow-moving cetaceans or those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., sperm whale), fin whales are actually struck most frequently (Laist et al., 2001). Manatees are also particularly susceptible to vessel interactions and collisions with watercraft constitute the leading cause of mortality (USFWS, 2007). Smaller marine mammals such as bottlenose and Atlantic spotted dolphins move more quickly throughout the water column and are often seen riding the bow wave of large ships. Marine mammal responses to vessels may include avoidance and changes in dive pattern (NRC, 2003).

After reviewing historical records and computerized stranding databases for evidence of ship strikes involving baleen and sperm whales, Laist et al. (2001) found that accounts of large whale ship strikes involving motorized boats in the area date back to at least the late 1800s. Ship collisions remained infrequent until the 1950s, after which point they increased. Laist et al. (2001) report that both the number and speed of motorized vessels have increased over time for trans-Atlantic passenger services, which transit through the area. They concluded that most strikes occur over or near the continental shelf, that ship strikes likely have a negligible effect on the status of most whale populations, but that for small populations or segments of populations the impact of ship strikes may be significant.

Although ship strike mortalities may represent a small proportion of whale populations, Laist et al. (2001) also concluded that, when considered in combination with other human-related mortalities in the area (e.g., entanglement in fishing gear), these ship strikes may present a concern for whale populations.

Of 11 species known to be hit by ships, fin whales are struck most frequently; right whales, humpback whales, sperm whales, and gray whales are all hit commonly (Laist et al, 2001). In some areas, one-third of all fin whale and right whale strandings appear to involve ship strikes. Sperm whales spend long periods (typically up to 10 min; Jacquet and Whitehead, 1996) "rafting" at the surface between deep dives. This could make them exceptionally vulnerable to ship strikes. Berzin (1972) noted that there were "many" reports of sperm whales of different age classes being struck by vessels, including passenger ships and tug boats. There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (NMFS, 2006b).

Accordingly, the Navy has adopted mitigation measures to reduce the potential for collisions with surfaced marine mammals (for more details refer to **Chapter 11**). These measures include the following:

- Using lookouts trained to detect all objects on the surface of the water, including marine mammals.
- Implementing reasonable and prudent actions to avoid the close interaction of Navy assets and marine mammals.
- Maneuvering to keep away from any observed marine mammal.

Navy shipboard lookouts (also referred to as "watchstanders") are highly qualified and experienced observers of the marine environment. Their duties require that they report all objects sighted in the water to the Officer of the Deck (OOD) (e.g., trash, a periscope, marine mammals, sea turtles) and all disturbances (e.g., surface disturbance, discoloration) that may be indicative of a threat to the vessel and its crew. There are personnel serving as lookouts on station at all times (day and night) when a ship or surfaced submarine is moving through the water. Navy lookouts undergo extensive training in order to qualify as a lookout. This training includes on-the-job instruction under the supervision of an experienced lookout, followed by completion of the Personal Qualification Standard (PQS) program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects).

The Navy includes marine species awareness as part of its training for its bridge lookout personnel on ships and submarines. Lookouts are trained how to look for marine species, and report sightings to the OOD so that action may be taken to avoid the marine species or adjust the exercise to minimize effects to the species. Marine Species Awareness Training (MSAT) was updated in 2006, and the additional training materials are now included as required training for Navy ship and submarine lookouts. Additionally, all Commanding Officers (COs) and Executive Officers (XOs) of units involved in training exercises are required to undergo marine species awareness training. This training addresses the lookout's role in environmental protection, laws governing the protection of marine species, Navy stewardship commitments, and general observation information to aid in avoiding interactions with marine species.

North Atlantic right whales are of particular concern. On average one or two right whales are killed annually in collisions. Between 2001 and 2007, at least eight right whales, including four adult females, a juvenile male, a juvenile female, and a female calf died as a result of being struck by ships. (MMC, 2008) (RWC, 2007)

In order to reduce the risk of ship strikes, the Navy has instituted North Atlantic right whale protective measures that cover vessels operating all along the Atlantic coast. Standing protective measures and annual guidance have been in place for ships in the vicinity of the right whale critical habitat off the southeast coast since 1997. In addition to specific operating guidelines, the Navy's efforts in the southeast include annual funding support to the EWS, and organization of a communication network and reporting system to ensure the widest possible dissemination of right whale sighting information to DoD and civilian shipping.

In 2002 right whale protective measures were promulgated for all Fleet activities occurring in the Northeast region and most recently in December 2004, the U.S. Navy issued further guidance for all Fleet ships to increase awareness of right whale migratory patterns and implement additional protective measures along the mid-Atlantic coast. This includes areas where ships transit between southern New England and northern Florida. The Navy coordinated with NOAA Fisheries for identification of seasonal right whale occurrence patterns in six major sections of the mid-Atlantic coast, with particular attention to port and coastal areas of key interest for vessel traffic management. The Navy's resulting guidance calls for extreme caution and operation at a slow, safe speed within 20 NM arcs of specified coastal and port reference points. The guidance reiterates previous instructions that Navy ships post two lookouts, one of whom must have completed marine mammal recognition training, and emphasizes the need for utmost vigilance in performance of these watchstander duties.

For the Action Area, the southeast protective measures covering the right whale consultation area and southeast critical habitat apply. These include:

- Annual message sent to all ships prior to the 1 December through 30 March calving season.
- Movement through the critical habitat will be in the most direct manner possible, avoiding north – south transits during the calving season.
- Vessels will use extreme caution and operate at a slow, safe speed; that is the slowest speed consistent with essential mission, training and operations at which the ship can take proper and effective action to avoid a collision and can be stopped within a distance appropriate to the prevailing circumstances and conditions.
- To the extent practicable and consistent with mission, training and operations, naval vessel operations in the critical habitat and associated area of concern will be limited to daylight and periods of good visibility.

Based on these standard operating procedures, collisions with right whales and other cetaceans or sea turtles are not expected in the Action Area.

The Navy has enacted additional protective measures to protect North Atlantic right whales in the mid-Atlantic region. As described in **Section 3.2**, the mid-Atlantic is a principal migratory corridor for North Atlantic right whales that travel between the calving/nursery areas in the Southeastern U.S. and feeding grounds in the northeast U.S. and Canada. Transit to and from mid-Atlantic ports requires Navy vessels to cross the migratory route of North Atlantic right whales. Southward right whale migration generally occurs from mid- to late November, although some right whales may arrive off the Florida coast in early November and stay into late March (Kraus et al., 1993). The northbound migration generally takes place between January and late March. Data indicate that during the spring and fall migration, right whales typically occur in shallow water immediately adjacent to the coast, with over half the sightings (63.8%) occurring within 18.5 km (10 NM), and 94.1% reported within 55 km (30 NM) of the coast.

Given the low abundance of North Atlantic right whales relative to other species, the frequency of occurrence of ship strikes to right whales suggests that the threat of ship strikes is proportionally greater to this species (Jensen and Silber, 2003). Therefore, in 2004, NMFS proposed a right whale vessel collision reduction strategy to consider the establishment of operational measures for the shipping industry to reduce the potential for large vessel ship strikes of North Atlantic right whales while transiting to and from mid-Atlantic ports during right whale migratory periods (NOAA, 2004d). Recent studies of right whales have shown that these whales tend to lack a response to the sounds of oncoming vessels (Nowacek et al., 2004). Although Navy vessel traffic generally represents only 2-3% of the overall large vessel traffic, based on this biological characteristic and the presence of critical Navy ports along the whales' mid-Atlantic migratory corridor, the Navy was the first federal agency to adopt additional protective measures for transits in the vicinity of mid-Alantic ports during right whale migration.

Specifically, the Navy has unilaterally adopted the following protective measures:

- During months of expected North Atlantic right whale occurrence, Navy vessels will practice increased vigilance with respect to avoidance of vessel-whale interactions along the mid-Atlantic coast, including transits to and from any mid-Atlantic ports.

- All surface units transiting within 30 NM of the coast in the mid-Atlantic will ensure at least two watchstanders are posted, including at least one lookout that has completed required marine mammal awareness training.

- Navy vessels will avoid knowingly approaching any whale head on and will maneuver to keep at least 460 m (1,500 ft) away from any observed whale, consistent with vessel safety.

For purposes of these measures, the mid-Atlantic is defined broadly to include ports south and east of Block Island Sound southward to South Carolina. These measures are similar to vessel transit procedures in place since 1997 for Navy vessels in the vicinity of designated right whale critical habitat in the southeastern U.S. Based on the implementation of Navy mitigation measures, especially during times of anticipated right whale occurrence, and the relatively low density of Navy ships in the Action Areas the likelihood that a vessel collision would occur is very low.

5.2 ACOUSTIC EFFECTS

This section therefore contains analyses of potential acoustic effects that may occur to cetaceans (dolphins and whales) and sirenians (manatees) from activities detailed in Chapter 1. Because all marine mammals are protected under the MMPA and tactical sonars have the potential to adversely affect these species, the bulk of this section (**5.2.1** to **5.2.10**) is devoted to analyzing the potential effects of underwater sonars on cetaceans. The potential effects of aircraft noise on marine mammals are discussed in **Section 5.2.10**.

Estimating potential acoustic effects on cetaceans entails answering the following questions:

- **What action will occur?** This requires identification of all acoustic sources that would be used in the exercises and the specific outputs of those sources. This information is provided in **Section 5.2.5**.

- **Where and when will the action occur?** The place, season, and time of the action are important to:

  - determine which marine mammal species are likely to be present. Species occurrence and density data (**Chapter 3**) are used to determine the subset of marine mammals for consideration and to estimate the distribution of those species.

  - predict the underwater acoustic environment that would be encountered. The acoustic environment here refers to environmental factors that influence the propagation of underwater sound. Acoustic parameters influenced by the place, season, and time are described in **Section 5.2.6**.

- **What are the predicted sound exposures for the species present?** This requires appropriate sound propogation models to predict the anticipated sound levels as a function of source location, animal location and depth, and season and time of the action. The sound propagation models and predicted acoustic exposures are described in **Section 5.2.7**.

- **What are the potential effects of sound on the species present?** This requires an analysis of the manner in which sound interacts with the physiology of marine mammals and the potential responses of those animals to sound. **Section 5.2.1** presents the conceptual framework used in this LOA to evaluate the potential effects of sound on marine mammal physiology and behavior. When possible, specific criteria and numeric values are derived to relate acoustic exposure to the likelihood of a particular effect.

- **How many marine mammals are predicted to be harassed?** This requires potential effects to be evaluated within the context of the existing regulations. **Section 5.2.2** reviews the regulatory framework and premises upon which the effects analyses in this LOA are based. Numeric criteria for MMPA harassment are presented in **Section 5.2.3**. **Sections 5.2.8** and **5.2.9** discuss the anticipated acoustic effects to ESA-listed and non-listed marine mammals, respectively.

5.2.1 Conceptual Biological Framework

The regulatory language of the MMPA and ESA requires that all anticipated responses to sound resulting from Navy exercises in the USWTR be considered relative to their potential impact on animal growth, survivability, and reproduction. Although a variety of effects may result from an acoustic exposure, not all effects will impact survivability or reproduction (e.g., short-term changes in respiration rate would have no effect on survivability or reproduction). Whether an effect significantly affects a marine mammal must be determined from the best available science regarding marine mammal responses to sound.

A conceptual framework has been constructed (**Figure 5-1**) to assist in ordering and evaluating the potential responses of marine mammals to sound. Although the framework is described in the context of effects of sonars on marine mammals, the same approach could be used for fish, turtles, sea birds, etc. exposed to other sound sources (e.g., impulsive sounds from explosions); the framework need only be consulted for potential pathways leading to possible effects.

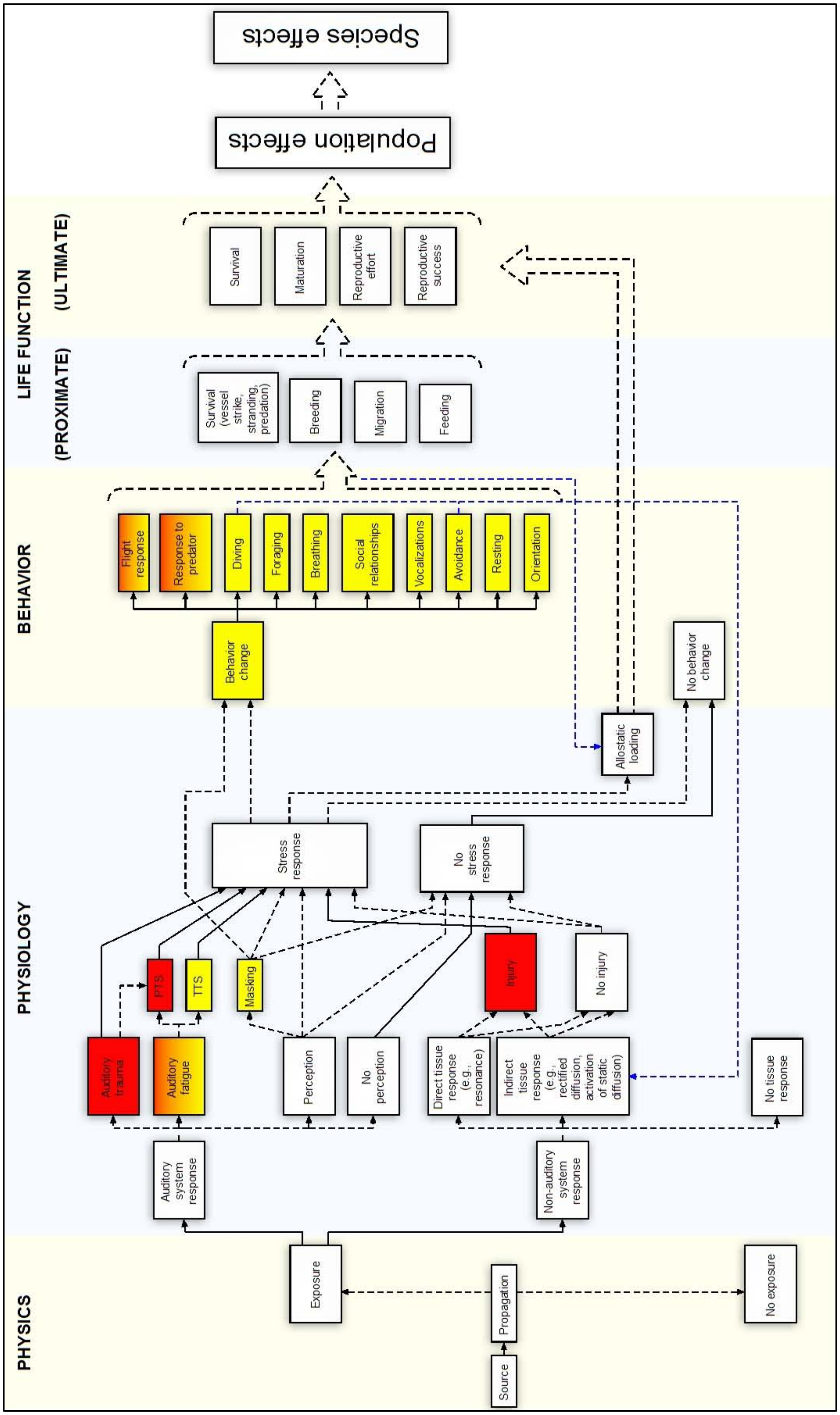

Figure 5-1. Conceptual biological framework used to order and evaluate the potential responses of marine mammals to sound.

5.2.1.1 Organization

The framework is a “block diagram” or “flow chart”, organized from left to right, and grossly compartmentalized according to the phenomena that occur within each. These include the physics of sound propagation (Physics block), the potential physiological responses associated with sound exposure (Physiology block), the behavioral processes that might be affected (Behavior block), and the life functions that may be immediately affected by changes in behavior at the time of exposure (Life Function – Proximate). These are extended to longer term life functions (Life Function – Ultimate) and into population and species effects.

Throughout the flow chart dotted and solid lines are used to connect related events. Solid lines are those items which “**will**” happen, dotted lines are those which “**might**” happen, but which must be considered (including those hypothesized to occur but for which there is no direct evidence). Blue dotted lines indicate instances of “feedback” — where the information flows back to a previous block. Some boxes are colored according to how they relate to the definitions of harassment in the MMPA, with red indicating Level A harassment (injury) and yellow indicating Level B harassment (behavioral disturbance) (see **Section 5.2.2.1**).

The following sections describe the flowthrough of the framework, starting with the production of a sound, and flowing through marine mammal exposures, responses to the exposures, and the possible consequences of the exposure. Along with the description of each block an overview of the state of knowledge is described with regard to marine mammal responses to sound and the consequences of those exposures. Application of the conceptual framework to impact analyses and regulations defined by the MMPA are discussed in subsequent sections.

5.2.1.2 Physics Block

Sounds emitted from a source propagate through the environment to create a spatially variable sound field. To determine if an animal is “exposed” to the sound, the received sound level at the animal’s location is compared to the background ambient noise. An animal is considered exposed if the predicted received sound level (at the animal’s location) is above the ambient level of background noise. If the animal is determined to be exposed, two possible scenarios must be considered with respect to the animal’s physiology– responses of the auditory system and responses of non-auditory system tissues.

These are not independent pathways and both must be considered since the same sound could affect both auditory and non-auditory tissues.

5.2.1.3 Physiology Block

5.2.1.3.1 Auditory system response

The primary physiological effects of sound are on the auditory system (Ward, 1997). The mammalian auditory system consists of the outer ear, middle ear, inner ear, and central nervous system. Sound waves are transmitted through the outer and middle ears to fluids within the inner ear. The inner ear contains delicate electromechanical hair cells that convert the fluid motions into neural impulses that are sent to the brain. The hair cells within the inner ear are the most vulnerable to overstimulation by noise exposure (Yost, 1994).

Potential auditory system effects are assessed by considering the characteristics of the received sound (e.g., amplitude, frequency, duration) and the sensitivity/susceptibility of the exposed animals. Some of these assessments can be numerically based, while others will be necessarily qualitative, due to lack of information, or will need to be extrapolated from other species for which information exists. Potential physiological responses to a sound exposure are discussed here in order of increasing severity, progressing from perception of sound to auditory trauma.

5.2.1.3.1.1 No perception

The received level is not of sufficient amplitude, frequency, and duration to be perceptible to the animal; i.e. the sound is not audible. By extension, this cannot result in a stress response or a change in behavior.

5.2.1.3.1.2 Perception

Sounds with sufficient amplitude and duration to be detected within the background ambient noise are assumed to be perceived (i.e., sensed) by an animal. This category includes sounds from the threshold of audibility through the normal dynamic range of hearing. To determine whether an animal perceives the sound, the received level, frequency, and duration of the sound are compared to what is known of the species' hearing sensitivity. Within this conceptual framework, a sound capable of auditory masking, auditory fatigue, or trauma are assumed to be perceived by the animal.

Information on hearing sensitivity exists for approximately 25 of the nearly 130 species of marine mammals. Within the cetacea, these studies have focused primarily on odontocete species (e.g., Szymanski et al., 1999; Kastelein et al., 2002a; Nachtigall et al., 2005; Yuen et al., 2005; Finneran and Houser, 2006). Because of size and availability, direct measurements of mysticete whale hearing are nearly non-existent (Ridgway and Carder, 2001). Measurements of hearing sensitivity have been conducted on species representing all of the families within the pinnipedia (Phocidae, Otariidae, Odobenidae, Schusterman et al., 1972; Moore and Schusterman, 1987; Terhune, 1988; Thomas et al., 1990a; Terhune and Turnbull, 1995; Kastelein et al., 2002b; Wolski et al., 2003; Kastelein et al., 2005). Hearing sensitivity measured in these studies can be compared to the amplitude, duration, and frequency of a received sound, as well as the ambient environmental noise, to predict whether or not an exposed marine mammal will perceive a sound to which it is exposed.

The features of a perceived sound (e.g., amplitude, frequency, duration, temporal pattern) are also used to judge whether the sound exposure is capable of producing a stress response (see **Section 5.2.1.3.3**). Factors to consider in this decision include the probability of the animal being naïve or experienced with the sound (i.e., what are the known/unknown consequences, to the animal, of the exposure). Although preliminary because of the small numbers of samples collected, different types of sounds (impulsive vs. continuous broadband vs. continuous tonal) have been shown to produce variable stress responses in marine mammals. Belugas demonstrated no catecholamine response to the playback of oil drilling sounds (Thomas et al., 1990) but showed an increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al., 2004). A dolphin, exposed to the same seismic water gun signals, did not demonstrate a catecholamine response but did demonstrate an elevation in aldosterone, a hormone that has been suggested as being a significant indicator of stress in odontocetes (St.Aubin and Geraci, 1989; St. Aubin et al., 2001). Increases in heart rate were observed in 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.

Audible natural and artificial sounds can potentially result in auditory masking, a condition that occurs when a sound 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. It is important to distinguish auditory fatigue, which persists after the sound exposure, from masking, which occurs during the sound exposure. Critical ratios have been determined for pinnipeds (Southall et al., 2000; Southall et al., 2003) and detections of signals under varying masking conditions have been determined for active echolocation and passive listening tasks in odontocetes (Johnson, 1971; Au and Pawloski, 1989; Erbe, 2000). These studies provide baseline information from which the probability of masking can be estimated. The potential impact to a marine mammal depends on the type of signal that is being masked; important cues from conspecifics, signals produced by predators, or interference with echolocation are likely to have a greater impact on a marine mammal when they are masked than will a sound of little biological consequence.

Unlike auditory fatigue, which always results in a localized stress response (see **Section 5.2.1.3.3**) because the sensory tissues are being stimulated beyond their normal physiological range, masking may or may not result in a stress response, depending on the degree and duration of the masking effect and the signal that is being masked. Masking may also result in a unique circumstance where an animal's ability to detect other sounds is compromised without the animal's knowledge. This could conceivably result in sensory impairment and subsequent behavior change; in this case the change in behavior is the *lack of a response* that would normally be made if sensory impairment did not occur. For this reason masking also may lead directly to behavior change without first causing a stress response.

The proposed USWTR areas are on the continental shelf away from harbors or heavily traveled shipping lanes. The most intense underwater sounds in the proposed Action Area are those produced by sonars and other acoustic sources that are in the mid-frequency or higher range. The sonar signals are likely within the audible range of most cetaceans, but are very limited in the temporal, frequency, and spatial domains. In particular, the pulse lengths are short, the duty cycle low, the total number of hours of operation per year small, and the tactical sonars transmit within a narrow band of frequencies (typically less than one-third octave). Finally, high levels of sound are confined to a volume around the source and are constrained by attenuation at mid- and high-frequencies, as well as by limited beam widths and pulse lengths. For these reasons, the likelihood of sonar operations causing masking effects is considered negligible in this LOA.

5.2.1.3.1.3 Auditory fatigue

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 (NITS), or simply a threshold shift (TS) (Miller, 1974). A TS may be either permanent, in which case it is called a permanent threshold shift (PTS), or temporary, in which case it is called a TTS. The distinction between PTS and TTS is based on whether there is a complete recovery of a TS following a sound exposure. If the TS eventually returns to zero (the threshold returns to the preexposure value), the TS is a TTS. If the TS does not return to zero but leaves some finite amount of TS, then that remaining TS is a PTS. **Figure 5-2** (Two Hypothetical Threshold Shifts) shows one hypothetical TS that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.

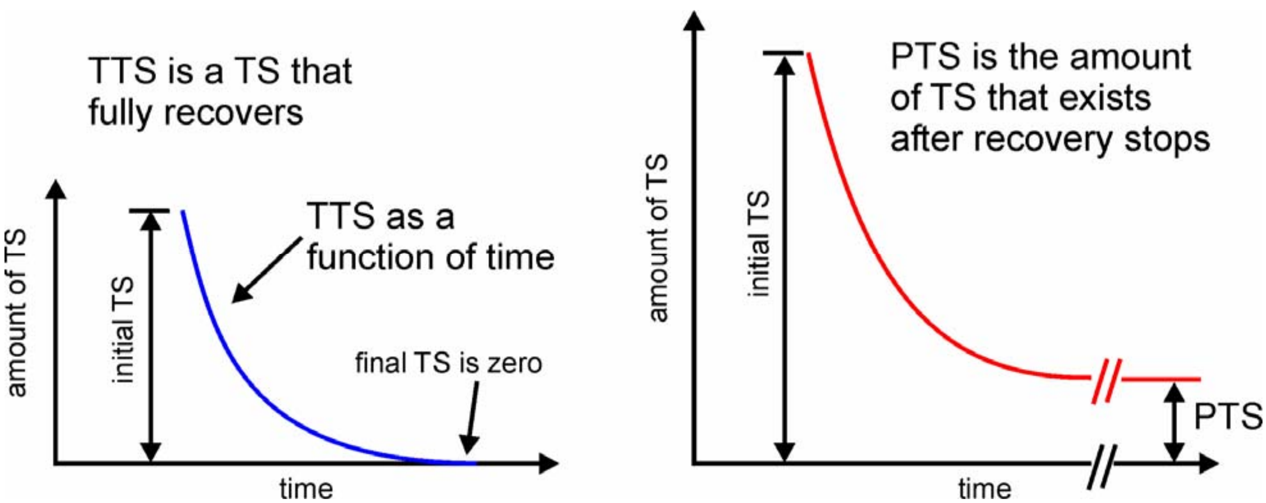

Figure 5-2. Two hypothetical threshold shifts.

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. Note that the term "auditory fatigue" is often used to mean "TTS"; however, in this LOA we use a more general meaning to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure). Auditory fatigue may result in PTS or TTS but is always assumed to result in a stress response. The actual amount of threshold shift depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure.

There are no PTS data for cetaceans; however, a number of investigators have measured TTS in cetaceans (Schlundt et al., 2000, 2006; Finneran et al., 2000, 2002, 2005, 2007; Nachtigall et al., 2003, 2004). In these studies hearing thresholds were measured in trained dolphins and belugas before and after exposure to intense sounds. 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). The existing cetacean TTS data show that, for the species studied (non-impulsive) mid-frequency sounds of interest in this LOA.

- **The growth and recovery of TTS are analogous to those in land mammals.** This means that, as in land mammals, cetacean TSs depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure. Threshold shifts will generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy will lead to approximately equal effects (Ward, 1997). For intermittent sounds, less TS will occur than from a continuous exposure with the same energy (some recovery will occur during the quiet period between exposures) (Kryter et al., 1966; Ward, 1997).

- **Sound pressure level (SPL) by itself is not a good predictor of onset-TTS**, since the amount of TTS depends on both SPL and duration.

- **Exposure energy flux density level (EL) is correlated with the amount of TTS** and is a good predictor for onset-TTS from single, continuous exposures with variable durations. This agrees with human TTS data presented by Ward et al. (1958, 1959).

The most relevant TTS data for analyzing the effects of mid-frequency sonars are from Schlundt et al. (2000, 2006) and Finneran et al. (2005). These studies point to an energy flux density level of, 195 dB re 1 μPa^2-s as the most appropriate predictor for onset-TTS in dolphins and belugas from a single, continuous exposure in the mid-frequency range. This finding is supported by the recommendations of a panel of scientific experts formed to study the effects of sound on marine mammals (Southall et al., 2007).

In contrast to TTS data, PTS data do not exist and are unlikely to be obtained, for marine mammals. Differences in auditory structures and the way that sound propagates and interacts with tissues prevent terrestrial mammal PTS thresholds from being directly applied to marine mammals; however, the inner ears of marine mammals are analogous to those of terrestrial mammals. Experiments with marine mammals have revealed similarities between marine and terrestrial mammals with respect to 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 from marine mammal TTS data and PTS/TTS relationships observed in terrestrial mammals. This involves:

- estimating the largest amount of TTS that may be induced without PTS. Exposures causing a TS greater than this value are assumed to cause PTS.

- estimating the additional exposure, above the onset-TTS exposure, necessary to reach the maximum allowable amount of TTS (assumed here to indicate PTS). This requires estimating the growth rate of TTS – how much additional TTS is produced by an increase in exposure level.

A variety of terrestrial mammal data sources indicate that TSs up to 40 to 50 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for TS to prevent PTS (Ward et al., 1958, 1959; Ward, 1960; Miller et al., 1963; Kryter et al., 1966). A conservative assumption is that continuous-type exposures producing TSs of 40 dB or more always result in some amount of PTS.

The TTS growth rate as a function of exposure EL is nonlinear; the growth rate at small amounts of TTS is less than the growth rate at larger amounts of TTS. In other words, the curve relating TTS and EL is not a straight line but a curve that becomes steeper as EL and TTS increase. This means that the relatively small amounts of TTS produced in marine mammal studies limit the applicability of these data to estimate the TTS growth rate — since the amounts of TTS are generally small the TTS growth rate estimates would likely be too low. Fortunately, data exist for the growth of TTS in terrestrial mammals at higher amounts of TTS. Data from Ward et al. (1958, 1959) reveal a linear relationship between TTS and exposure EL with growth rates of 1.5 to 1.6 dB TTS per dB increase in EL. Since there is a 34 dB TS difference between onset-TTS (6 dB) and onset-PTS (40 dB), the additional exposure above onset-TTS that is required to reach PTS would be 34 dB divided by 1.6 dB/dB, or approximately 20 dB. Therefore, exposures with ELs 20 dB above those producing TTS may be assumed to produce a PTS. For an onset-TTS exposure with EL = 195 dB re 1 μPa^2-s, the estimate for onset-PTS would be 215 dB re 1 μPa^2-s. This extrapolation process and the resulting TTS prediction is identical to that recently proposed by a panel of scientific experts formed to study the effects of sound on marine mammals (Southall et al., 2007). The method predicts larger (worse) effects than have actually been observed in tests on a bottlenose dolphin (Schlundt et al. [2006] reported a TTS of 23 dB [no PTS] in a bottlenose dolphin exposed to a 3 kHz tone with an EL = 217 dB re 1 μPa^2-s).

5.2.1.3.1.4 Auditory trauma

Auditory trauma represents 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. The potential for trauma is related to the frequency, duration, onset time, and received sound pressure as well as the sensitivity of the animal to the sound frequencies. Because of these interactions, the potential for auditory trauma will vary among species. Auditory trauma is always injurious, but could be temporary and not result in permanent hearing loss. Auditory trauma is always assumed to result in a stress response.

Relatively little is known about auditory system trauma in marine mammals resulting from known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5000 kg explosive (Ketten et al., 1993). The exact magnitude of the exposure in this study cannot be determined and it is possible that the trauma was caused by the shock wave produced by the explosion (which would not be generated by a sonar). There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonars.

5.2.1.3.2 Non-auditory system response

Potential impacts to tissues other than those related to the auditory system are assessed by considering the characteristics of the sound (e.g., amplitude, frequency, duration) and the known or estimated response characteristics of non-auditory tissues. Some of these assessments can be numerically based (e.g., exposure required for rectified diffusion). Others will be necessarily qualitative, due to lack of information on the mechanical properties of the tissues and their function. Each of the potential responses may or may not result in a stress response.

5.2.1.3.2.1 Direct tissue effects

Direct tissue responses to sound stimulation may range from tissue trauma (injury) to mechanical vibration with no resulting injury. Any tissue injury would produce a stress response whereas non-injurious stimulation may or may not.

Resonance is a phenomenon that exists when an object is vibrated at a frequency near its natural frequency of vibration – the particular frequency at which the object vibrates most readily. The size and geometry of an air cavity determine the frequency at which the cavity will resonate. Displacement of the cavity boundaries during resonance has been suggested as a cause of injury. Large displacements have the potential to tear tissues that surround the air space (for example, lung tissue).

Understanding resonant frequencies and the susceptibility of marine mammal air cavities to resonance is important in determining whether certain sonars have the potential to affect different cavities in different species. In 2002, NMFS convened a panel of government and private scientists to address this issue (NOAA, 2002b). They modeled and evaluated the likelihood that Navy mid-frequency sonars caused resonance effects in beaked whales that eventually led to their stranding (DoC and DoN, 2001). The conclusions of that group were that resonance in air-filled structures was not likely to have caused the Bahamas stranding (NOAA, 2002b). The frequencies at which resonance was predicted to occur were below the frequencies utilized by the sonar systems employed. Furthermore, air cavity vibrations, even at resonant frequencies, were not considered to be of sufficient amplitude to cause tissue damage, even under the worst-case scenario in which air volumes would be undamped by surrounding tissues and the amplitude of the resonant response would be maximal. These same conclusions would apply to other actions involving mid-frequency tactical sonar.

5.2.1.3.2.2 Indirect tissue effects

Based upon the amplitude, frequency, and duration of the sound, it must be assessed whether exposure is sufficient to indirectly affect tissues. For example, one 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. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs; (2) bubbles develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury); or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based upon 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 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 supersaturation (Houser et al., 2001b). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness (DCS).

It is unlikely that the short duration of sonar pings would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs; however, an alternative but related hypothesis has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario the marine mammal would need to be in a gas-supersaturated state for a long enough period of time for bubbles to become of a problematic size.

Recent research with *ex vivo* supersaturated tissues suggested that sound exposures of ~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 10 m (33 ft) of the sonar dome to be exposed to such sound levels. Furthermore, tissues were supersaturated by exposing them to pressures of 400-700 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 400-700%. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al., 2001b). It is improbable that this mechanism is 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.

Yet another hypothesis has speculated that rapid ascent to the surface following exposure to a startling sound might produce tissue gas saturation sufficient for the evolution of nitrogen bubbles (Jepson et al., 2003; Fernandez et al., 2005). This is accounted for in the conceptual framework via a feedback path from the behavioral changes of “diving” and “avoidance” to the “indrect tissue response” block. 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 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 et al., 2007). Recently, Tyack et al. (2006) suggested that emboli observed in animals exposed to mid-frequency range sonar (Jepson et al., 2003; Fernandez et al., 2005) could stem instead from a behavioral response that involves repeated dives shallower than the depth of lung collapse. Given that nitrogen gas accumulation is a passive process (i.e. nitrogen is metabolically inert), a bottlenose dolphin was trained to repetitively dive a profile predicted to elevate nitrogen saturation to the point that nitrogen bubble formation was predicted to occur. However, inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of even asymptomatic nitrogen gas bubbles (Houser, 2007).

There is considerable disagreement among scientists as to the likelihood of this phenomenon (Piantadosi and Thalmann, 2004; Evans and Miller, 2004). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Jepson et al., 2003; Fernandez et al., 2005), 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 has demonstrated the post-mortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al., 1980).

Additionally, the fat embolic syndrome identified by Fernández et al. (2005) is the first of its kind. The pathogenesis of fat emboli formation is as yet undetermined and remains largely unstudied, and it would therefore be inappropriate to causally link it to nitrogen bubble formation. Because evidence of nitrogen bubble formation following a rapid ascent by beaked whales is arguable and requires further investigation, this LOA makes no assumptions about it being the causative mechanism in beaked whale strandings associated with sonar operations. No similar findings to those found in beaked whales stranding coincident with sonar activity have been reported in other stranded animals following known exposure to sonar operations. By extension, no marine mammals addressed in this LOA are given differential treatment due to the possibility for acoustically mediated bubble growth.

5.2.1.3.2.3 No tissue effects

The received sound is insufficient to cause either direct (mechanical) or indirect effects to tissues. No stress response occurs.

5.2.1.3.3 The stress response

The acoustic source is considered a potential stressor if by its action on the animal, via auditory or non-auditory means, it may produce a stress response in the animal. The term “stress” has taken on an ambiguous meaning in the scientific literature, but with respect to the conceptual framework and discussions of allostasis and allostatic loading in this LOA, the stress response will refer to an increase in energetic expenditure that results from exposure to the stressor and which is predominantly characterized by either the stimulation of the sympathetic nervous system (SNS), the hypothalamic-pituitary-adrenal (HPA) axis (Reeder and Kramer, 2005), or through oxidative stress, as occurs in noise-induced hearing loss (Henderson et al., 2006). The SNS response to a stressor is immediate and acute and is characterized by the release of the catecholamine neurohormones norepinephrine and epinephrine (i.e., adrenaline). These hormones produce elevations in the heart and respiration rate, increase awareness, and increase the availability of glucose and lipid for energy. The HPA response is ultimately defined by increases in the secretion of the glucocorticoid steroid hormones (e.g. cortisol, aldosterone). The amount of increase in circulating glucocorticoids above baseline may be an indicator of the overall severity of a stress response (Hennessy et al., 1979). Each component of the stress response is variable in time; e.g., adrenalines are released almost immediately and are used or cleared by the system quickly, whereas glucocorticoid levels may take long periods of time to return to baseline.

The presence and magnitude of a stress response in an animal depends on a number of factors. These include the animal's life history stage (e.g., neonate, juvenile, adult), the environmental conditions, reproductive or developmental state, and experience with the stressor. Not only will these factors be subject to individual variation, but they will also vary within an individual over time. 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). In considering potential stress responses of marine mammals to acoustic stressors, each of these should be considered. For example, is the acoustic stressor in an area where animals engage in breeding activity? Are animals in the region resident and likely to have experience with the stressor (i.e., repeated exposures)? Is the region a foraging ground or are the animals passing through it transients? What is the ratio of young (naïve) to old (experienced) animals in the population? It is unlikely that all such questions can be answered from empirical data; however, they should be addressed in any qualitative assessment of a potential stress response as based on the available literature.

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 conspecifics, 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; e.g., chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), has been 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 above and beyond those that occur naturally. Potential stressors resulting from anthropogenic activities must be considered not only as to their direct impact on the animal but also as to their cumulative impact with environmental stressors already experienced by the animal.

Studies on the stress response of odontocete cetaceans to acute acoustic stimuli were previously discussed (**Section 5.2.1.3.1**; Thomas et al., 1990; Miksis et al., 2001; Romano et al., 2004). 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. Pursuit, capture, and short-term holding of belugas have been observed to result in a decrease in thyroid hormones (St. Aubin and Geraci, 1988) and increases in epinephrine (St. Aubin and Dierauf, 2001). In dolphins the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (St. Aubin et al., 1996; Ortiz and Worthy, 2000; St. Aubin, 2002). Elephant seals demonstrate an acute cortisol response to handling, but do not demonstrate a chronic reponse; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al., 2002). With respect to anthropogenic sound as a stressor, the current limited body of knowledge will require extrapolation from species for which information exists to those for which no information exists.

The stress response may or may not result in a behavioral change, depending on the characteristics of the sound and the experience, gender and life history stage of the exposed animal; however, provided a stress response occurs, it is assumed that some contribution is made to the animal's allostatic load. Allostasis is the ability of an animal to maintain stability through change by adjusting its physiology in response to both predictable and unpredictable events (McEwen and Wingfield, 2003). The same hormones associated with the stress response vary naturally throughout an animal's life providing support for particular life history events (e.g., pregnancy) and predictable environmental conditions (e.g., seasonal changes). The allostatic load is the cumulative cost of allostasis incurred by an animal and is generally characterized with respect to an animal's energetic expenditure. Perturbations to an animal which may occur with the presence of a stressor, either biological (e.g., predator) or anthropogenic (e.g., construction), can contribute to the allostatic load (Wingfield, 2003). Additional costs are cumulative and additions to the allostatic load over time may contribute to reductions in the probability of achieving ultimate life history functions (e.g., survival, maturation, reproductive effort and success) by producing pathophysiological states. The contribution to the allostatic load from a stressor requires estimating the magnitude and duration of the stress response as well as any secondary contributions that might result from a change in behavior (*see below*).

If the acoustic source does not produce tissue effects, is not perceived by the animal, or does not produce a stress response by any other means, the conclusion from within the conceptual framework is that the exposure does not contribute to the allostatic load. Additionally, without a stress response or auditory masking, it is assumed that there is no change in behavior. Conversely, any immediate effect of exposure that produces an injury (i.e., red boxes on the flow chart) or auditory fatigue is assumed, within this LOA, to also produce a stress response and to contribute to the allostatic load.

5.2.1.3.4 Behavior block

Acute stress responses may or may not result in a behavioral reaction; however, all changes in behavior are expected to result from an acute stress response. This expectation is conservatively based on the assumption that some form of physiological trigger must exist for an anthropogenic stimulus to alter a biologically significant behavior that is already being performed. The exception to this rule is the case of masking. The presence of a masking sound may not produce a stress response, but may interfere with the animal's ability to detect and discriminate biologically relevant signals. The inability to detect and discriminate biologically relevant signals hinders the potential for normal behavioral responses to auditory cues and is thus considered a behavioral change (see **Section 5.2.1.3.1.3**).

Numerous behavioral changes can occur as a result of stress responses resulting from acoustic exposure and the flow chart lists only those that might be considered the most common types of response for a marine animal. For each potential behavioral change, the magnitude of the change and the severity of the response need to be estimated. Certain conditions, such as a flight response, might have a probability of resulting in injury. For example, a flight response, if significant enough, could lead to a stranding event. Under the MMPA such an event precipitated by anthropogenic noise would be considered a Level A harassment (see **Section 5.2.2.1**). Each altered behavior may also have the potential to disrupt biologically significant events (e.g. breeding or nursing) and may need to be qualified as Level B harassment (see **Section 5.2.2.1**). All behavioral disruptions also have the potential to contribute to the allostatic load. This secondary potential is signified by the feedback from the collective behaviors to allostatic loading (Physiology block).

The response of a marine mammal to an anthropogenic sound source will depend on the frequency content, 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 direction of the responses can vary, with some changes resulting in either increases or decreases from baseline (e.g., decreased dive times and increased respiration rate). Responses can also 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 ecology of individual species is unlikely to completely overlap.

A review of marine mammal responses to anthropogenic sound was first conducted by Richardson and others in, 1995. A more recent review (Nowacek et al., 2007) addresses studies conducted since, 1995 and focuses on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated. The following sections provide a very brief overview of the state of knowledge of behavioral responses as they are listed in **Figure 5-1**. The overviews focus on studies conducted since 2000 but are not meant to be comprehensive; rather, they provide an idea of the variability in behavioral responses that would be expected given the differential sensitivities of marine mammal species to sound and the wide range of potential acoustic sources to which a marine mammal may be exposed. Estimates of the types of behavioral responses that could occur for a given sound exposure should be determined from the literature that is available for each species or extrapolated from closely related species when no information exists.

<u>Flight Response</u>**–**A flight response is a dramatic change in normal movement to a directed and rapid movement away from the perceived location of a sound source. Relatively little information on flight responses of marine mammals to anthropogenic signals exists, although observations of flight responses to the presence of predators have occurred (Connor and Heithaus, 1996). Flight responses have been speculated as being a component of marine mammal strandings associated with sonar activities (Evans and England, 2001).

<u>Response to Predator</u>–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 or not 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.

<u>Diving</u>–Changes in dive behavior can vary widely. They may consist of increased or decreased dive times and surface intervals as well as changes in the rates of ascent and descent during a dive. Variations in dive behavior may reflect interruptions in biologically significant activities (e.g., foraging) or they may be of little biological significance. Variations in dive behavior may also expose an animal to potentially harmful conditions (e.g., increasing the chance of ship-strike) or may serve as an avoidance response that enhances survivorship. The impact of a variation in diving resulting from an acoustic exposure depends on what the animal is doing at the time of the exposure and the type and magnitude of the response.

Nowacek et al. (2004) reported disruptions of dive behaviors in foraging North Atlantic right whales when exposed to an alerting stimulus, an action, they noted, that could lead to an increased likelihood of ship strike; however, the whales did not respond to playbacks of either rigtht whale social sounds or vessel noise, highlighting the importance of the sound characteristics in producing a behavioral reaction.

Conversely, Indo-Pacific humpback dolphins have been observed to dive for longer periods of time in areas where vessels were present and/or approaching (Ng and Leung, 2003). In both of these studies, the influence of the sound exposure cannot be decoupled from the physical presence of a surface vessel, thus complicating intepretations of the relative contribution of each stimulus to the response. Indeed, the presence of surface vessels, their approach and speed of approach, seemed to be significant factors in the response of the Indo-Pacific humpback dolphins (Ng and Leung, 2003). Low-frequency signals of the Acoustic Thermometry of Ocean Climate (ATOC) 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). They did, however, produce subtle effects that varied in direction and degree among the individual seals, illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Due to past incidents of beaked whale strandings associated with sonar operations, feedback paths are provided between avoidance and diving and indirect tissue effects. This feedback accounts for the hypothesis that variations in diving behavior and/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). Although hypothetical, the potential process is currently popular and controversial; see **Section 5.2.1.3.2.2** for a treatment of this issue.

<u>Foraging</u>–Disruption of feeding behavior can be difficult to correlate with anthropogenic sound exposure, so it is usually inferred by observed displacement from known foraging areas, the appearance of

secondary indicators (e.g., bubble nets or sediment plumes), or changes in dive behavior. Noise from seismic surveys was not found to impact the feeding behavior in western grey whales off the coast of Russia (Yazvenko et al., 2007) and sperm whales engaged in foraging dives did not abandon dives when exposed to distant signatures of seismic airguns (Madsen et al., 2006). Balaenopterid whales exposed to moderate low-frequency signals similar to the ATOC sound source demonstrated no variation in foraging activity (Croll et al., 2001), whereas five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives (Nowacek et al., 2004). Although the received sound pressure level at the animals was similar in the latter two studies, the frequency, duration, and temporal pattern of signal presentation were different. These factors, as well as differences in species sensitivity, are likely contributing factors to the differential response. A determination of whether foraging disruptions incur fitness consequences will require information on or estimates of the energetic requirements of the individuals and the relationship between prey availability, foraging effort and success, and the life history stage of the animal.

Breathing–Variations in respiration naturally vary with different behaviors and variations in respiration rate as a function of acoustic exposure can be expected to co-occur with other behavioral reactions, such as a flight response or an alteration in diving. However, respiration rates in and of themselves may be representative of annoyance or an acute stress response. Mean exhalation rates of gray whales at rest and while diving were found to be unaffected by seismic surveys conducted adjacent to the whale feeding grounds (Gailey et al., 2007). Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms (Kastelein et al., 2001; Kastelein et al., 2006b) and emissions for underwater data transmission (Kastelein et al., 2005). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al., 2006b), again highlighting the importance in understanding species differences in the tolerance of underwater noise when determining the potential for impacts resulting from anthropogenic sound exposure.

Social relationships–Social interactions between mammals can be affected by noise via the disruption of communication signals or by the displacement of individuals. Disruption of social relationships therefore depends on the disruption of other behaviors (e.g., caused avoidance, masking, etc.) and no specific overview is provided here; however, social disruptions must be considered in context of the relationships that are affected. Long-term disruptions of mother/calf pairs or mating displays have the potential to affect the growth and survival or reproductive effort/success of individuals, respectively.

Vocalizations–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. Changes may result in response to a need to compete with an increase in background noise or may reflect an increased vigilance or startle response. For example, in the presence of low-frequency active (LFA) sonar, humpback whales have been observed to increase the length of their ‘songs’ (Miller et al., 2000; Fristrup et al., 2003), possibly due to the overlap in frequencies between the whale song and the LFA sonar. A similar compensatory effect for the presence of low-frequency vessel noise has been suggested for right whales; right whales have been 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). Killer whales off the northwestern coast of the U.S. have been observed to increase the duration of primary calls once a threshold in observing vessel density (e.g., whale watching) was reached, which has been suggested as a response to increased masking noise produced by the vessels (Foote et al., 2004). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test (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.

Avoidance–Avoidance is the displacement of an individual from an area as a result of the presence of a sound. It is qualitatively different from the flight response, but differs in the magnitude of the response (i.e., directed movement, rate of travel, etc.). Oftentimes avoidance is temporary, and animals return to the area once the noise has ceased. Longer term displacement is possible, however, which 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 (Blackwell et al., 2004; Bejder et al., 2006; Teilmann et al., 2006). Acute avoidance responses have been observed in captive porpoises and pinnipeds exposed to a number of different sound sources (Kastelein et al., 2001; Finneran et al., 2003; Kastelein et al., 2006b; Kastelein et al., 2006a). Short term avoidance of seismic surveys, low-frequency emissions, and acoustic deterrants has also been noted in wild populations of odontocetes (Bowles et al., 1994; Goold, 1996, 1998; Stone et al., 2000; Morton and Symonds, 2002) and to some extent in mysticetes (Gailey et al., 2007), while longer term or repetitive/chronic displacement for some dolpin groups and for manatees has been suggested to be due to the presence of chronic vessel noise (Haviland-Howell et al., 2007; Miksis-Olds et al., 2007).

<u>Orientation</u>–A shift in an animal's resting state or an attentional change via an orienting response represent behaviors that would be considered mild disruptions if occurring alone, and thus are placed at the bottom of the framework behavior list. As previously mentioned, the responses may co-occur with other behaviors – e.g. an animal may initially orient toward a sound source, and then move away from it. Thus, any orienting response should be considered in context of other reactions that may occur.

5.2.1.3.5 Life function

Proximate life history functions are the functions that the animal is engaged in at the time of acoustic exposure. The disruption of these functions, and the magnitude of the disruption, must be considered in determining how the ultimate life history functions are affected. Consideration of the magnitude of the impact to each of the proximate life history functions depends on the life stage of the animal. For example, an animal on a breeding ground which is sexually immature will suffer relatively little consequence to disruption of breeding behavior when compared to an actively displaying adult of prime reproductive age.

The ultimate life functions are those which enable an animal to contribute to the population (or stock, or species, etc.) and which relate to the animal's *fitness* (see **Section 5.2.2.2**). The impact to ultimate life functions will depend on the nature and magnitude of the perturbation to proximate life history functions. Depending on the severity of the response to the stressor, acute perturbations may have nominal to profound impacts on ultimate life functions. Assessment of the magnitude of the stress response from a chronic perturbation would require an understanding of how and whether animals acclimate to a specific, repeated stressor and whether a chronic stress response occurs and results in subsequent fitness deficits.

The proximate life functions are loosely ordered in decreasing severity of impact. Mortality (Survival) has an immediate impact in that no future reproductive success is feasible and there is no further addition to the population resulting from reproduction. Severe injuries may also lead to reduced survivorship (longevity) and prolonged alterations in behavior. The latter may further affect an animal's overall reproductive success and reproductive effort. Disruptions of breeding have an immediate impact on reproductive effort and may impact reproductive success. The magnitude of the effect will depend on the duration of the disruption and the type of behavior change that was provoked. Disruptions to feeding and migration can affect all of the ultimate life functions; however, the impacts to reproductive effort and success are not likely to be as severe or immediate as those incurred by mortality and breeding disruptions.

5.2.2 The Regulatory Framework

To complete the acoustic effects analysis, the **conceptual framework** (**Section 5.2.1**) must be related to the existing **regulatory frameworks** of the MMPA. The following sections describe the relationship between analyses conducted within the conceptual framework and regulations established by the MMPA.

MMPA Harassment

For military readiness activities, **MMPA Level A harassment** includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury, as defined in this LOA and previous rulings (NOAA, 2001, 2002a), is the destruction or loss of biological tissue.

Consistent with prior actions and rulings (NOAA, 2001), this LOA assumes that all injuries (slight to severe) are considered Level A harassment under the MMPA.

For military readiness activities, **MMPA Level B harassment** includes all actions that disturb or are likely to disturb a marine mammal or marine mammal stock in the wild through the 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.

Some physiological responses to sound exposure can occur that are non-injurious but that can potentially disrupt the behavior of a marine mammal. These include temporary distortions in sensory tissue that alter physiological function, but that are fully recoverable without the requirement for tissue replacement or regeneration. For example, an animal that experiences a TTS suffers no injury to its auditory system, but may not perceive some sounds due to the reduction in sensitivity. As a result, the animal may not respond to sounds that would normally produce a behavioral reaction. This lack of response qualifies as a temporary disruption of normal behavioral patterns – the animal is impeded from responding in a normal manner to an acoustic stimulus. This LOA assumes that all TTS (slight to severe) is considered Level B harassment, even if the effect from the temporary impairment is biologically insignificant.

The harassment status of slight behavior disruption (without physiological effects as defined in this LOA) has been addressed in workshops, previous actions, and rulings (NOAA, 1999, 2001; DoN 2001a). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic event does not qualify as Level B harassment. A more general conclusion, that Level B harassment occurs only when there is "a potential for a significant behavioral change or response in a biologically important behavior or activity," is found in recent rulings (NOAA, 2002a). Public Law (PL) 108-136 (2004) amended the definition of Level B harassment for military readiness activities, which applies to this action. For military readiness activities, Level B harassment is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns…to a point where such behaviors are abandoned or significantly altered." These conclusions and definitions, including the 2004 amendments to the definitions of harassment, were considered in the context of the proposed use of an offshore USWTR in developing conservative thresholds for behavioral disruptions, as presented in **Section 5.2.3.2**. As a result, the actual incidental harassment of marine mammals associated with this action may be less than calculated.

The volumes of ocean in which Level A and Level B harassment are predicted to occur are described as **harassment zones**. The **Level A harassment zone** extends from the source out to the distance and exposure at which the slightest amount of injury is predicted to occur. The acoustic exposure that produces the slightest degree of injury is therefore the threshold value defining the outermost limit of the Level A harassment zone. Use of the threshold associated with the onset of slight injury as the most distant point and least injurious exposure takes account of all more serious injuries by inclusion within the Level A harassment zone. The threshold used to define the outer limit of the Level A harassment zone is given in **Section 5.2.3.1**. The **Level B harassment zone** begins just beyond the point of slightest injury and extends outward from that point to include all animals with the potential to experience Level B harassment. The animals predicted to be in the portion of the zone where temporary impairment of sensory function (altered physiological function) is expected are all assumed to experience Level B harassment because of the potential impediment of behaviors that rely on acoustic cues. Beyond that distance, the Level B harassment zone continues to the point at which no behavioral disruption is expected to occur. The criterion and threshold used to define the outer limit of the Level B harassment zone are given in **Section 5.2.3.2**.

Because the tissues of the ear appear to be the most susceptible to the physiological effects of sound and TSs tend to occur at lower exposures than other more serious auditory effects, **PTS and TTS are used in this LOA as biological indicators of physiological responses that qualify as harassment**.

PTS is non-recoverable and, by definition, must result from the destruction of tissues within the auditory system. In this LOA, the smallest amount of PTS (onset-PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with **onset-PTS is used to define the outer limit of the Level A harassment zone**.

TTS is recoverable and, as in recent rulings (NOAA, 2001, 2002a), is considered to result from the temporary, non-injurious distortion of hearing-related tissues. In this LOA, the smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered non-injurious, the acoustic exposure associated with **onset-TTS is used to define the outer limit of the portion of the Level B harassment zone attributable to a physiological impairment, and within which all animals are assumed to incur Level B harassment**. This follows from the concept that hearing loss potentially affects an animal's ability to react normally to the sounds around it. Therefore, in this LOA the potential for TTS is considered as a Level B harassment that is mediated by a physiological effect upon the auditory system.

At exposure levels below those which can cause TTS, animals may respond to the sound and alter their natural behaviors. Whether or not these alterations result in "a potential for a significant behavioral change or response in a biologically important behavior or activity" depends on the physical characteristics of the sound (e.g., amplitude, frequency characteristics, temporal pattern, duration, etc.) as well as the animal's experience with the sound, the context of the exposure (e.g., what is the animal doing at the time of the exposure), and the animal's life history stage. Responses will be species-specific and must consider the acoustic sensitivity of the species. In this LOA a **risk function (Section 5.2.3.2) is used to determine the outer limit of the portion of the Level B harassment zone attributable to significant changes in biologically important behaviors, but which is not a function of TTS.** The risk function defines a probability of a significant change in biologically important behaviors as a function of the received sound pressure level. This follows from the concept that the probability of a behavioral response will generally decline as a function of decreasing exposure level.

Figure 5-3 (Summary of the Acoustic Effect Framework Used in This LOA) is a visual depiction of the MMPA acoustic effects framework used in this LOA. (This figure is intended to illustrate the general relationships between harassment zones and does not represent the sizes or shapes of the actual harassment zones for this LOA.) The Level A harassment zone extends from the source out to the distance and exposure where onset-PTS is predicted to occur. The Level B harassment zone begins just beyond the point of onset-PTS and extends outward to the distance and exposure where no (biologically significant) behavioral disruption is expected to occur. The Level B harassment zone includes both the region in which TTS is predicted to occur and the region in which significant behavioral responses without TS are predicted to occur. Criteria and thresholds used to define the outer limits of the Level A and Level B harassment zones are given in **Section 5.2.3**.

5.2.3 Criteria and Thresholds for MMPA Harassment

Section 5.2.2 identified the tissues of the ear as being the most susceptible to physiological effects of underwater sound. PTS and TTS were determined to be the most appropriate biological indicators of physiological effects that equate to the onset of injury (Level A harassment) and behavioral disturbance (Level B harassment), respectively. In this LOA, sound exposure thresholds for TTS and PTS are

195 dB re 1 μPa^2-s received EL for TTS

215 dB re 1 μPa^2-s received EL for PTS

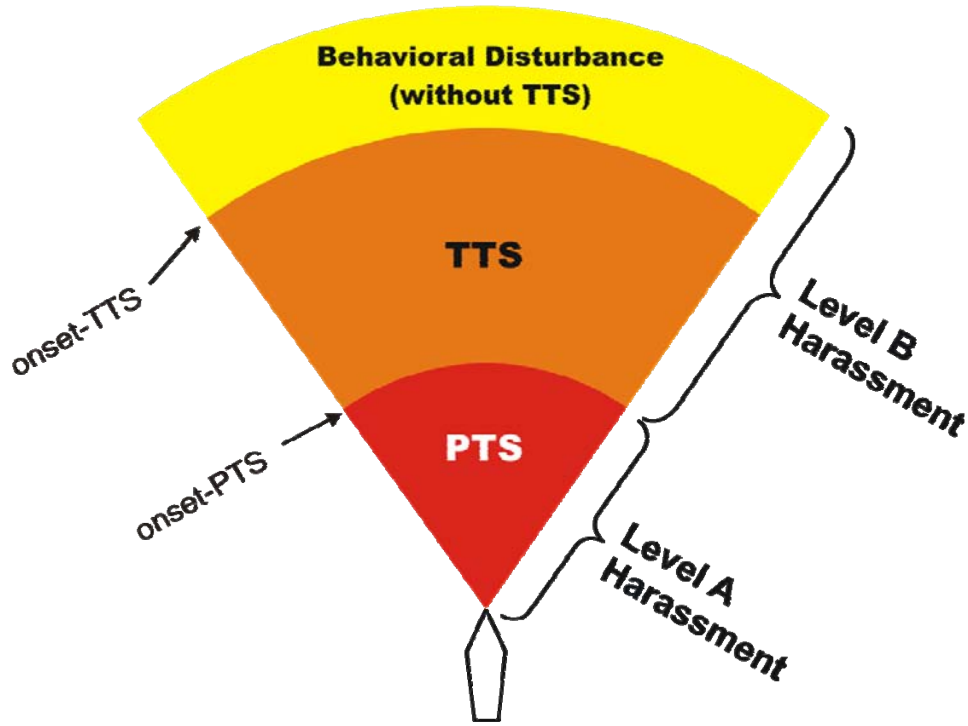

Figure 5-3. Summary of the acoustic effect framework used in this LOA (This figure is intended to illustrate the general relationships between harassment zones and does not represent the sizes or shapes of the actual harassment zones for this LOA.)

A marine mammal predicted to receive a sound exposure with EL of 215 dB re 1 µPa^2-s or greater is assumed to experience PTS and is counted as a Level A harassment. A marine mammal predicted to receive a sound exposure with EL greater than or equal to 195 dB re 1 µPa^2-s but less than 215 dB re 1 µPa^2-s is assumed to experience TTS and is counted as Level B harassment. The only exceptions to this approach are a limited number of species where the predicted sound exposure is not expected to occur, due to significant differences in the expected species presence at a specific USWTR site versus the modeled density inputs for the larger OPAREAs. **Sections 5.2.8** and **5.2.9** contain analyses for each individual species.

Derivation of Effect Threshold

The TTS threshold is primarily based on the cetacean TTS data from Schlundt et al. (2000). Since these tests used short-duration tones similar to sonar pings, they are the most directly relevant data for this LOA. The mean exposure EL required to produce onset-TTS in these tests was 195 dB re 1 µPa^2-s. This result is corroborated by the mid-frequency tone data of Finneran et al. (2005) and Schlundt et al. (2006) and the long-duration noise data from Nachtigall et al. (2003, 2004). Together, these data demonstrate that TTS in cetaceans is correlated with the received EL and that onset-TTS exposures are fit well by an equal-energy line passing through 195 dB re 1 µPa^2-s.

The PTS threshold is based on a 20 dB increase in exposure EL over that required for onset-TTS. The 20 dB value is based on estimates from terrestrial mammal data of PTS occurring at 40 dB or more of TS, and on TS growth occurring at a rate of 1.6 dB/dB increase in exposure EL. This estimate is conservative because (1) 40 dB of TS is actually an upper limit for TTS used to approximate onset-PTS; (2) the 1.6 dB/dB growth rate is the highest observed in the data from Ward et al. (1958, 1959) and larger than that experimentally observed in dolphins; and (3) a bottlenose dolphin exposed to a 3 kHz tone at 217 dB re 1 µPa^2-s experienced only TTS and no permanent effects.

Mysticetes and Odontocetes

Information on auditory function in mysticetes is extremely lacking. Sensitivity to low-frequency sound by baleen whales has been inferred from observed vocalization frequencies, observed reactions to playback of sounds, and anatomical analyses of the auditory system. Baleen whales are estimated to hear from 15 Hz to 20 kHz, with good sensitivity from 20 Hz to 2 kHz (Ketten, 1998). Filter-bank models of the humpback whale's ear have been developed from anatomical features of the humpback's ear and optimization techniques (Houser et al., 2001a). The results suggest that humpbacks are sensitive to frequencies between 40 Hz and 16 kHz, but best sensitivity is likely to occur between 100 Hz and 8 kHz. However, absolute sensitivity has not been modeled for any baleen whale species. Furthermore, there is no indication of what sorts of sound exposure produce threshold shifts in these animals.

The criteria and thresholds for PTS and TTS developed for odontocetes in this LOA are also used for mysticetes. This generalization is based on the assumption that the empirical data at hand are representative of both groups until data collection on mysticete species shows otherwise. For the frequencies of interest in this LOA there is no evidence that the total amount of energy required to induce onset-TTS and onset-PTS in mysticetes is different than that required for odontocetes.

Use of EL for PTS/TTS Thresholds in this LOA

Thresholds for PTS/TTS are expressed in terms of total received EL. Energy flux density is a measure of the flow of sound energy through an area. Marine and terrestrial mammal data show that, for continuous-type sounds (non-impulsive sounds) of interest in this LOA, TTS and PTS are more closely related to the energy in the sound exposure than to the exposure SPL.

The EL for each individual ping is calculated from the following equation:

$$EL = SPL + 10\log_{10}(\text{duration})$$

The EL includes both the ping SPL and duration. Longer-duration pings and/or higher-SPL pings will have a higher EL.

If an animal is exposed to multiple pings, the energy flux density in each individual ping is summed to calculate the total EL. Since mammals exhibit lower TSs from intermittent exposures compared to continuous exposures with the same energy (Ward, 1997), basing the thresholds on the total received EL is a conservative approach for treating multiple pings; in reality, some recovery will occur between pings and lessen the severity of a particular exposure. Therefore, estimates in this LOA are conservative because recovery is not taken into account – intermittent exposures are considered equivalent to continuous exposures.

The total EL depends on the SPL, duration, and number of pings received. The TTS and PTS thresholds do not imply any specific SPL, duration, or number of pings. The SPL and duration of each received ping are used to calculate the total EL and determine whether the received EL meets or exceeds the effect thresholds. For example, the TTS threshold would be reached through any of the following exposures:

- A single ping with SPL = 195 dB re 1 µPa and duration = 1 s

- A single ping with SPL = 192 dB re 1 µPa and duration = 2 s

- Two pings with SPL = 192 dB re 1 µPa and duration = 1 s

- Two pings with SPL = 189 dB re 1 µPa and duration = 2 s

Previous Use of EL for PTS/TTS

Energy measures have been used as a part of dual criteria for cetacean auditory effects in shock trials, which only involve impulsive-type sounds (DoN, 1997, 2001a). These actions used 192 dB re 1 μPa^2-s as a reference point to derive a TTS threshold in terms of EL. A second TTS threshold, based on peak pressure, was also used. If either threshold was exceeded, effect was assumed.

The 192 dB re 1 μPa^2-s reference point differs from the threshold of 195 dB re 1 μPa^2-s used for TTS in this LOA. The 192 dB re 1 μPa^2-s value was based on the minimum observed by Ridgway et al. (1997) and Schlundt et al. (2000) during TTS measurements with bottlenose dolphins exposed to 1-s tones. At the time, no impulsive test data for marine mammals were available and the 1-s tonal data were considered to be the best available. The minimum value of the observed range of 192 to 201 dB re 1 μPa^2-s was used to protect against misinterpretation of the sparse data set available. The 192 dB re 1 μPa^2-s value was reduced to 182 dB re 1 μPa^2-s to accommodate the potential effects of pressure peaks in impulsive waveforms.

The additional data now available for onset-TTS in small cetaceans confirm the original range of values and increase confidence in it (Finneran et al., 2005; Nachtigall et al., 2003, 2004; Schlundt et al., 2006). This LOA, therefore, uses the more complete data available and the mean value of the entire Schlundt et al. (2000) data set (195 dB re 1 μPa^2-s), instead of the minimum of 192 dB re 1 μPa^2-s. The threshold is applied in this LOA as an “all-or-nothing” value, where 100% of animals receiving EL ≥195 dB re 1 μPa^2-s are considered to experience TTS. From the standpoint of statistical sampling and prediction theory, the mean is the most appropriate predictor – the “best unbiased estimator” – of the EL at which onset-TTS should occur; predicting the number of harassment incidents in future actions relies (in part) on using the EL at which onset-TTS will most likely occur. When the EL is applied over many pings in each of many sonar exercises, that value will provide the most accurate prediction of the actual number of harassment incidents by onset-TTS over all of those exercises. Use of the minimum value would overestimate the amount of incidental harassment because many animals counted would not have experienced onset-TTS. Further, there is no logical limiting minimum value of the distribution that would be obtained from continued successive testing. Continued testing and use of the minimum would produce more and more erroneous estimates for the “all-or-nothing” threshold for effect.

5.2.3.1 Summary

In this LOA, PTS and TTS are used as the criteria for physiological effects resulting in injury (Level A harassment) and behavioral disturbance (Level B harassment), respectively. Sound exposure thresholds for TTS and PTS are 195 dB re 1 μPa^2-s received EL for TTS and 215 dB re 1 μPa^2-s received EL for PTS. The TTS threshold is primarily based on cetacean TTS data from Schlundt et al. (2000). Since these tests used short-duration tones similar to sonar pings, they are the most directly relevant data. The PTS threshold is based on a 20 dB increase in exposure EL over that required for onset-TTS. The 20-dB value is based on extrapolations from terrestrial mammal data indicating that PTS occurs at 40 dB or more of TS, and that TS growth occurring at a rate of approximately 1.6 dB/dB increase in exposure EL. The application of the model results to estimate marine mammal harassment for each species is discussed in **Section 5.2.8**.

5.2.3.2 Analytical Methodology – MMPA Behavioral Harassment for MFA/HFA Sources

5.2.3.2.1 Background

Based on available evidence, marine animals are likely to exhibit any of a suite of potential behavioral responses or combinations of behavioral responses upon exposure to sonar transmissions. Potential behavioral responses include, but are not limited to: avoiding exposure or continued exposure; behavioral disturbance (including distress or disruption of social or foraging activity); habituation to the sound; becoming sensitized to the sound; or not responding to the sound.

Existing studies of behavioral effects of human-made sounds in marine environments remain inconclusive, partly because many of those studies have lacked adequate controls, applied only to certain kinds of exposures (which are often different from the exposures being analyzed in the study), and had limited ability to detect behavioral changes that may be significant to the biology of the animals that were being observed. These studies are further complicated by the wide variety of behavioral responses marine mammals exhibit and the fact that those responses can vary significantly by species, individuals, and the context of an exposure. 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., 1995a; Wartzok et al., 2003; Southall et al., 2007). 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.

It is possible that some marine mammal behavioral reactions to anthropogenic sound may result in strandings. Several "mass stranding" events—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. Sonar exposure has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Advisory Committee Report on Acoustic Impacts on Marine Mammals, 2006).

In these circumstances, exposure to acoustic energy has been considered an indirect cause of the death of marine mammals (Cox et al., 2006). Based on studies of lesions in beaked whales that have stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, several investigators have hypothesized that there are two potential physiological mechanisms that might explain why marine mammals stranded: tissue damage resulting from resonance effects (Ketten, 2005) and tissue damage resulting from "gas and fat embolic syndrome" (Fernandez et al., 2005; Jepson et al., 2003; 2005; Zimmer and Tyack, 2007). It is also likely that stranding is a behavioral response to a sound under certain contextual conditions and that the subsequently observed physiological effects of the strandings (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).

5.2.3.2.2 Methodology for applying risk function

Risk Function Adapted from Feller (1968)

The particular acoustic risk function developed by the Navy and NMFS estimates the probability of behavioral responses that NMFS would classify as harassment for the purposes of the MMPA given exposure to specific received levels of MFA sonar. The mathematical function is derived from a solution in Feller (1968) for the probability as defined in the Surveillance Towed Array Sensor System (SURTASS) LFA Sonar Final OEIS/EIS (DoN, 2001c), and relied on in the Supplemental SURTASS LFA Sonar EIS (DoN, 2007d) for the probability of MFA sonar risk for MMPA Level B behavioral harassment with input parameters modified by NMFS for MFA sonar for mysticetes, odontocetes, and pinnipeds.

In order to represent a probability of risk, the function should have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfies this criterion is cumulative probability distributions, a type of cumulative distribution function. In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on areas of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

As described in DoN (2001), the mathematical function below is adapted from a solution in Feller (1968):

$$R = \frac{1-\left(\dfrac{L-B}{K}\right)^{-A}}{1-\left(\dfrac{L-B}{K}\right)^{-2A}}$$

Where R = risk (0 – 1.0);
L = Received Level (RL) in dB;
B = basement RL in dB; (120 dB);
K = the RL increment above basement in dB at which there is 50% risk;
A = risk transition sharpness parameter (explained in **Section 5.2.3.2.4**).

In order to use this function, the values of the three parameters (B, K, and A) need to be established. As further explained in **Section 5.2.3.2.3**, the values used in this analysis are based on three sources of data: TTS experiments conducted at Space and Naval Warfare Systems Center (SSC) and documented in Finneran, et al. (2001, 2003, and 2005; 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 and documented in Department of Commerce (NMFS, 2005a); DoN (2004b); and Fromm (2004a, 2004b); 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). The input parameters, as defined by NMFS, are based on very limited data that represent the best available science at this time.

5.2.3.2.3 Data sources used for risk function

There is widespread consensus that cetacean response to MFA sound signals needs to be better defined using controlled experiments (Cox et al., 2006; Southall et al., 2007). The Navy is contributing to an ongoing behavioral response study in the Bahamas that is anticipated to provide some initial information on beaked whales, the species identified as the most sensitive to MFA sonar. NMFS is leading this international effort with scientists from various academic institutions and research organizations to conduct studies on how marine mammals respond to underwater sound exposures.

Until additional data is available, NMFS and the Navy have determined that the following three data sets are most applicable for the direct use in developing risk function parameters for MFA/HFA sonar. These data sets represent the only known data that specifically relate altered behavioral responses to exposure to MFA sound sources. Until applicable data sets are evaluated to better qualify harassment from HFA sources, the risk function derived for MFA sources will apply to HFA.

Data from SSC's Controlled Experiments

Most of the observations of the behavioral responses of toothed whales resulted from a series of controlled experiments on bottlenose dolphins and beluga whales conducted by researchers at SSC's facility in San Diego, California (Finneran et al., 2001, 2003, 2005; Finneran and Schlundt, 2004; Schlundt et al., 2000). In experimental trials with marine mammals trained to perform tasks when prompted, scientists evaluated whether the marine mammals performed these tasks when exposed 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. (Schlundt et al, 2000, Finneran et al., 2002a) Bottlenose dolphins exposed to 1-s intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa rms, and beluga whales did so at received levels of 180 to 196 dB and above. Test animals sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al., 2002a). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al., 1997; Schlundt et al., 2000).

1. Finneran and Schlundt (2004) examined behavioral observations recorded by the trainers or test coordinators during the Schlundt et al. (2000) and Finneran et al. (2001, 2003, 2005) experiments featuring 1-s tones. These included observations from 193 exposure sessions (fatiguing stimulus level >141 dB re 1µPa) conducted by Schlundt et al. (2000) and 21 exposure sessions conducted by Finneran et al. (2001, 2003, 2005). The observations were made during exposures to sound sources at 0.4 kHz, 3 kHz, 10 kHz, 20 kHz, and 75 kHz. The TTS experiments that supported Finneran and Schlundt (2004) are further explained below:

    a. Schlundt et al. (2000) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at SSC San Diego with 1-s tones. Schlundt et al. (2000) reported eight individual TTS experiments. Fatiguing stimuli durations were 1-sec; exposure frequencies were 0.4 kHz, 3 kHz, 10 kHz, 20 kHz and 75 kHz. The experiments were conducted in San Diego Bay. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise. Schlundt et al. (2000) reported that "behavioral alterations," or deviations from the behaviors the animals being tested had been trained to exhibit, occurred as the animals were exposed to increasing fatiguing stimulus levels.

    b. Finneran et al. (2001, 2003, 2005) conducted TTS experiments using tones at 3 kHz. The test method was similar to that of Schlundt et al. (2000) except the tests were conducted in a pool with very low ambient noise level (below 50 dB referenced to 1 micropascal squared per hertz [dB re 1 µPa^2/Hz]), and no masking noise was used. Two separate experiments were conducted using 1-s tones. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB SPL were randomly presented.

Data from Studies of Baleen (Mysticetes) Whale Responses

The only mysticete data available resulted from a field experiments in which baleen whales (mysticetes) were exposed to a range of frequency sound sources from 500 Hz to 4500 Hz (Nowacek et al., 2004). An alert stimulus, with a mid-frequency component, was the only portion of the study used to support the risk function input parameters.

2. Nowacek et al. (2004, 2007) documented observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components. To assess risk factors involved in ship strikes, a multi-sensor acoustic tag was used to measure the responses of whales to passing ships and experimentally tested their responses to controlled sound exposures, which included recordings of ship noise, the social sounds of conspecifics and a signal designed to alert the whales. The alert signal was 18 min of exposure consisting of three 2-min signals played sequentially three times over. The three signals had a 60% duty cycle and consisted of: (1) alternating 1-s pure tones at 500 Hz and 850 Hz; (2) a 2-s logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)-high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. The purposes of the alert signal were (a) to provoke an action from the whales via the auditory system with disharmonic signals that cover the whales' estimated hearing range; (b) to maximize the signal to noise ratio (obtain the largest difference between background noise) and c) to provide localization cues for the whale. Five out of six whales reacted to the signal designed to elicit such behavior. Maximum received levels ranged from 133 to 148 dB re 1µPa^2/Hz.

Observations of Killer Whales in Haro Strait in the Wild

In May 2003, killer whales (*Orcinus orca*) were observed exhibiting behavioral responses while USS SHOUP was engaged in MFA sonar operations in the Haro Strait in the vicinity of Puget Sound, Washington. Although these observations were made in an uncontrolled environment, the sound field associated with the sonar operations had to be estimated, and the behavioral observations were reported for groups of whales, not individual whales, the observations associated with the USS SHOUP provide the only data set available of the behavioral responses of wild, non-captive animal upon exposure to the AN/SQS-53 MFA sonar.

3. U.S. Department of Commerce (National Marine Fisheries, 2005a); U.S. DoN (2004b); Fromm (2004a, 2004b) documented reconstruction of sound fields produced by USS SHOUP associated with the behavioral response of killer whales observed in Haro Strait. Observations from this reconstruction included an approximate closest approach time which was correlated to a reconstructed estimate of received level at an approximate whale location (which ranged from 150 to 180 dB), with a mean value of 169.3 dB SPL.

Limitations of the Risk Function Data Sources

There are significant limitations and challenges to any risk function derived to estimate the probability of marine mammal behavioral responses; these are largely attributable to sparse data. Ultimately there should be multiple functions for different marine mammal taxonomic groups, but the current data are insufficient to support them. The goal is unquestionably that risk functions be based on empirical measurement.

The risk function presented here is based on three data sets that NMFS and Navy have determined are the best available science at this time. The Navy and NMFS acknowledge each of these data sets has limitations.

While NMFS considers all data sets as being weighted equally in the development of the risk function, the Navy believes the SSC San Diego data is the most rigorous and applicable for the following reasons:

- The data represents the only source of information where the researchers had complete control over and ability to quantify the noise exposure conditions.

- The altered behaviors were identifiable due to long-term observations of the animals.

- The fatiguing noise consisted of tonal exposures with limited frequencies contained in the MFA sonar bandwidth.

However, the Navy and NMFS do agree that the following are limitations associated with the three data sets used as the basis of the risk function:

- The three data sets represent the responses of only four species: trained bottlenose dolphins and beluga whales, North Atlantic right whales in the wild and killer whales in the wild.

- None of the three data sets represent experiments designed for behavioral observations of animals exposed to MFA sonar.

- The behavioral responses of marine mammals that were observed in the wild are based solely on an estimated received level of sound exposure; they do not take into consideration (due to minimal or no supporting data):

    - Potential relationships between acoustic exposures and specific behavioral activities (e.g., feeding, reproduction, changes in diving behavior, etc.), variables such as bathymetry, or acoustic waveguides; or

    - Differences in individuals, populations, or species, or the prior experiences, reproductive state, hearing sensitivity, or age of the marine mammal.

SSC San Diego Trained Bottlenose Dolphins and Beluga Data Set

- The animals were trained animals in captivity; therefore, they may be more or less sensitive than cetaceans found in the wild (Domjan, 1998).

- The tests were designed to measure TTS, not behavior.

- Because the tests were designed to measure TTS, the animals were exposed to much higher levels of sound than the baseline risk function (only two of the total 193 observations were at levels below 160 dB re 1 μPa^2-s).

- The animals were not exposed in the open ocean but in a shallow bay or pool.

    - o The tones used in the tests were 1-second pure tones similar to MFA sonar.

North Atlantic Right Whales in the Wild Data Set

- The observations of behavioral response were from exposure to alert stimuli that contained mid-frequency components but was not similar to an MFA sonar ping. The alert signal was 18 minutes of exposure consisting of three 2-minute signals played sequentially three times over. The three signals had a 60 percent duty cycle and consisted of: (1) alternating 1-sec pure tones at 500 Hz and 850 Hz; (2) a 2-sec logarithmic down-sweep from 4,500 Hz to 500 Hz; and (3) a pair of low (1,500 Hz)-high (2,000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. This 18-minute alert stimuli is in contrast to the average 1-sec ping every 30 sec in a comparatively very narrow frequency band used by military sonar.

- The purpose of the alert signal was, in part, to provoke an action from the whales through an auditory stimulus.

Killer Whales in the Wild Data Set

- The observations of behavioral harassment were complicated by the fact that there were other sources of harassment in the vicinity (other vessels and their interaction with the animals during the observation).

- The observations were anecdotal and inconsistent. There were no controls during the observation period, with no way to assess the relative magnitude of the observed response as opposed to baseline conditions.

5.2.3.2.4 Input parameters for the feller-adapted risk function

The values of B, K, and A need to be specified in order to utilize the risk function defined in **Section 5.2.3.2.2**. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment. In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on an exposed population.

Basement Value for Risk—The B Parameter

The B parameter defines the basement value for risk, below which the risk is so low that calculations are impractical. This 120 dB level is taken as the estimate received level (RL) below which the risk of significant change in a biologically important behavior approaches zero for the MFA sonar risk assessment. This level is based on a broad overview of the levels at which multiple species have been reported responding to a variety of sound sources, both mid-frequency and other, was recommended by the scientists, and has been used in other publications. The Navy recognizes that for actual risk of changes in behavior to be zero, the signal-to-noise ratio of the animal must also be zero.

The K Parameter

NMFS and the Navy used the mean of the following values to define the midpoint of the function: (1) the mean of the lowest received levels (185.3 dB) at which individuals responded with altered behavior to 3 kHz tones in the SSC data set; (2) the estimated mean received level value of 169.3 dB produced by the reconstruction of the USS SHOUP incident in which killer whales exposed to MFA sonar (range modeled possible RLs: 150 to 180 dB); and (3) the mean of the 5 maximum RLs at which Nowacek et al. (2004) observed significantly altered responses of right whales to the alert stimuli than to the control (no input signal) is 139.2 dB SPL. The arithmetic mean of these three mean values is 165 dB SPL. The value of K is the difference between the value of B (120 dB SPL) and the 50% value of 165 dB SPL; therefore, K=45.

Risk Transition—The A Parameter

T he A parameter controls how rapidly risk transitions from low to high values with increasing receive level. As A increases, the slope of the risk function increases. For very large values of A, the risk function can approximate a threshold response or step function. NMFS has recommended that Navy use A=10 as the value for odontocetes, and pinnipeds, and A=8 for mysticetes, (**Figures 5-4** and **5-5**) (National Marine Fisheries Service, 2008).

Justification for the Steepness Parameter of A=10 for the Odontocete Curve

The NMFS used an independent review process described in DoN (2008) to provide the impetus for the selection of the parameters for the risk function curves. One scientist recommended staying close to the risk continuum concept as used in the SURTASS LFA sonar EIS. This scientist opined that both the basement and slope values; B=120 dB and A=10 respectively, from the SURTASS LFA sonar risk continuum concept are logical solutions in the absence of compelling data to select alternate values supporting the Feller-adapted risk function for MFA sonar. Another scientist indicated a steepness parameter needed to be selected, but did not recommend a value. Four scientists did not specifically address selection of a slope value. After reviewing the six scientists' recommendations, the two NMFS scientists recommended selection of A=10. Direction was provided by NMFS to use the A=10 curve for odontocetes based on the scientific review of potential risk functions explained in **Section** 5.2.3.2.

As background, a sensitivity analysis of the A=10 parameter was undertaken and presented in Appendix D of the SURTASS/LFA FEIS (DoN, 2001c). The analysis was performed to support the A=10 parameter for mysticete whales responding to a low-frequency sound source, a frequency range to which the mysticete whales are believed to be most sensitive to. The sensitivity analysis results confirmed the increased risk estimate for animals exposed to sound levels below 165 dB. Results from the Low Frequency Sound Scientific Research Program (LFS SRP) phase II research showed that whales (specifically gray whales in their case) did scale their responses with received level as supported by the A=10 parameter (Buck and Tyack, 2000). In the second phase of the LFS SRP research, migrating gray whales showed responses similar to those observed in earlier research (Malme et al., 1983, 1984) when the low-frequency source was moored in the migration corridor (2 km [1.1 NM] from shore). The study extended those results with confirmation that a louder SL elicited a larger scale avoidance response; however, when the source was placed offshore (4 km [2.2 NM] from shore) of the migration corridor, the avoidance response was not evident. This implies that the inshore avoidance model – in which 50% of the whales avoid exposure to levels of 141±3 dB – may not be valid for whales in proximity to an offshore source (DoN, 2001c). As concluded in the SURTASS LFA Sonar Final OEIS/EIS (DoN, 2001c), the value of A=10 produces a curve that has a more gradual transition than the curves developed by the analyses of migratory gray whale studies (Malme et al., 1984; Buck and Tyack, 2000; and SURTASS LFA Sonar EIS, Subchapters 1.43, 4.2.4.3 and Appendix D, and National Marine Fisheries Service, 2008).

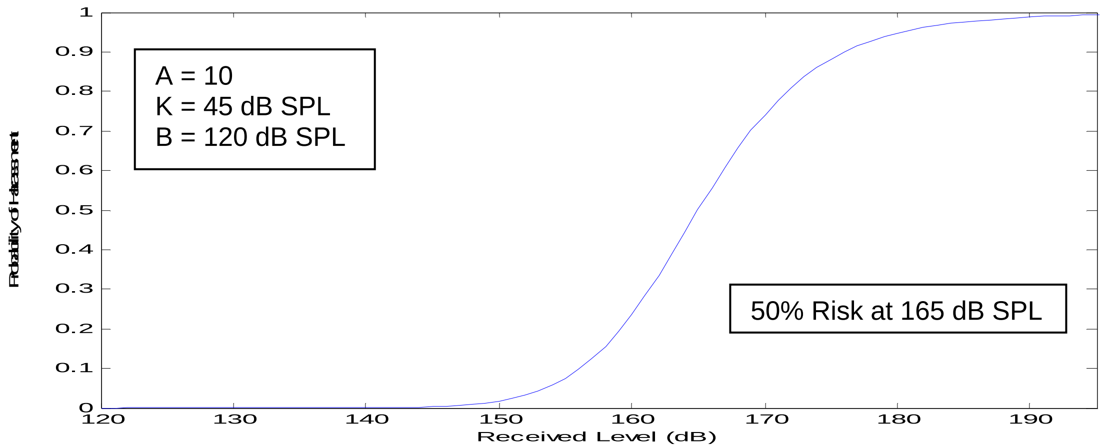

Figure 5-4. Risk function curve for Odontocetes (except harbor porpoises) (toothed whales) and pinnipeds.

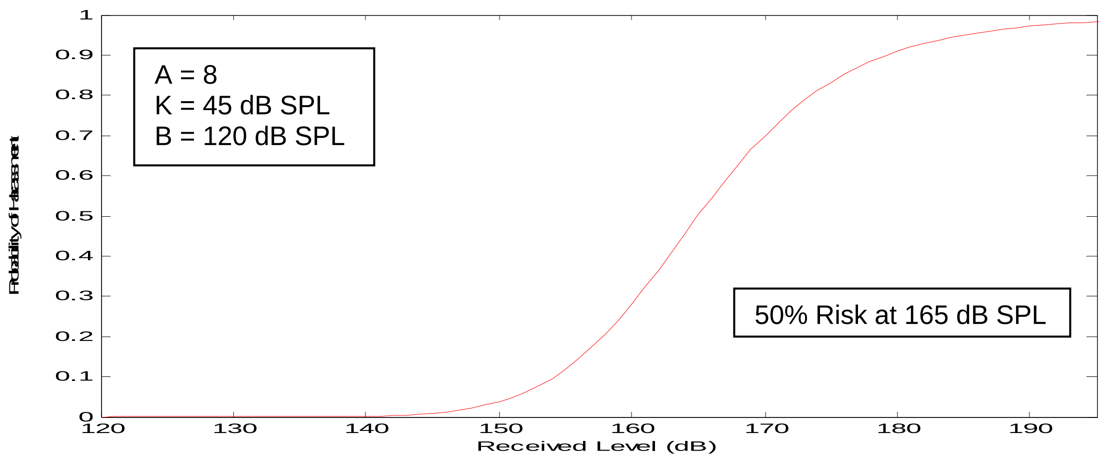

Figure 5-5. Risk function curve for Mysticetes (Baleen Whales).

Justification for the Steepness Parameter of A=8 for the Mysticete Curve

The Nowacek et al. (2004) study provides the only available data source for a mysticete species behaviorally responding to a sound source (*i.e*., alert stimuli) with frequencies in the range of tactical mid-frequency sonar (1-10 kHz), including empirical measurements of RLs. While there are fundamental differences in the stimulus used by Nowacek et al. (2004) and tactical mid-frequency sonar (*e.g.*, source level, waveform, duration, directionality, likely range from source to receiver), they are generally similar in frequency band and the presence of modulation patterns. Thus, while they must be considered with caution in interpreting behavioral responses of mysticetes to mid-frequency sonar, they seemingly cannot be excluded from this consideration given the overwhelming lack of other information. The Nowacek et al. (2004) data indicate that five out the six North Atlantic right whales exposed to an alert stimuli "significantly altered their regular behavior and did so in identical fashion" (*i.e*., ceasing feeding and swimming to just under the surface). For these five whales, maximum RLs associated with this response ranged from rms SPLs of 133-148 dB re 1 µPa.

When six scientists (one of them being Nowacek) were asked to independently evaluate available data for constructing a dose response curve based on a solution adapted from Feller (1968), the majority of them (4 out of 6; one being Nowacek) indicated that the Nowacek et al. (2004) data were not only appropriate but also necessary to consider in the analysis. While other parameters associated with the solution adapted from Feller (1968) were provided by many of the scientists (*i.e.*, basement parameter [B], increment above basement where there is 50% risk [K]), only one scientist provided a suggestion for the risk transition parameter, A.

A single curve may provide the simplest quantitative solution to estimating behavioral harassment; however, the policy decision, by NMFS-Office of Protected Resources (OPR), to adjust the risk transition parameter from A=10 to A=8 for mysticetes and create a separate curve was based on the fact the use of this shallower slope better reflected the increased risk of behavioral response at relatively low RLs suggested by the Nowacek et al. (2004) data. In other words, by reducing the risk transition parameter from 10 to 8, the slope of the curve for mysticetes is reduced. This results in an increase the proportion of the population being classified as behaviorally harassed at lower RLs. It also slightly reduces the estimate of behavioral response probability at quite high RLs, though this is expected to have quite little practical result owing to the very limited probability of exposures well above the mid-point of the function. This adjustment allows for a slightly more conservative approach in estimating behavioral harassment at relatively low RLs for mysticetes compared to the odontocete curve and is supported by the only dataset currently available. It should be noted that the current approach (with A=8) still yields an extremely low probability for behavioral responses at RLs between 133-148 dB, where the Nowacek data indicated significant responses in a majority of whales studied. (Note: Creating an entire curve based strictly on the Nowacek et al. [2004] data alone for mysticetes was advocated by several of the reviewers and considered inappropriate, by NMFS-OPR, since the sound source used in this study was not identical to tactical mid-frequency sonar, and there were only 5 data points available). The policy adjustment made by NMFS-OPR was also intended to capture some of the additional recommendations and considerations provided by the scientific panel (*i.e.*, the curve should be more data driven and that a greater probability of risk at lower RLs be associated with direct application of the Nowacek et al. (2004) data).

5.2.3.2.5 Basic application of the risk function

Relation of the Risk Function to the Current Regulatory Scheme

The risk 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 MFA sonar) at a given received level of sound. For example, at 165 dB SPL (dB re 1µPa rms), the risk (or probability) of harassment is defined according to this function as 50%, and Navy/NMFS applies that by estimating that 50% of the individuals exposed at that received level are likely to respond by exhibiting behavior that NMFS would classify as behavioral harassment. The risk function is not applied to individual animals, only to exposed populations.

The data used to produce the risk function were compiled from four species that had been exposed to sound sources in a variety of different circumstances. As a result, the risk function represents a general relationship between acoustic exposures and behavioral responses that is then applied to specific circumstances. That is, the risk function represents a relationship that is deemed to be generally true, based on the limited, best-available science, but may not be true in specific circumstances. In particular, the risk function, as currently derived, treats the received level as the only variable that is relevant to a marine mammal's behavioral response; however, we know that many other variables—the marine mammal's gender, age, and prior experience; the activity it is engaged in during an exposure event, 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). The data that are currently available do not allow for incorporation of these other variables in the current risk functions; however, the risk function represents the best use of the data that are available.

NMFS and Navy made the decision to apply the MFA risk function curve to HFA sources due to lack of available and complete information regarding HFA sources. As more specific and applicable data become available for MFA/HFA sources, NMFS can use these data to modify the outputs generated by the risk function to make them more realistic. Ultimately, data may exist to justify the use of additional, alternate, or multi-variate functions. As mentioned above, it is known that the distance from the sound source and whether it is perceived as approaching or moving away can affect the way an animal responds to a sound (Wartzok et al., 2003). In the Hawai'i Range Complex (HRC) example, animals exposed to RLs between 120 and 130 dB may be more than 65 NM (131,651 yards [yd]) from a sound source; those distances would influence whether those animals might perceive the sound source as a potential threat, and their behavioral responses to that threat. Though there are data showing marine mammal responses to sound sources at that received level, NMFS does not currently have any data that describe the response of marine mammals to sounds at that distance (or to other contextual aspects of the exposure, such as the presence of higher frequency harmonics), much less data that compare responses to similar sound levels at varying distances; however, if data were to become available that suggested animals were less likely to respond (in a manner NMFS would classify as harassment) to certain levels beyond certain distances, or that they were more likely to respond at certain closer distances, the Navy will re-evaluate the risk function to try to incorporate any additional variables into the "take" estimates.

Last, pursuant to the MMPA, an applicant is required to estimate the number of animals that will be "taken" by their activities. This estimate informs the analysis that NMFS must perform to determine whether the activity will have a "negligible impact" on the species or stock. Level B (behavioral) harassment occurs at the level of the individual(s) and does not assume any resulting population-level consequences, though there are known avenues through which behavioral disturbance of individuals can result in population-level effects. Alternately, a negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (i.e., population-level effects). An estimate of the number of Level B harassment takes, alone, is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be "taken" through harassment, NMFS must consider other factors, such as the nature of any responses (their intensity, duration, etc.), the context of any responses (critical reproductive time or location, migration, etc.), or any of the other variables mentioned in the first paragraph (if known), as well as the number and nature of estimated Level A takes, the number of estimated mortalities, and effects on habitat. Generally speaking, the Navy and NMFS anticipate more severe effects from takes resulting from exposure to higher received levels (though this is in no way a strictly linear relationship throughout species, individuals, or circumstances) and less severe effects from takes resulting from exposure to lower received levels.

Table 5-1
Harassments at Each Received Level Band

Received Level	Distance at which Levels Occur in USWTR	Percent of Harassments Occurring at Given Levels
Below 140 dB SPL	36 km–125 km	<1%
140>Level>150 dB SPL	15 km–36 km	2%
150>Level>160 dB SPL	5 km–15 km	20%
160>Level>170 dB SPL	2 km–5 km	40%
170>Level>180 dB SPL	0.6–2 km	24%
180>Level>190 dB SPL	180–560 m	9%
Above 190 dB SPL	0–180 m	2%
TTS (195 dB EL)	0–110 m	2%
PTS (215 dB EL)	0–10 m	<1%

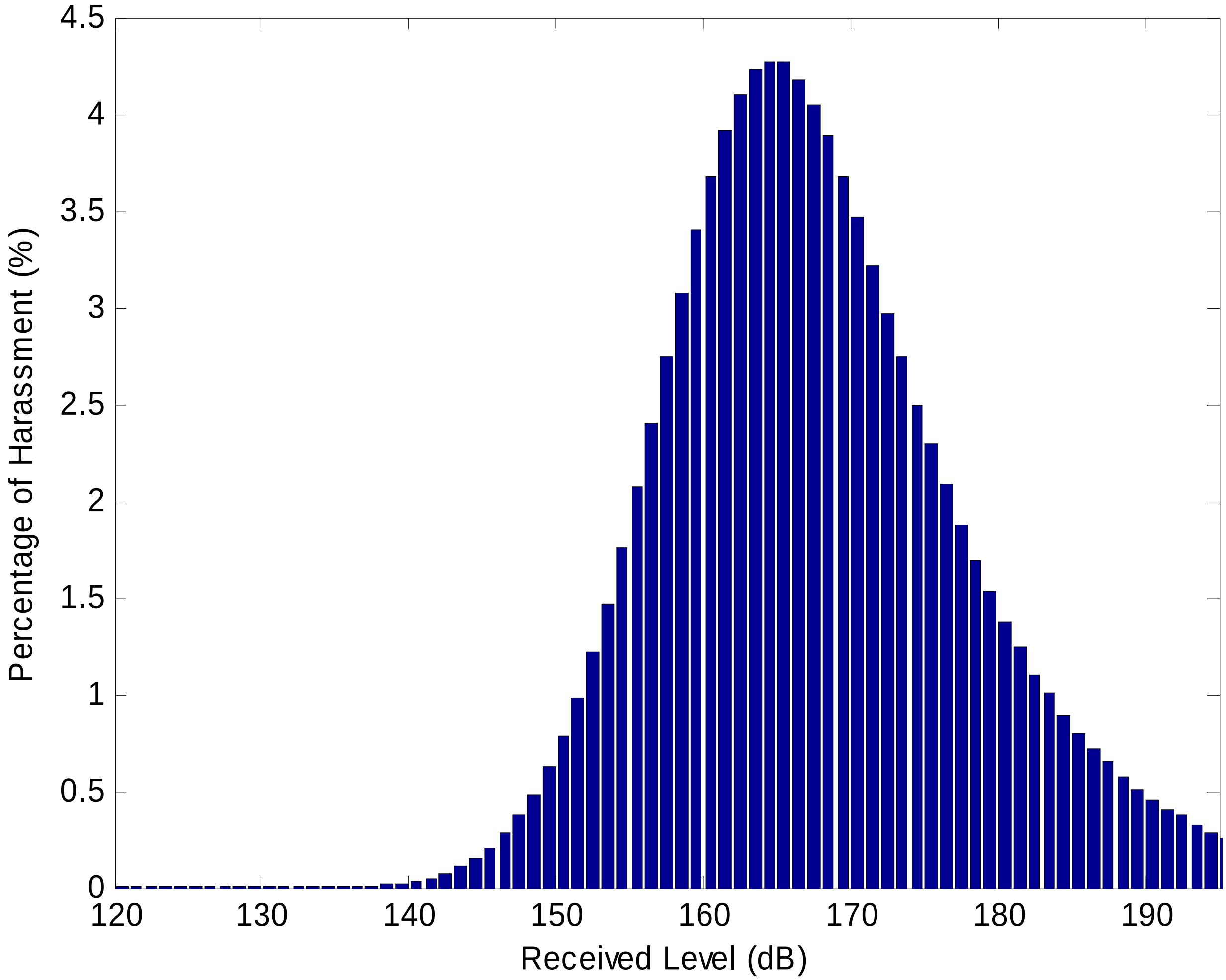

Figure 5-6. The percentage of behavioral harassments resulting from the risk function for every 1 dB of Received Level.

Navy Post Acoustic Modeling Analysis

The quantification of the acoustic modeling results includes additional analysis to increase the accuracy of the number of marine mammals affected. **Table 5-2** provides a summary of the modeling protocols used in this analysis. Post modeling analysis includes reducing acoustic footprints where they encounter land masses, accounting for acoustic footprints for sonar sources that overlap to accurately sum the total area when multiple ships are operating together, and to better account for the maximum number of individuals of a species that could potentially be exposed to sonar within the course of one day or a discreet continuous sonar event.

Table 5-2
Navy Protocols Providing for Accurate Modeling Quantification of Marine Mammal Exposures

Historical Data	Sonar Positional Reporting System (SPORTS)	Annual active sonar usage data is obtained from the SPORTS database to determine the number of active sonar hours and the geographic location of those hours for modeling purposes.
Acoustic Parameters	AN/SQS-53 and AN/SQS-56	The AN/SQS-53 and the AN/SQS-56 active sonar sources separately to account for the differences in source level, frequency, and exposure effects.
	Submarine Sonar	Submarine active sonar use is included in effects analysis calculations using the SPORTS database.
Post Modeling Analysis	Land Shadow	
	Multiple Ships	Correction factors are used to address the maximum potential of exposures to marine mammals resulting from multiple counting based on the acoustic footprint when there are occasions for more than one ship operating within approximately 130 NM of one another.
	Multiple Exposures	

5.2.4 Potential for Prolonged Exposure and Long-Term Effects

5.2.4.1 Likelihood of Prolonged Exposure

One concern for the proposed operations at the USWTR is the possibility that an animal (or group of animals) may experience long-term effects because of repeated, prolonged exposures to high-level sonar signals. As discussed below, this is unlikely because the sonars have limited effect ranges and relatively high platform speeds.

The list of sonar actions for the proposed USWTR is complicated. The focus here is on the sonars with the most potential for effect. More detail may be found in the Naval Undersea Warfare Center (NUWC) Marine Mammals Effect Model (MMEM) report (NUWC, 2005).

Planned use of the USWTR may be described as follows:

- Range use is 161 events per year.
- Each event lasts approximately 6 hr.
- Surface ship sonar operations occur in 48 events (Scenario 2: 30 events that involve one ship; Scenario 4: 18 events that typically involve two ships that are active one at a time for a portion of the time and are active simultaneously for a period of time).
- Of the events incorporating surface ship sonar, use of the SQS-53 is planned for 70% of the events (Scenario 2: 21 times, Scenario 4: 12.6 times; a total of 33.6 events); the SQS-56 is used for the remaining 30% of the events.

- The total operational time for each event involving the SQS-53 would be split 50% for the surface ship sonar and 50% for either dipping sonar or sonobuoys (Scenario 2: 21 events x 6 hr x 50% = 63 hr); the calculation is similar for Scenario 4 except that each ship is potentially active for two hours, of which, the ships are active concurrently for one hour. This is equivalent to a total of four hours, or 66.7% of a 6-hr event (Scenario 4: 12.6 events x 6 hr x 66.7% = 50.4 hr; total operational time for Scenarios 2 and 4 = 113.4 hr).

- When the SQS-53 is in search mode, which has the greatest potential for acoustic effects; the sonar is used 67% of the operational time (113.4 hr x 67% search mode = 76.0 hr). The remaining time the sonar is in target mode, which has lower acoustic effects.

- The SQS-53 would be operational in search mode, the mode with the greatest potential for acoustic effect, 7.9% of the yearly training time (76.0 hr/[161 events x 6 hr] x 100% = 7.9%).

- Ping repetition rate is about 25 s.

- Ship speed is approximately 10 kt (18.52 km/hr).

Because of the directional nature of the sonar transmission, the time delay between pings, and platform speed, an animal encountering the sonar will accumulate significant energy for only a few sonar pings over the course of a few minutes. The chance that any single animal will be exposed to sound levels approaching the harassment thresholds more than once in a 6-hr event is small.

5.2.4.2 Long-Term Effects

The proposed USWTR would repeatedly use the same area of ocean over a period of years, so there could be effects to marine mammals that may occur as a result of repeated use over time that may become evident over longer periods of time (e.g., changes in habitat use or habituation). However, as described in **Sections 5.2.3.1** and **5.2.4**, this LOA assumes that short-term non-injurious SELs predicted to cause TTS or temporary behavioral disruptions qualify as Level B harassment. Application of this criterion assumes an effect even though it is highly unlikely that all behavioral disruptions or instances of TTS will result in long-term impacts. The Navy considers this overestimate of Level B harassment to be prudent due to the proposed repetitive use of a USWTR off the east coast of the U.S. This approach is conservative because:

- There is no established scientific correlation between mid-frequency sonar use and long-term abandonment or significant alteration of behavioral patterns in marine mammals.

- It is highly unlikely that a marine mammal (or group of animals) would experience any long-term effects because the proposed training use of the instrumented range makes individual mammals' repeated and/or prolonged exposures to high-level sonar signals unlikely. Specifically, mid-frequency sonars have limited marine mammal effect ranges and relatively high platform speeds (see discussion in **Section 5.2.4.3**).

- In addition to the conservative approach for estimating Level B harassment, as an additional measure, a monitoring program will be implemented to study the potential long-term effects of repeated short-term sound exposures over time. Significant long-term changes in habitat use or behavior, if they occur, might only become evident over an extended monitoring period. Further information on the program to be implemented to monitor for these potential changes is provided in **Chapter 11**.

5.2.5 Acoustic Sources

Potential acoustic sources for the USWTR were examined with regard to their operational characteristics. Based on this analysis, ten acoustic sources were selected for marine mammal acoustic effect analysis. The other acoustic sources used during training were determined, due to their operational characteristics, to have a negligible potential to affect marine mammals and therefore did not require further examination. Systems with an operating frequency greater than 100 kHz were not analyzed, as these signals attenuate rapidly during propagation (30 dB/km or more signal spreading losses), resulting in very short propagation distances.

Table 5-3 provides a list of active acoustic sources that were determined to be non-problematic. Non-problematic acoustic sources would have a negligible potential to affect marine mammals for the reasons discussed in the foregoing paragraph. Each source is described and not further addressed from an acoustic effect standpoint. Some of the operating characteristics of these sources are classified and are therefore described in general terms.

Table 5-3
Other Acoustic Sources Not Considered Further

Acoustic Source	Comment
Underwater mobile sound communications (UQC) (surface ships, submarines, sensor nodes)	Source levels 188–193 dB re 1 µPa between 8–11 kHz.
MK 30 Target	Source level is not problematic but is classified.
MK 39 Expensable Mobile Acoustic Torpedo Targets (EMATT)	Source level is not problematic but is classified.
Surface Ship Fathometer	12 kHz System is not unique to military and operates identically to any commercially available bottom sounder.

Two systems were examined more closely for inclusion, independent of their source level, due to the duty cycle or ping length that would be used.

- A more detailed examination was performed for lightweight torpedo sonar. These were not problematic based on the established criteria and thresholds.

- The operational parameters of acoustic countermeasures also warranted a closer analysis despite a source level below the 205 dB re 1 µPa level. The results indicate that the sources are not likely to harass, based on established criteria and thresholds.

Following are the acoustic sources modeled in this analysis:

- AN/SQS-53 operated by surface ships
- AN/SQS-56 operated by surface ships
- AN/BQQ-5/10 spherical array operated by submarines
- AN/AQS-22 dipping sonar operated by helicopters
- MK 48 torpedo sonar
- MK 84 tracking pinger
- Acoustic countermeasures (MK 3 and Nixie)
- Directional Command Activated Sonobuoy System (DICASS) sonobuoys
- MK 46 lightweight torpedo

Helicopters also use the AN/AQS-13, but all helicopters were modeled using the AN/AQS-22, which has a somewhat higher source level. The AN/SQS-22 Airborne Low-Frequency Sonar (ALFS) was used as the worst-case source for the dipping sonar, thus preempting the need to model the AN/AQS-13 dipping sonar. These five acoustic sources would be employed in various combinations in each exercise scenario.

In addition to identifying the sonars modeled and used in each scenario, details of the operational duty cycles for the training platforms and active systems are needed to permit calculation of the total operating time of each source. **Table 5-4** (and the bulleted items that follow) contains summary information pertaining to the operation duty cycles.

- **Helicopter Operation** – The helicopter prosecutes the target using active sonobuoys and dipping sonar each 50% of the time. The helicopter splits its active transmission time 50% with surface ships.

- **Surface Ship Operation** – The surface ship and helicopter split active searching for the target 50% of the time each. The distribution between AN/SQS-53 sonar and AN/SQS-56 sonar is 70% and 30%, respectively, for the Fleet. The surface ship sonar operates 67% in a search mode and 33% in a track mode. The nominal source level for USWTR training scenarios would be 235 and 225 dB re 1 μPa^2-s at 1 m for the SQS-53 and SQS-56, respectively.

- **Dipping Sonar** – Each dipping sonar transmission consists of ten pings at the dip point with 3,000 m (9,840 ft) and 15 min between dips.

- **MK 48 Torpedoes** – An average of 1.5 MK 48 EXTORPs would be launched per Scenario 3. An average of 0.5 torpedoes would be used per Scenarios 2 and 4.

- **Submarine Sonar** – The prosecuting submarine pings infrequently (one ping/hour) in Scenario 3 and is silent in the other scenarios.

- **MK 46 Torpedos** – An average of 0.82 MK 46 EXTORPS would be launched per Scenario 1. An average of 0.80 Mk 46 EXTORPS would be launched per Scenario 2. An average of 1.56 Mk 46 EXTORPS would be launched per Scenario 4.

- **MK 84 Pinger** – Used 100% of the time by the submarine when involved in the scenario. Pinger has a repetition rate of 4 s.

The following data were collated for each acoustic source:

- Platform speed
- Source center frequency
- Source output levels
- Source pulse length and repetition rate
- Source beam widths (horizontal and vertical)
- Operating depth(s)

When multiple operating modes or depths were modeled for a source, the characteristics for each were uniquely identified. Some sources such as the surface sonar have variable operating parameters. In these cases, the Fleet defined typical operational characteristics based on its expectations in the USWTR environment.

Table 5-4
Acoustic Sources Used by Training Scenario and Operational Duty Cycles

Scenario	Participants	Acoustic Sources	Operational Duty Cycles Applied	Estimated USWTR Training Events/Yr
1	P3 or helicopter vs. submarine	ALFS; DICASS; pinger; fathometer; MK 46, acoustic countermeasures	50% ALFS/50% DICASS	98
2	One helicopter and one surface ship vs. submarine	ALFS; DICASS; SQS-53; SQS-56; MK 48; MK 46; pinger; fathometer; acoustic countermeasures	50% ALFS/50% DICASS; 50% helo/50% surface ship; 67% search/33% target	30
3	Submarine vs. submarine	BQQ-5/10; MK 48; pinger; fathometer; acoustic countermeasures	1 ping/hour	15
4	Two surface ships and two helicopters vs. submarine	SQS-53; SQS-56; ALFS; DICASS; MK 48; MK 46; pinger; fathometer; acoustic countermeasure	50% ALFS/50% DICASS; 50% helo/50% surface ship; 67% search/33% target; 67% for each ship/helo team	18

5.2.6 Acoustic Environment Data

Four types of data are used to define the acoustic environment for each analysis site.

- **Seasonal Sound Velocity Profiles (SVPs)** – Seasonal SVPs for the range sites were obtained from the Generalized Digital Environmental Model, Variable (GDEMV) resolution of the Oceanographic and Atmospheric Master Library (OAML). These data are available through the Naval Oceanographic Office's (NAVOCEANO) Data Warehouse. Any single observation taken at the range sites will necessarily vary from the seasonal mean. Site A is subject to the meanders of the Gulf Stream, and variations on a daily basis are expected. Training scenarios were evenly distributed through all four seasons.

- **Seabed Geoacoustics** – The type of sea floor influences how much sound is absorbed and how much sound is reflected back into the water column. For Site A the seafloor description was obtained from the MRA for the CHASN/JAX OPAREA (DoN, 2007b).

- **Wind Speeds** – Several environmental inputs, such as wind speed, are necessary to model acoustic propagation on the prospective ranges. Wind speeds were averaged for each season to correspond to the seasonal velocity profiles. At the proposed Site A USWTR, seasonal wind speeds ranged from 0.8 to 2.6 m/s.

- **Bathymetry** – Bathymetry data for the Site A area were obtained from the NAVOCEANO's Digitized Bathymetric Data Base - Variable Resolution (DBDB-V). The resulting bathymetry map covers a larger area than the range area to account for acoustic energy propagating off the test area.

5.2.7 Acoustic Effect Analysis Modeling

The modeling occurred in five broad steps. An overview of each step is provided below and a flow diagram of the process is shown in **Figure 5-7** (Acoustic Effect Analysis Modeling Flow Diagram). Results were calculated on a per-scenario basis and are summed to annual totals. Acoustic propagation and mammal population data are analyzed by season. The analysis estimated the sound exposure for marine mammals produced by each active source type independently.

- **Step 1.** Perform a propagation analysis for Level A and Level B harassment zones (based on the criteria and thresholds defined in **Section 5.2.3** and **5.2.4**) using spherical spreading loss and the Navy's Gaussian Ray Bundle (GRAB) program, respectively.

- **Step 2.** Convert the propagation data into a two-dimensional acoustic footprint for each of the acoustic sources.

- **Step 3.** Calculate the sound exposure level (SEL) and maximum received energy level (SPL) for each range cell area. For SEL each range cell area has accumulated all received pings.

- **Step 4.** Compare the total SEL to the physiological harassment thresholds and determine the area at or above the threshold to arrive at a marine mammal effect area for Level A (PTS) and Level B (TTS). For cells beyond the range of the 195 dB SEL threshold, compute the area using the risk function for all SPL levels 120 dB or greater to evaluate Level B behavioral harassment.

- **Step 5.** Multiply the harassment areas by the corresponding mammal population densities for the shallow and deep-water depths. Sum the two products to produce species sound exposure rate. Apply the exposure rate to the scenario descriptions to generate annual sound exposure estimates. Apply these exposure estimates to produce annual incidental harassment estimates.

5.2.7.1 Propagation Analysis – Step 1

The initial modeling step consists of calculating the propagation loss functions for Level A and Level B threshold analyses. The thresholds for Level A and Level B harassment analyses were developed in **Sections 5.2.3** and **5.2.4**.

Level A Propagation Modeling

In comparing the threshold level for Level A harassment to the source characteristics for the systems analyzed, it was apparent that detailed propagation analysis would overcomplicate the analysis without significant benefit. This is due to the short distances necessary to reach the Level A thresholds with spherical spreading losses alone. An example is shown in **Table 5-5** for a source assumed to ping with a pulse duration of 1 s. As a result of these short distances, few or no surface and bottom interactions occur and absorption is negligible in comparison to the spreading losses. Also, there is little accumulation of energy from multiple pings above or near the thresholds for the moving sources.

The Level A harassment range corresponds to that for each ping independently. Thus, to determine the Level A harassment range for each source, propagation losses were modeled equal to spherical spreading. For sources where multiple pings from a single point would occur, such as the dipping sonar, the harassment range was defined by the total EL from all pings at each transmission point.

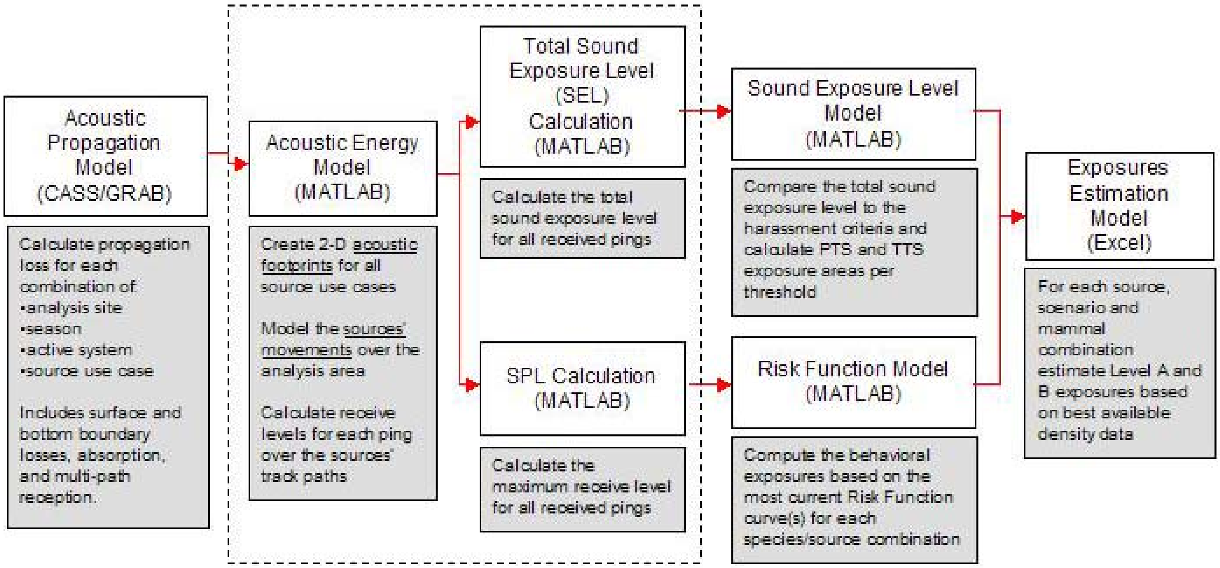

Figure 5-7. Acoustic effect analysis modeling flow diagram.

Table 5-5
Level A Harassment Range Example

Source Level (dB re μPa @ 1 m)	Ping Length(s)	Total Energy Flux (dB re 1 μPa² s)	Level A Threshold (dB re 1 μPa² s)	Allowable Spreading Loss (dB)	Distance to Reach Level A Threshold (20 Log R) m
215	1	215.00	215	0.00	1.00
220	1	220.00	215	5.00	1.8
225	1	225.00	215	10.00	3.1
230	1	230.00	215	15.00	5.6

Some caveats exist for the Level A harassment analysis, all of which produce an expectation of very rare or no Level A harassment. Despite this low likelihood, assessment of Level A harassment was included using the following methodology for completeness.

- For the physically larger sources (i.e., the surface ship and submarine sonars), the Level A harassment ranges would be within the near field of the acoustic transducers. In this circumstance, the actual levels received by any mammal would be limited by the shielding effect of the sonar's structure. In some circumstances, the Level A harassment range of a ping would correspond to a distance smaller than the size of the sonar dome itself.

- The analysis assumes that the acoustic energy is constant throughout the vertical water column at a given horizontal range from the source. This is done to account for the lack of knowledge of the location of mammals in the water column. For short distances, the slant range between the source and mammal may significantly exceed the horizontal distance, resulting in a lower energy level actually being received versus the level modeled, and a corresponding overestimate of the potential for acoustic exposures within the Level A harassment zone.

- For lower-power sources, the harassment range may be less than the size of the mammal itself.

- Level A harassment ranges for all sonars correspond to distances where striking the mammals is possible. Mitigation to avoid ship strikes of mammals simultaneously eliminates the potential for Level A harassment.

Level B Propagation Modeling

Propagation analysis for Level B acoustic harassment estimates is performed using the Comprehensive Acoustic Simulation System (CASS) using the GRAB model. The CASS/GRAB model is an acoustic model developed by NUWC for modeling active acoustic systems in a range-dependent environment. This model has been approved by the OAML for acoustic systems that operate in the 150 Hz to 100 Hz frequency range. The OAML was originally created in 1984 to provide consistency and standardization for all oceanographic and meteorological programs used by the Navy. Today the OAML's role is expanded to provide the Navy a standard library for meteorological and oceanographic databases, models, and algorithms.

CASS/GRAB provides detailed multi-path propagation information as a function of range and bearing. GRAB allows range-dependent environmental information input so that, for example, as bottom depths and sediment types change across the range, their acoustic effects can be modeled.

Propagation loss functions for each unique combination (i.e., acoustic source, season, source depth, etc.) are produced at 45° bearing angles versus range and depth from three chosen analysis points. For each bearing angle, the maximum receive level curve is used to populate all angles around the source, ±22.5°. This results in a continuous 360° characterization of the receive level from the source. The three representative points are used to characterize acoustic propagation in different depth regimes to reflect the topography of the site. The analysis is performed to a distance of 100 km (330,000 ft) at intervals in distance and depths of 5 m (16 ft).

A means of representing propagating sound is by acoustic rays. As acoustic rays travel through the ocean, their paths are affected by absorption, back-scattering, reflection, boundary interaction, etc. The CASS/GRAB model determines the acoustic ray paths between the source and a particular location in the water which, in this analysis, is referred to as a receive cell. The rays that pass through a particular point are called eigenrays. Each eigenray, based on its intensity and phase, contributes to the complex pressure field, hence the total energy received at a point. By summing the modeled eigenrays, the total received energy for a receive cell is calculated. This is illustrated in **Figure 5-8** (CASS/GRAB Propagation Loss Calculations). The propagation losses are normally less than those predicted by spherical spreading versus range due to the multiple eigenrays present.

Propagation Model Considerations

The total EL for all pings will exceed the level of the most-intense ping when multiple pings are received. To calculate the accumulation of energy from multiple pings, the acoustic propagation analysis must be done up to a distance ensuring that the potential for cumulative energy exceeding the threshold is assessed. The extent to which receive levels need to be accumulated depends on the source operational characteristics, including source level, source movement, ping duration, and ping repetition rate. Based on an examination of these parameters, propagation losses for all sources were calculated to a distance of 100,000 m (330,000 ft).

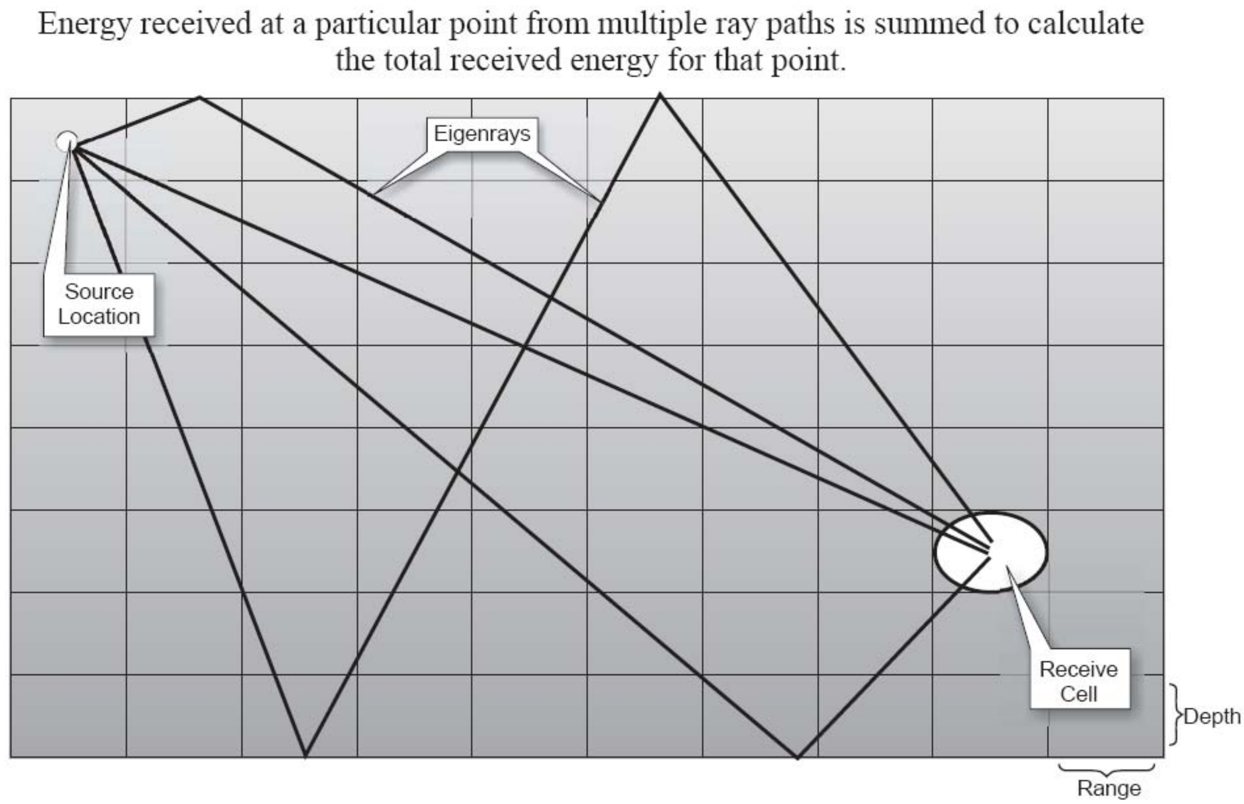

Figure 5-8. CASS/GRAB propagation loss calculations.

5.2.7.2 Acoustic Footprint Generation and Source Movement Modeling – Step 2

Figure 5-9 (Relative Received Level vs. Range) displays a sample propagation loss function for a single bearing angle. These curves are produced by selecting the maximum receive levels in the vertical water column at each horizontal distance. The propagation loss curves are then converted into a two-dimensional acoustic footprint. First, the EL is calculated by applying the source's output level and duration to the propagation loss function. Second, the result for each bearing line is spread to cover a 45° wedge. This step is illustrated in **Figure 5-10** (Bearing Angles for CASS). For horizontally directional sources, the beam width is applied to produce the final acoustic footprint.

The acoustic footprint represents the ping coverage from each transmission point as the movement of the source is modeled. Representative ship tracks are used for moving sources: surface ship sonars, torpedo sonar, and dipping sonar. As the movement is modeled, the ping's receive level at all points covered by the acoustic footprint is recorded at each point. Both the acoustic footprint and receive cells are defined to represent areas of 25 by 25 m (82 by 82 ft), or 0.000625 km^2 (0.0001822 NM^2).

5.2.7.3 Total Energy Flux Calculation – Step 3

For each of the receive area cells, the total EL is calculated for all received pings recorded for that area cell. EL is calculated by using the sound energy flux density level equation as follows:

$$EL = SPL + 10\log_{10} T$$

where EL has units of dB re 1 μPa^2-s, SPL has units of dB re 1 µPa, and T is in seconds.

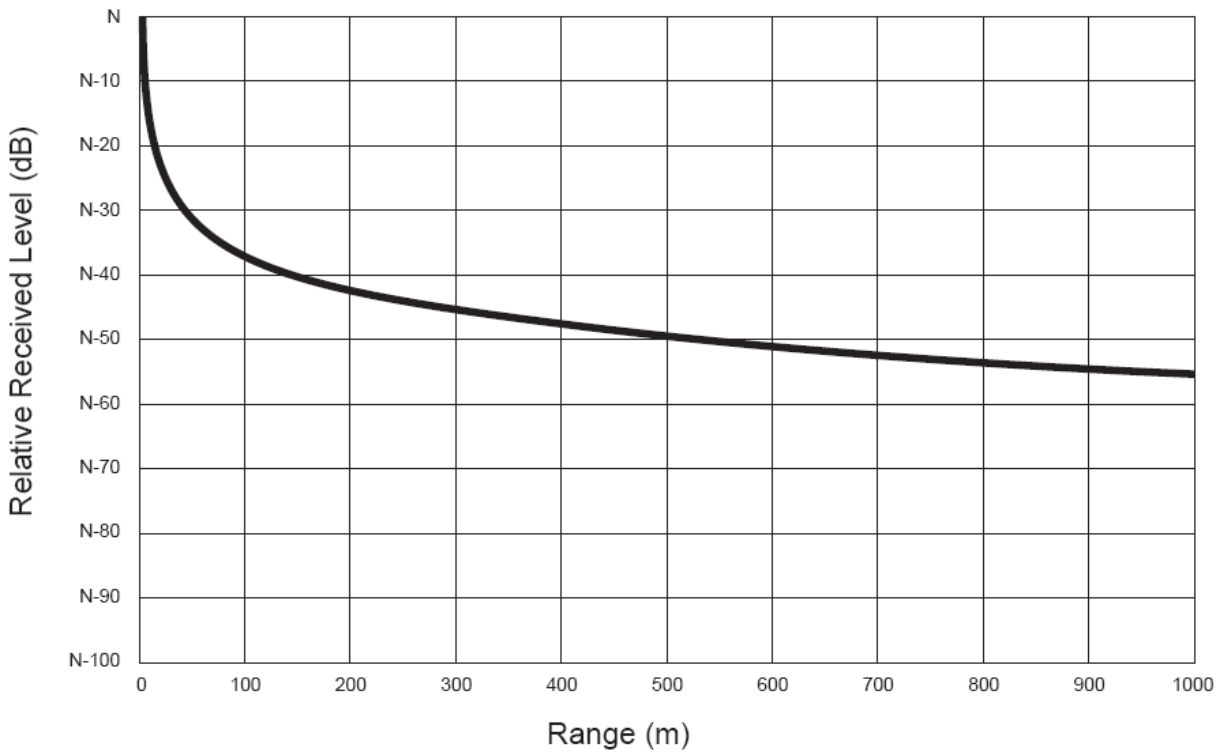

Figure 5-9. Relative received level versus range.

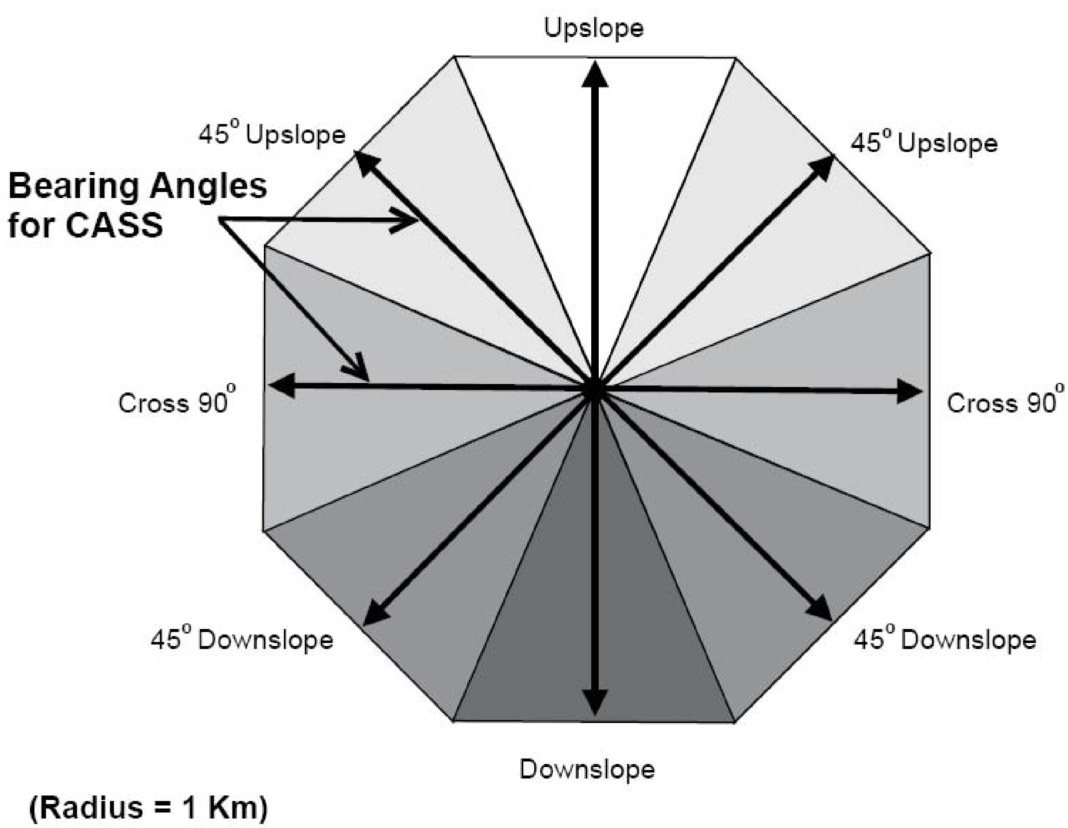

Figure 5-10. Bearing angles for CASS.

5.2.7.4 Marine Mammal Effect Area Analysis – Step 4

The physiological harassment exposures for each species are generated by comparing the total calculated SEL for each receive cell to the Level B harassment threshold of 195 dB re µPa^2-s, and the cells >= 195. The total harassment area is then calculated by multiplying the number of cells by the area per cell, 0.000625 km^2 (0.0001822 NM^2). The total harassment area is then multiplied by the densities for each species at those respective cells. Densities are given using the Navy OPAREA Density Estimates (NODEs) database and are converted to animals/cell throughout the range. The total harassment exposures for each species are then calculated by summing the results.

The behavioral exposures are determined by finding all cells greater than 120 dB SPL and beyond the range of the 195 dB SEL threshold, applying the risk curve to those cells and multiplying the risk (0.0 – 1.0) times the area for that cell. The total harassment area is then multiplied by the densities for each species at those respective cells. The total behavioral exposures for each species are then calculated by summing the results.

5.2.7.5 Annual Marine Mammal Acoustic Effect Estimation – Step 5

To determine the mammal harassment estimates, the total harassment exposures for each source are converted to a harassment rate (i.e., harassment exposures per km). This is done for each mammal distribution region and for both Level A and Level B criteria thresholds. Level A harassment areas are subtracted from Level B harassment areas to prevent double-counting incidents. For the surface, the harassment rate is expressed in exposures per kilometer of movement. The torpedo exposures are calculated per run and the submarine exposures are expressed per ping. For the dipping sonars, the harassment rate is expressed as the exposures per dip.

This is done for every species and all four seasons. The results from each depth region are summed to produce a species harassment rate used in the final calculations.

The species harassment rates are multiplied by the operational duty cycle for each source, the length of each scenario, and the number of yearly scenario occurrences. This produces the estimated number of animals incidentally harassed annually for each combination of source, season, and animal. An example of this process is presented in **Table 5-6**. The only exception to this approach is for a limited number of species where the predicted sound exposure is not expected to occur, due to significant differences in the expected species presence at a specific USWTR site versus the modeled density inputs for the larger OPAREAs.

Section 5.2.8 contains analyses for each individual species.

Acoustic Effects Analysis

The analysis occurred in five broad steps. An overview of each step is provided below.

1. Each source emission is modeled according to the particular operating mode of the sonar. The “effective” energy source and sound pressure level is computed by integrating over the bandwidth of the source, scaling by the pulse length, and adjusting for gains due to source directivity. The location of the source at the time of each emission must also be specified.

2. For the relevant environmental acoustic parameters, transmission loss (TL) estimates are computed, sampling the water column over the appropriate depth and range intervals. TL data are sampled at the typical depth(s) of the source and at the nominal frequency of the source. If the source is relatively broadband, a geometric mean of the low and high frequencies may be appropriate.

Table 5-6
Example Calculation – Common Dolphin Level B Sound Exposure Estimate for SQS-53 Operation in Scenario 2 during Autumn at the Proposed Site D USWTR

Factor	**Value**
Yearly Scenario Occurrences	30
Scenario Duration	6 hr
# of Surface Sonar Platforms in the Scenario	1
# of Total Source 53 Platforms Used (70% of total surface sonars)	0.7
# of Total Source Platforms Used in Autumn	5.25
Operational Duty Cycle with Helicopters	50%
Ship Speed (km/hr)	18.52
Search Mode Operational % (split with track mode)	67%
Applicable Species Harassment Rate	0.394744
53 Search Mode Exercise Harassment Incidents	77.1457
53 Search Mode Exercise Harassment Incidents with Unidentified Species	118.187

Notes: This is an example looking at the SQS-53 in search mode in autumn and the estimated Level B harassment of common dolphin, as follows:

1. Determine the number of times this scenario will be executed in autumn = yearly scenario occurrences (30) x # of surface sonar platforms (1) x # of SQS-53 platforms (0.7) x 0.25 (one season out of four) = (30*1*0.7*.25) = 5.25 (the number of total source platforms used in autumn – SQS-53).

2. Determine the amount of time the system is operational = # of total source platforms used in autumn (5.25) x operational duty cycles with helicopters (0.50) x scenario duration (6) x search mode operational % (0.67) = (5.25*0.50 x 6*0.67) = 10.55 hr.

3. The amount of time the system is operational (10.55 hours) is multiplied by the ship speed in km/hr (18.52) x species harassment rate (animals/km) (0.394744) = (10.55*18.52* 0.394744) = 77.1457 = SQS-53 search mode exercise harassment incidents in autumn.

4. The final harassment number is calculated by multiplying the factor 1.532, which accounts for the percentage of unidentified species, by the harassment number, yielding 118.187.

This species harassment rate value does not appear elsewhere in the document because it is representative of a particular species for a particular sonar.

3. The accumulated energy and maximum received sound pressure level within the waters in which the sonar is operating is sampled over a volumetric grid. At each grid point, the received sound from each source emission is modeled as the effective energy source and sound pressure level reduced by the appropriate propagation loss from the location of the source at the time of the emission to that grid point.

4. For energy criteria, the zone of influence (ZOI) for a given threshold (that is, the volume for which the accumulated energy level exceeds the threshold) is estimated by summing the incremental volumes represented by each grid point for which the accumulated energy flux density exceeds that threshold. For the sound pressure level, the maximum received sound pressure level is

compared to the appropriate dose response function for the marine mammal group and source frequency of interest. The percentage of animals likely to respond corresponding to the maximum received level is found, and the volume of the grid point is multiplied by that percentage to find the adjusted volume. Those adjusted volumes are summed across all grid points to find the overall ZOI.

5. The number of animals exposed to any given acoustic threshold is estimated by multiplying the animal densities by the effect area (derived from the effect volume). Acoustic propagation and mammal population data are analyzed by season. The analysis estimated the sound exposure for marine mammals produced by each active source type independently. Results from each acoustic source were added on a per-training exercise basis and then activities were summed to annual totals.

The relevant measure of potential physiological effects to marine mammals due to sonar training is the modeled accumulated (summed over all source emissions) energy flux density level received by the animal over the duration of the activity. To calculate the estimated exposures using EL, the seasonal exposure zones generated during the acoustic modeling are multiplied by the average density of each species per season by OPAREA. Behavioral effects below the 195 dB EL threshold were modeled using the dose function.

When analyzing the results of the acoustic effects modeling to provide an estimate of effects, it is important to understand that there are limitations to the ecological data and to the acoustic model, which in turn, leads to an overestimation (i.e., conservative estimate) of the total exposures to marine mammals. Specifically, the modeling results are conservative for the following reasons:

Acoustic footprints for sonar sources are added independently and, therefore, do not account for overlap they would have with other sonar systems used during the same active sonar activity. As a consequence, the calculated acoustic footprint is larger than the actual acoustic footprint.

Acoustic exposures do not reflect implementation of mitigation measures, such as reducing sonar source levels when marine mammals are present.

In this analysis, the acoustic footprint is assumed to extend from the water surface to the ocean bottom. In reality, the acoustic footprint radiates from the source like a bubble, and a marine animal may be outside this region.

Harbor porpoise and sei whale densities are unavailable for certain areas due to the lack of sightings (resulting from low densities). In this analysis, areas of unknown densities were overestimated because they were projected from areas of higher densities.

5.2.8 Summary of Potential Acoustic Effects to Marine Mammals by Species

The acoustic analysis model is good at producing rough estimates of marine species physiological effects and behavioral reactions, but should not be relied upon solely as final assessment of the effects to marine mammals. A qualitative analysis of oceanographic and habitat conditions is also an important consideration in the overall marine mammal analysis. Oceanographic features and conditions often determine primary productivity, which drives prey availability and therefore the distribution of marine mammals.

When analyzing the results of the acoustic effect modeling to provide an estimate of harassment, it is important to understand that there are limitations to the ecological data used in the model, and to interpret the model results within the context of a given species' ecology. In particular, density estimates used in the model were calculated for an area much larger than the range itself, encompassing a diverse swath of habitats beginning with inshore coastal environments and moving to the shelf edge and pelagic systems well offshore in the Gulf Stream. Although the model differentiates between off-shelf and on-shelf depth strata, actual distributions of animals are patchy and more isolated than they appear in the density estimates used.

Quantitative analysis alone should not be relied upon for a complete assessment of the proposed actions, although the quantitative acoustic analysis can help to inform the decision making process.

When reviewing the acoustic effect modeling results, it is also important to understand that the estimates of marine mammal sound exposures are presented **without** consideration of mitigation.

As described in an earlier section, with respect to discussing effects in terms of the acoustic modeling results, MMPA regulations provide guidance as to which traits should be used when determining effects.

Table 5-7
Harassment Estimates of Marine Mammals for Annual Operations in the Action Area

Species	PTS	TTS	Dose Function
North Atlantic Right Whale	0	1	44
Humpback Whale	0	2	97
Sei Whale[3]	-	-	-
Fin Whale	0	0	0
Sperm Whale	0	0	0
Minke Whale	0	0	7
Pygmy/dwarf Sperm Whale	0	3	151
Beaked Whales[1]	0	0	26
Rough Toothed Dolphin	0	1	72
Bottlenose Dolphin	4	698	45717
Pantropical Spotted Dolphin	0	55	3321
Atlantic Spotted Dolphin[2]	3	762	43507
Striped Dolphin	0	0	0
Clymene Dolphin	0	26	1587
Common Dolphin	0	0	0
Risso’s Dolphin	0	27	2324
Pilot Whales	0	22	1657

Notes: These estimates are prior to implementation of mitigation measures (**Chapter 11**).
[1] Beaked whale species here are assumed to include *Mesoplodon europaeus, M. densirostris, M. mirus,* and *Ziphus cavirostris*.
[2] Based on the schooling nature of these dolphins, the protective measures discussed in **Chapter 6** are considered to be effective in reducing the potential for a Level A harassment of this species.
[3] Insufficient observation data exists to calculate density estimates for these species in the JAX OPAREA; however rare observations have been made indicating that these species may be present in the OPAREA.

Potential Effects to ESA-Listed Species

The section below addresses potential impacts to ESA-listed species in the USWTR Action Area. Through the consultation process and the implementation of mitigation measures (see **Chapter 11**) to further reduce the potential for adverse affects to marine mammals, no significant impacts to ESA-listed species are likely to occur as a result of installation and operation of the USWTR.

North Atlantic Right Whale

While the acoustic modeling results show that the proposed action may affect up to one right whale per year to the level of TTS and up to 44 whales to the level of behavioral reaction. These exposures would not necessarily occur to 44 different individuals. The same individual could experience behavioral disruption more than once over the course of a year.

Actual effects from USWTR activities are likely to be less than predicted estimates due to the following:

- Because this species is highly endangered, the use of the **maximum** number of right whales potentially on the calving grounds was used as the basis for calculating density. The estimated abundance of right whales was applied uniformly across the entire shelf region – a much larger area than the known “high use habitat.” This results in an overestimate of density in the area of the Action Area, because they are rarely found in the deeper, offshore waters. Therefore, the acoustic model overestimates the potential effects in comparison to the whales’ actual spatial distribution.

- Although there have not been studies evaluating acoustic disturbance of migrating right whales, Richardson (1999) studied reactions of bowhead whales to seismic surveys during their autumn migration. While bowheads avoided the area within 20 km (10.8 NM) of operating airguns, they were common in the same location on days that surveys were not underway. Because of the similarity between right whales and bowheads, it may be inferred that even in the unlikely event a right whale was momentarily disturbed by active acoustics, it would not exhibit long-term displacement in the area of the proposed range, nor would the overall migratory pattern be significantly affected.

In addition, lookouts will likely detect a group of North Atlantic right whales out to 914 m (1,000 yd) given their large size (Leatherwood and Reeves, 1982), surface behavior, pronounced blow, and mean group size of approximately three animals. The probability of trackline detection in Beaufort Sea States (BSSs) of 6 or less is 0.90 or 90% (Barlow, 2003). Implementation of mitigation measures and probability of detecting a large North Atlantic right whale reduce the likelihood of exposure and potential effects. Thus, the number of actual North Atlantic right whale exposures may be lower than the number predicted by the model. Additionally, even though the right whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

No tests on North Atlantic right whale hearing have been conducted although a right whale audiogram has been constructed using a mathematical model based on the internal structure of the ear. The predicted audiogram indicates hearing sensitivity to frequencies from 15 Hz to 20 kHz, with maximum relative sensitivity between 20 Hz and 2 kHz (Ketten, 1998).

The Navy considered potential effects to stocks based on the best abundance estimate for each stock of marine mammal species, as published in the SAR by NMFS. According to the North Atlantic right whale report card released annually by the North Atlantic Right Whale Consortium, approximately 393 individuals are thought to occur in the western North Atlantic (NARWC, 2007). The most recent stock assessment report states that in a review of the photo-id recapture database for June 2006, 313 individually recognized whales were known to be alive during 2001 (Waring et al., 2008). This number represents a minimum population size, and no abundance estimate has been calculated for this population (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to North Atlantic right whales due to USWTR activities would result in short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to North Atlantic right whales.

Humpback Whale

The acoustic modeling estimates that the proposed action may affect up to 2 humpback whales to the level of TTS and up to 97 to the level of behavioral reaction. Humpbacks in the vicinity of the Action Area are most likely migrating to or from the Caribbean wintering grounds; thus, it is beneficial to examine studies performed on other populations of migrating humpbacks.

Lookouts would likely detect humpback whales at the surface because of their large size (up to 16 m [53 ft]) (Leatherwood and Reeves, 1982), and pronounced vertical blow. Thus, the number of humpback whale exposures indicated by the acoustic analysis is likely a conservative overestimate of actual exposures. Additionally, even though the humpback whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

No tests on humpback whale hearing have been made although a humpback whale audiogram has been constructed using a mathematical model based on the internal structure of the ear. The predicted audiogram indicates sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz. Recent information on the songs of humpback whales suggests that their hearing may extend to frequencies of at least 24 kHz and source levels of 151-173 dB re 1μPa (Au et al., 2006). A single study suggested that humpback whales responded to mid frequency sonar (3.1-3.6 kHz re 1 μPa^2-s) sound (Maybaum, 1989), however the hand-held sonar system used had a sound artifact below 1,000 Hz which apparently caused a response to the control playback (a blank tape) and may have confounded the results from the treatment (i.e., the humpback whale may have responded to the low frequency artifact rather than the mid-frequency sonar sound).

McCauley (1998) investigated reactions of migrating humpbacks to seismic exploration off Exmouth, western Australia. Although some animals displayed localized avoidance behavior, such displacements were short in duration and their overall migratory track was not significantly altered.

The Navy considered potential effects to stocks based on the best available data for each stock of marine mammal species. Humpback whales in the North Atlantic are thought to belong to five different feeding stocks: Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland. Previously, the North Atlantic humpback whale population was treated as a single stock for management purposes (Waring et al., 1999). However, based upon the strong regional fidelity by individual whales the Gulf of Maine has been reclassified as a separate feeding stock (Waring et al., 2008). Recent genetic analyses have also found significant differences in mitochondrial deoxyribonucleic acid (mtDNA) haplotype frequencies among whales sampled in four western feeding areas, including the Gulf of Maine (Palsbøll et al., 2001). As a result, the International Whaling Commission acknowledged the evidence for treating the Gulf of Maine as a separate stock for the purpose of management (IWC, 2002). The current best estimate of population size for humpback whales in the North Atlantic, including the Gulf of Maine Stock, is 11,570 individuals (Waring et al., 2008). The best abundance estimate for the Gulf of Maine humpback stock is 847 individuals (Waring et al., 2008). During the winter, most of the North Atlantic population of humpback whales is believed to migrate south to calving grounds in the West Indies region (Whitehead and Moore, 1982; Smith et al., 1999; Stevick et al., 2003). During this time individuals from the various feeding stocks mix through migration routes as well as on the feeding grounds. Additionally, there has been an increasing occurrence of humpbacks, which appear to be primarily juveniles, during the winter along the U.S. Atlantic coast from Florida north to Virginia (Clapham et al., 1993; Swingle et al., 1993; Wiley et al., 1995; Laerm et al., 1997). Although the population composition of the mid-Atlantic is apparently dominated by Gulf of Maine whales, the lack of recent photographic effort in Newfoundland makes it likely that other feeding stocks may be under-represented in the photo identification matching data (Waring et al., 2008). Although the majority of acoustic exposures in the Northeast are likely to be from the Gulf of Maine feeding stock, the mixing of multiple stocks through the migratory season suggests that exposures in the Southeast are likely spread across all of the North Atlantic populations. Sufficient data to estimate the percentage of exposures to each stock is currently not available.

Based on best available science the Navy concludes that exposures to humpback whales due to USWTR activities would result in short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to humpback whales.

Sei Whale

No modeling estimates are available for the sei whale due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect sei whales since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Lookouts would likely detect sei whales at the surface because they have high likelihood of detection (0.90 in BSSs of 6 or less; Barlow, 2003). Sei whales generally form groups of three animals or more, have a pronounced vertical blow, and are large animals. Thus, the number of sei whale exposures indicated by the acoustic analysis is likely a conservative overestimate of actual exposures. Additionally, even though the sei whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

The Navy considered potential effects to stocks based on the best available data for each stock of marine mammal species. Sei whales in the North Atlantic belong to three stocks: Nova Scotia, Iceland-Denmark Strait, and Northeast Atlantic (Perry et al., 1999). The Nova Scotia Stock occurs in U.S. Atlantic waters (Waring et al., 2008). Prior to 1999, the North Atlantic humpback whale population was identified as the western North Atlantic Stock for management purposes (Waring et al., 2005). The boundaries of the Nova Scotian stock of sei whales include the continental shelf waters of the northeastern United States and extend northeastward to the south of Newfoundland (Waring et al., 1999). NMFS adopted the boundaries based on the proposed International Whaling Commission stock definition, which extends from the East Coast to Cape Breton, Nova Scotia, and east to longitude 42°W (Warring et al., 1999). The best abundance estimate for sei whales in the western North Atlantic is 207; however this is considered conservative due to uncertainties in population movements and structure (Waring et al., 2008). Sufficient data to estimate the percentage of exposures to the stock is currently not available.

Based on best available science the Navy concludes that exposures to sei whales due to USWTRactivities would result in short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to sei whales.

Fin Whale

Modeling estimates predict zero takes for fin whales based on the density estimate of zero for the Action Area. Density estimates of zero do not necessarily indicate the absence of animals, but may reflect the rarity of animals in the area.

Lookouts would likely detect a group of fin whales at the surface because they have a high likelihood of detection (0.90 in BSSs of 6 or less; Barlow, 2003). Additionally, even though the fin whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the stock assessment reports by NMFS. Fin whales are currently considered as a single stock in the western North Atlantic. The best abundance estimate for the Western North Atlantic stock of fin whales is 2,269 (Waring et al., 2008). The population is likely to be larger than the best estimate because as Waring et al. (2008) survey coverage of known and potential fin whale habitat was incomplete.

Based on best available science the Navy concludes that exposures to the western North Atlantic fin whale stock due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to fin whales.

Blue Whale

No modeling estimates are available for the blue whale due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect blue whales since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

At least two discrete populations are found in the North Atlantic. One ranges from West Greenland to New England and is centered in eastern Canadian waters; the other is centered in Icelandic waters and extends south to northwest Africa (Sears et al., 2005). There are no current estimates of abundance for the North Atlantic blue whale (Waring et al., 2008); however, the 308 photo-identified individuals from the Gulf of St. Lawrence area are considered to be a minimum population estimate for the western North Atlantic stock (Sears et al., 1987; Waring et al., 2008). The entire population may total only in the hundreds, but no conclusive data exist to confirm or refute this estimate.

An undetermined number of blue whales could be exposed to sound levels likely to result in Level B harassment. Based on the presumed relatively small population and low number of recorded sightings in the OPAREAs, the number of potential exposures is probably low. No exposure of individuals to sound levels likely to result in Level A harassment is expected. No mortality due to explosive sonobuoys is expected. Lookouts would likely detect blue whales at the surface. Additionally, even though blue whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

Based on best available science the Navy concludes that exposures to blue whales due to USWTR activities would result in short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to blue whales.

Sperm Whale

Modeling estimates predict zero takes for sperm whales based on the density estimate of zero for the Action Area. Density estimates of zero do not necessarily indicate the absence of animals, but may reflect the rarity of animals in the area. Based on habitat preference, sperm whales are likely to occur in deep waters that fall outside of the Action Area.

Lookouts would likely detect a group of sperm whales at the surface because they have a high likelihood of detection (0.87 in BSSs of 6 or less; Barlow, 2003) given their large size (up to 17 m [56 ft]) (Leatherwood and Reeves, 1982), pronounced blow (large and angled), and mean group size (approximately seven animals). Additionally, even though the sperm whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

No direct tests on sperm whale hearing have been made, although the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high frequency to ultrasonic frequency sounds. Behavioral observations have been made whereby during playback experiments off the Canary Islands, André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions. When resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al., 1997).

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the stock assessment reports by NMFS. Sperm whales are currently considered as a single stock in the western North Atlantic (Waring et al., 2008). Genetic analyses, coda vocalizations, and population structure support this (Jochens et al., 2006). Stock structure for sperm whales in the North Atlantic is not known (Dufault et al., 1999). The current combined best estimate of sperm whale abundance from Florida to the Bay of Fundy in the western North Atlantic Ocean is 4,804 individuals (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to the western North Atlantic sperm whale stock due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to sperm whales.

Manatees

No modeling estimates are available for the manatee due to lack of a density estimate for the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is not anticipated that manatees will venture to the Action Area where acoustic effects are possible. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Behavioral data on two animals indicate an underwater hearing range of approximately 0.4 to 46 kHz, with best sensitivity between 16 and 18 kHz (Gerstein et al., 1999), while earlier electrophysiological studies indicated best sensitivity from 1 to 1.5 kHz (Bullock et al., 1982). Therefore, it appears that manatees have the capability of hearing active sonar. In one study, manatees were shown to react to the sound from approaching or passing boats by moving into deeper waters or increasing swimming speed (Nowacek et al., 2004). By extension, manatees could react to active sonar; however, there is no evidence to suggest the reaction would likely disturb the manatee to a point where their behaviors are abandoned or significantly altered. Specifically, manatees did not respond to sound at levels of 10 to 80 kHz produced by a pinger every 4 s for 300 ms (Bowles et al., 2001). The pings' energy was predominantly in the 10 to 40 kHz range (the mid to high portion of manatee hearing). The level of sound was approximately 130 dB re 1 μPa.

Additionally, Hubbs-SeaWorld Research Institute (HSWRI) initially tested a manatee detection device based on sonar (Bowles, et al., 2004). In addition to conducting sonar reflectivity, the experiments also included a behavioral response study. Experiments were conducted with 10 kHz pings, whereby the sound level was increased by 10 dB from 130 dB to 180 dB or until the researchers observed distress. Rapid swimming, thrashing of the body or paddle, and spinning while swimming indicated distress. Researchers found that manatees detected the 10 kHz pings and approached the transducer cage when the sonar was turned on initially; however, none of the responses indicated that the manatees responded with intense avoidance or distress. The authors concluded that manatees do not exhibit strong startle responses or an aggressive nature towards acoustic stimuli, which differs from experiments conducted on cetaceans and pinnipeds (Bowles, et al., 2004).

Based on best available science manatees would hear mid-frequency and high-frequency sonar, but would not likely show a strong reaction or be disturbed from their normal range of behaviors. Additionally, active sonar activities would not take place in the vicinity of manatee habitat.

5.2.9 MMPA: Estimated Harassment of Non-ESA-Listed Marine Mammals

The process for establishing criteria and thresholds for assessing the effect of sound on marine mammals was presented in **Sections 5.2.3**. The application of the thresholds to establish sound exposure zones for the purpose of the acoustic model was described in **Section 5.2.3**. The subsequent use of these zones to estimate the potential for incidental harassment of marine mammals is described in this section. As previously discussed, exposure to sound levels predicted to result in TTS and behavioral effects at levels below TTS may not result in abandonment or significant alteration of natural behavioral patterns (the military readiness standard for Level B harassment). However, all exposures exceeding the thresholds predicted to induce TTS or behavioral disruption are conservatively considered as Level B harassment for this LOA.

A two-step process was used to estimate harassment under the MMPA.

- First, as described in **Section 5.2.7**, an acoustic model was run using density estimates for the JAX OPAREA (DoN, 2007d).

- Second, the analysis was focused on the smaller geographic areas that would actually be affected by operations on the USWTR. As described in **Section 5.2.8**, when interpreting the results of the acoustic effect modeling, it is important to understand whether there are any limitations to the ecological data used in the model, and, if so, to interpret the model results within the context of a given species' ecology. Life history information and the distribution of species on the actual USWTR site, versus the larger OPAREA data that were input to the acoustic model, were evaluated to verify that the model results accurately reflect expected species presence.

The resulting annual MMPA harassment estimates for the Action Area are presented in **Table 5-7**.

The model results and the estimates of harassment primarily **without** consideration of mitigation are presented below.

The following section presents the marine mammal incidental harassment estimates for the Action Area. Only species predicted to experience one or more incidents of harassment are presented here, and these numbers reflect the species, numbers, and type of harassment for which a MMPA LOA is requested.

Minke Whale

The harassment analysis results show that no Level A harassment of minke whales would occur. The modeling shows that up to seven incidental exposures of minke whales to non-injurious levels of acoustic harassment (Level B harassment) may occur on an annual basis (**Table 5-7**). These exposures would not necessarily occur to nine different individuals. The same individual could experience behavioral disruption more than once over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual minke whales experiencing Level B harassment may be fewer than seven. Mitigation measures detailed in **Chapter 11** would further reduce the potential for any effect on minke whales.

Lookouts would likely detect a group of minke whales at the surface given their large size (up to 8 m [27 ft]), pronounced blow, and breaching behavior (Barlow, 2003). Additionally, even though the minke whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the stock assessment reports by NMFS. There are four recognized populations in the North Atlantic Ocean: Canadian East Coast, West Greenland, Central North Atlantic, and Northeastern North Atlantic (Donovan, 1991; Waring et al., 2008). Minke whales off the eastern U.S. are considered to be part of the Canadian East Coast stock which inhabits the area from the eastern half of the Davis Strait to 45°W and south to the Gulf of Mexico (Waring et al., 2008). The best available abundance estimate for minke whales from the Canadian East Coast stock is 3.312 animals (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to the Canadian East Coast minke whale stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to minke whales.

Bryde's Whale

No modeling estimates are available for the Bryde's whale due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect Bryde's whales since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Lookouts would likely detect a group of Bryde's whales at the surface because they have a high likelihood of detection (0.87 in BSSs of 6 or less; Barlow, 2003; 2006) given their large size (up to 14 m [46 ft]) and pronounced blow. Additionally, even though the Bryde's whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

No abundance information is currently available for Bryde's whales in the western North Atlantic (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to the western North Atlantic Bryde's whale stock due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to Bryde's whales.

Kogia spp.

The analysis results show that no Level A harassment of *Kogia* spp., up to one incident of Level B harassment with TTS, and up to 151 Level B harassment to the level of behavioral disruption could occur annually. Mitigation measures detailed in **Chapter 11** would reduce the potential for any effect on pygmy or dwarf sperm whales.

Even though the pygmy and dwarf sperm whales may exhibit a reaction when initially exposed to active acoustic energy, the exposures are not expected to be long-term due to the likely low received level of acoustic energy and relatively short duration of potential exposures.

The Navy evaluated potential exposures to stocks based on the best estimates presented in the stock assessment reports published by NMFS. There is currently no information to differentiate Atlantic stock(s) (Waring et al., 2008). The best abundance estimate for both species combined in the western North Atlantic is 395 individuals (Waring et al., 2008). Species-level abundance estimates cannot be calculated due to uncertainty of species identification at sea (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to the Atlantic pygmy and dwarf sperm whale stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on these species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to pygmy and dwarf sperm whales.

Beaked Whales

The sea floor of the USWTR lacks the submarine canyons and other high-relief features that many beaked whales find important components of their habitat, and that were found in association with previous beaked whale strandings. The USWTR area represents a small fraction of the normal habitat of beaked whales. Further, the USWTR area is not known to be an area that has historically been favored by any of the species.

The modeling estimates show that up to 26 incidental exposures of beaked whales to sound levels that could cause behavioral disruption (Level B harassment) may occur on an annual basis (**Table 5-6**). These exposures would not necessarily occur to 26 different individuals. The same beaked whale could be exposed multiple times over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual beaked whales experiencing harassment may be fewer than 26. Mitigation measures detailed in **Chapter 11** should reduce the potential for any effect on the beaked whales.

The best estimate of *Mesoplodon* spp. and Cuvier's beaked whale abundance combined in the western North Atlantic is 3,513 individuals (Waring et al., 2008). A recent study of global phylogeographic structure of Cuvier's beaked whales suggested that some regions show a high level of differentiation (Dalebout et al., 2005); however, Dalebout et al., (2005) could not discern finer-scale population differences within the North Atlantic.

Based on best available science the Navy concludes that exposures to beaked whales due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on these species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to beaked whales.

Rough-toothed Dolphins

The analysis estimates no incidents of Level A harassment of spotted dolphins annually. The acoustic model estimates that up to one incident of Level B harassment with TTS and up to 72 incidents of behavioral disruption (Level B harassment) would occur annually. These exposures would not necessarily occur to 72 different individuals. The same spotted dolphin could be exposed multiple times over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual spotted dolphins experiencing Level B harassment may be less than 72. The actual incidents of behavioral disruption would be reduced beyond these estimates by the mitigation measures presented in **Chapter 11**.

Lookouts would likely detect a group of rough-toothed dolphins at the surface because of their high probability of detection (0.76 in BSSs of 6 or less; Barlow, 2006) given their frequent surfacing and mean group sizes (14.8 animals). Implementation of mitigation measures and probability of detecting large groups of rough-toothed dolphins reduce the likelihood of exposure. Thus, rough-toothed dolphin exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimates presented in the stock assessment reports published by NMFS. There is no information on stock differentiation for the western North Atlantic stock of this species and no abundance estimate is available for rough-toothed dolphins in the western North Atlantic (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to rough-toothed dolphins due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and impacts to the species would be negligible. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to rough-toothed dolphins.

Bottlenose Dolphin

The analysis results show that up to 4 incidents Level A harassment, up to 698 incidents of Level B harassment with TTS and up to 45,717 incidents of behavioral disruption (Level B harassment) may occur annually (**Table 5-7**). These exposures would not necessarily occur to 108 different individuals. The same bottlenose dolphin could be exposed multiple times over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual bottlenose dolphins experiencing Level B harassment may be fewer than 45,717. The actual incidents of behavioral disruption would be reduced beyond these estimates by the mitigation measures presented in **Chapter 11**.

Bottlenose dolphins tend to have relatively short dives and given their frequent surfacing, lookouts would be more likely detect a group of bottlenose dolphins at the surface. The probability of detecting groups of bottlenose dolphins and the subsequent implementation of mitigation measures would reduce the likelihood of exposures, especially at very close ranges that would potentially cause Level A harassment and especially. Thus, the number of bottlenose dolphin exposures indicated by the acoustic analysis is likely a conservative over-estimate of actual exposures.

For the western North Atlantic, these stocks include both the coastal and offshore stocks. The best estimate for the western North Atlantic coastal stock of bottlenose dolphins is 15,620 and the best estimate for the western North Atlantic offshore stock of bottlenose dolphins is 81,588 (Waring et al., 2008). Torres et al*.* (2003) found a statistically significant break in the distribution of the morphotypes at 34 km (18 NM) from shore based upon the genetic analysis of tissue samples collected in nearshore and offshore waters. The offshore morphotype was found exclusively seaward of 34 km (18 NM) and in waters deeper than 34 m (18 NM). Within 7.5 km (4 NM) of shore, all animals were of the coastal morphotype. More recently, offshore morphotype animals have been sampled as close as 7.3 km (4 NM) from shore in water depths of 13 m (43 ft) (Garrison et al., 2003). Due to the apparent mixing of the coastal and offshore stocks of bottlenose dolphins along the Atlantic coast it is impossible to estimate the percentage of each stock potentially exposed to sonar from USWTR. The location of USWTR suggests that the majority of estimated exposures to bottlenose dolphins will be to the offshore stock, however some small proportion of exposures will likely apply to the coastal stock as well.

Based on best available science the Navy concludes that exposures to both Atlantic bottlenose dolphins due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to bottlenose dolphins.

Pantropical Spotted Dolphins

The analysis estimates no Level A harassment. The acoustic model estimates that up to 55 incidents of TTS (Level B harassment) and 3321 incidents of behavioral disruption (Level B harassment) would occur annually. These exposures would not necessarily occur to 3376 different individuals. The same spotted dolphin could be exposed multiple times over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual spotted dolphins experiencing Level B harassment may be less than 3376. The actual incidents of behavioral disruption would be reduced beyond these estimates by the mitigation measures presented in **Chapter 11**.

Given their frequent surfacing and large group size encompassing hundreds of animals (Leatherwood and Reeves, 1982), mean group size of 60.0 animals and probability of trackline detection of 1.00 in BSSs of 6 or less (Barlow, 2006), lookouts would likely detect a group of pantropical spotted dolphins at the surface. Implementation of mitigation measures and probability of detecting large groups of pantropical spotted dolphins reduce the likelihood of exposure. Thus, the estimated number of pantropical spotted dolphins experiencing harassment may be fewer than previously stated.

No direct measures of hearing ability are available for pantropical spotted dolphins, but ear anatomy has been studied and indicates that this species should be adapted to hear the lower range of ultrasonic frequencies (less than 100 kHz).

The best estimate of abundance of the western North Atlantic stock of pantropical spotted dolphins is 4,439 individuals (Waring et al., 2008). There is no information on stock differentiation for pantropical spotted dolphins in the U.S. Atlantic (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to pantropical spotted dolphins due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and impacts to the species would be negligible. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to pantropical spotted dolphins.

Atlantic Spotted Dolphins

The analysis estimates up to three incidents of Level A harassment of Atlantic spotted dolphins may occur annually. The mitigation measures detailed in **Chapter 11** would lower probability of injurious effect on Atlantic spotted dolphins; therefore, it is likely that fewer actual incidents Level A harassment would occur. The acoustic model estimates that up to 762 incidents of TTS (Level B harassment) and up to 43,507 incidents of behavioral disruption (Level B harassment) would occur annually. These exposures would not necessarily occur to 44,269 different individuals. The same spotted dolphin could be exposed multiple times over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual spotted dolphins experiencing Level B harassment may be less than 44,269. The actual incidents of behavioral disruption would be reduced beyond these estimates by the mitigation measures presented in **Chapter 11**.

Lookouts would likely detect a group of pantropical spotted dolphins at the surface because of their high probability of detection (1.00 in BSSs of 6 or less; Barlow, 2006) given their frequent surfacing and large group size encompassing hundreds of animals (Leatherwood and Reeves, 1982). Implementation of mitigation measures and probability of detecting large groups of Atlantic spotted dolphins reduce the likelihood of exposure. Thus, the estimated number of Atlantic spotted dolphins experiencing harassment may be fewer than previously stated.

In general, the Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. The best estimate of Atlantic spotted dolphin abundance in the western North Atlantic is 50,978 individuals (Waring et al., 2008). Recent genetic evidence suggests that there are at least two populations in the western North Atlantic (Adams and Rosel, 2006), as well as possible continental shelf and offshore segregations. Atlantic populations are divided along a latitudinal boundary corresponding roughly to Cape Hatteras (Adams and Rosel, 2006).

Spinner Dolphin

No modeling estimates are available for spinner dolphins due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect spinner dolphins since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Lookouts would likely detect a group of spinner dolphins at the surface because of their high probability of detection (1.00 in BSSs of 6 or less; Barlow, 2006) given their frequent surfacing, aerobatics, and large mean group size of 31.7 animals. Implementation of mitigation measures and probability of detecting large groups of spinner dolphins reduce the likelihood of exposure. Thus, spinner dolphin exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

No estimates of abundance are currently available for the western North Atlantic stock of spinner dolphins (Waring et al., 2008). Stock structure in the western North Atlantic is unknown (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to the western North Atlantic spinner dolphin stock due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to spinner dolphins.

Striped Dolphin

Modeling estimates predict zero takes for striped dolphins based on the density estimate of zero for the Action Area. Density estimates of zero do not necessarily indicate the absence of animals, but may reflect the rarity of animals in the area. Through the consultation process and the implementation of mitigation measures (see **Chapter 11**) to further reduce the potential for effects to marine mammals.

Given their gregarious behavior and large group size of up to several hundred or even thousands of animals (Baird et al., 1993), it is likely that lookouts would detect a group of striped dolphins at the surface. Implementation of mitigation measures and probability of detecting large groups of striped dolphins reduce the likelihood of exposure. Thus, striped dolphin exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. Striped dolphins are currently considered as a single stock in the western North Atlantic. The best estimate of striped dolphin abundance in the western North Atlantic is 94,462 individuals (Waring et al., 2008).

Clymene Dolphin

The modeling results show that no Level A harassment of Clymene dolphins would occur. The analysis results show that up to 26 incidents of TTS (Level B harassment) and 1587 incidental exposures of Clymene dolphins to non-injurious levels of acoustic harassment (Level B harassment) may occur on an annual basis (**Table 5-7**). These exposures would not necessarily occur to 1613 different individuals. The same individual could experience behavioral disruption more than once over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual Clymene dolphins experiencing Level B harassment may be fewer than 1613. The actual incidents of behavioral disruption would be reduced beyond these estimates by the mitigation measures presented in **Chapter 11**.

Given their gregarious behavior and potentially large group size of up to several hundred or even thousands of animals (Jefferson, 2006), it is likely that lookouts would detect a group of Clymene dolphins at the surface. Implementation of mitigation measures and probability of detecting large groups of Clymene dolphins reduce the likelihood of exposure. Thus, Clymene dolphin exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. The population in the western North Atlantic is currently considered a separate stock for management purposes although there is not enough information to distinguish this stock from the Gulf of Mexico stock(s) (Waring et al., 2008). The best estimate of abundance for the western North Atlantic stock of Clymene dolphins is 6,086 individuals (Waring et al., 2008).

Based on the best available science the Navy concludes that exposures to both Northwest Atlantic and Gulf of Mexico Clymene dolphin stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to Clymene dolphins.

Common Dolphin

Modeling estimates predict zero takes for common dolphins based on the density estimate of zero for the Action Area. Density estimates of zero do not necessarily indicate the absence of animals, but may reflect the rarity of animals in the area. Through the consultation process and the implementation of mitigation measures (see **Chapter 11**) to further reduce the potential for effects to marine mammals.

Given their gregarious behavior and large group size of up to thousands of animals (Jefferson et al. 1993), it is likely that lookouts would detect a group of common dolphins at the surface. Implementation of mitigation measures and probability of detecting large groups of common dolphins reduce the likelihood of exposure. Thus, common dolphin exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. The best estimate of abundance for the Western North Atlantic *Delphinus* spp. stock is 120,743 individuals (Waring et al., 2008). There is no information available for western North Atlantic common dolphin stock structure (Waring et al., 2008).

Based on the best available science the Navy concludes that exposures to weatern North Atlantic common dolphins due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to common dolphins.

Fraser’s Dolphin

No modeling estimates are available for Fraser’s dolphins due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect Fraser’s dolphins since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Given their typical aggregations in large, fast-moving groups of up to several hundred animals (Jefferson and Leatherwood, 1994; Reeves et al., 1999b; Gannier, 2000), it is likely that lookouts would detect a group of Fraser’s dolphins at the surface. Implementation of mitigation measures and probability of detecting large groups of Fraser’s dolphins reduce the likelihood of exposure. Thus, Fraser’s dolphin exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.
The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. Fraser’s dolphins are currently considered as a single stock in the western North Atlantic. No abundance estimate of Fraser’s dolphins in the western North Atlantic is available (Waring et al., 2008).

Based on the best available science the Navy concludes that exposures to weatern North Atlantic Fraser’s dolphin stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to Fraser’s dolphins.

Risso’s Dolphin

The modeling results show that no Level A harassment of Risso’s dolphin would occur. The analysis results show that up to 27 incidents of exposure to the level of TTS (Level B harassment) and 2324 incidental exposures of Risso’s dolphins to non-injurious levels of acoustic harassment (Level B harassment) may occur on an annual basis (**Table 5-7**). These exposures would not necessarily occur to 2351 different individuals. The same individual could experience behavioral disruption more than once over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual Risso's dolphins experiencing Level B harassment may be fewer than 2351. The actual incidents of behavioral disruption would be reduced beyond these estimates by the mitigation measures presented in **Chapter 11**.

Given their frequent surfacing and large group size of up to several hundred animals (Leatherwood and Reeves, 1982), it is likely that lookouts would detect a group of Risso's dolphins at the surface. Implementation of mitigation measures and probability of detecting large groups of Risso's dolphins reduce the likelihood of exposure. Thus, Risso's dolphin exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. Risso's dolphins are currently considered as a single stock in the western North Atlantic. The best estimate of Risso's dolphin abundance in the western North Atlantic is 20,479 individuals (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to western North Atlantic Risso's dolphin stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to Risso's dolphins.

Melon-headed Whale

No modeling estimates are available for the melon-headed whale due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect melon-headed whales since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Melon-headed whales are typically found in large groups of between 150 and 1,500 individuals (Perryman et al., 1994; Gannier, 2002), although Watkins et al. (1997) described smaller groups of 10 to 14 individuals. These animals often log at the water's surface in large schools composed of subgroups. Given their large body size, gregarious behavior, and large group size, it is likely that lookouts would detect a group of melon-headed whales at the surface. Implementation of mitigation measures and probability of detecting large groups of melon-headed whales reduce the likelihood of exposure. Thus, melon-headed whale exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.
The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. Melon-headed whales are currently considered as a single stock in the western North Atlantic. There are no abundance estimates for melon-headed whales in the western North Atlantic (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to melon-headed whale stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to melon-headed whales.

Pygmy Killer Whale

No modeling estimates are available for the pygmy killer whale due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect pygmy killer whales since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Pygmy killer whales are typically found in groups of up to 50 individuals (Perrin et al., 2002). Given their large body size, gregarious behavior, and group size, it is likely that lookouts would detect a group of pygmy killer whales at the surface. Implementation of mitigation measures and probability of detecting groups of pygmy killer whales reduce the likelihood of exposure. Thus, pygmy killer whale exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. Pygmy killer whales are currently considered as a single stock in the western North Atlantic. There are no estimates of abundance for pygmy killer whales in the western North Atlantic (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to pygmy killer whale stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to pygmy killer whales.

False Killer Whale

No modeling estimates are available for the false killer whale due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect false killer whales since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

False killer whales may occur in groups as large as 1,000 individuals (Cummings and Fish, 1971), although groups of less than 100 are most common. Given their large body size, gregarious behavior, and group size, it is likely that lookouts would detect a group of false killer whales at the surface. Implementation of mitigation measures and probability of detecting large groups of false killer whales reduce the likelihood of exposure. Thus, false killer whale exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

There are no abundance estimates available for this species in the western North Atlantic (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to false killer whale stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to false killer whales.

Killer Whale

No modeling estimates are available for the killer whale due to lack of a density estimate for the Action Area. USWTR activities still have the potential to affect killer whales since whales may be present in the Action Area. Density estimates are not available due to the paucity of sighting data in the Action Area and vicinity. It is therefore assumed that any exposures would be far below levels predicted for species with more common occurrence.

Killer whale group size appears to vary geographically, and ranges from 10 to 40 individuals (Katona et al., 1988; O'Sullivan and Mullin, 1997). Given their large body size, gregarious behavior, and group size, it is likely that lookouts would detect a group of killer whales at the surface. Implementation of mitigation measures and probability of detecting groups of killer whales reduce the likelihood of exposure. Thus, killer whale exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. There are no estimates of abundance for killer whales in the western North Atlantic (Waring et al., 2008).

Based on best available science the Navy concludes that exposures to killer whale stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on this species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to killer whales.

Pilot Whales

The modeling results show that no Level A harassment of pilot whales would occur. The modeling results show that up to 22 incidents of exposures to the level of TTS (Level B harassment) and 1657 incidental exposures of pilot whales to non-injurious levels of acoustic harassment (Level B harassment) may occur on an annual basis (**Table 5-7**). These exposures would not necessarily occur to 1679 different individuals. The same individual could experience behavioral disruption more than once over the course of a year, particularly if the animal is resident in the area of the range. Thus, the estimated number of individual pilot whales experiencing Level B harassment may be fewer than 1679. Mitigation measures detailed in **Chapter 11** would further reduce the potential for any effect on pilot whales.

Pilot whale group size typically ranges from several to several hundred individuals (Jefferson et al., 1993). Given their large body size, gregarious behavior, and group size, it is likely that lookouts would detect a group of pilot whales at the surface. Implementation of mitigation measures and probability of detecting groups of pilot whales reduce the likelihood of exposure. Thus, pilot whale exposure indicated by the acoustic analysis is likely a conservative overestimate of actual exposures.

The Navy evaluated potential exposures to stocks based on the best estimate for each stock of marine mammal species, as published in the SARs by NMFS. The best estimate of pilot whale abundance (combined short-finned and long-finned) in the western North Atlantic is 31,139 individuals (Waring et al., 2008). Only short-finned pilot whales are anticipated in the vicinity of the Action Area.

Based on best available science the Navy concludes that exposures to pilot whale stocks due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival and would have a negligible impact on these species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures to occur to pilot whales

5.2.10 Aircraft Noise

5.2.10.1 Background on Aircraft Noise

Transmission of sound from a moving airborne source to a receptor underwater is influenced by numerous factors and has been addressed by Urick (1972), Young (1973), Richardson et al. (1995), Eller and Cavanagh (2000), Laney and Cavanagh (2000), and others. Sound is transmitted from an airborne source to a receptor underwater by four principal means: (1) a direct path, refracted upon passing through the air-water interface; (2) direct-refracted paths reflected from the bottom in shallow water; (3) lateral (evanescent) transmission through the interface from the airborne sound field directly above; and (4) scattering from interface roughness due to wave motion.

Aircraft sound is refracted upon transmission into water because sound waves move faster through water than through air (a ratio of about 0.23:1). Based on this difference, the direct sound path is totally reflected if the sound reaches the surface at an angle more than 13° from vertical. As a result, most of the acoustic energy transmitted into the water from an aircraft arrives through a relatively narrow cone with a 26°-apex angle extending vertically downward from the aircraft (**Figure 5-11**). The intersection of this cone with the surface traces a "footprint" directly beneath the flight path, with the width of the footprint being a function of aircraft altitude.

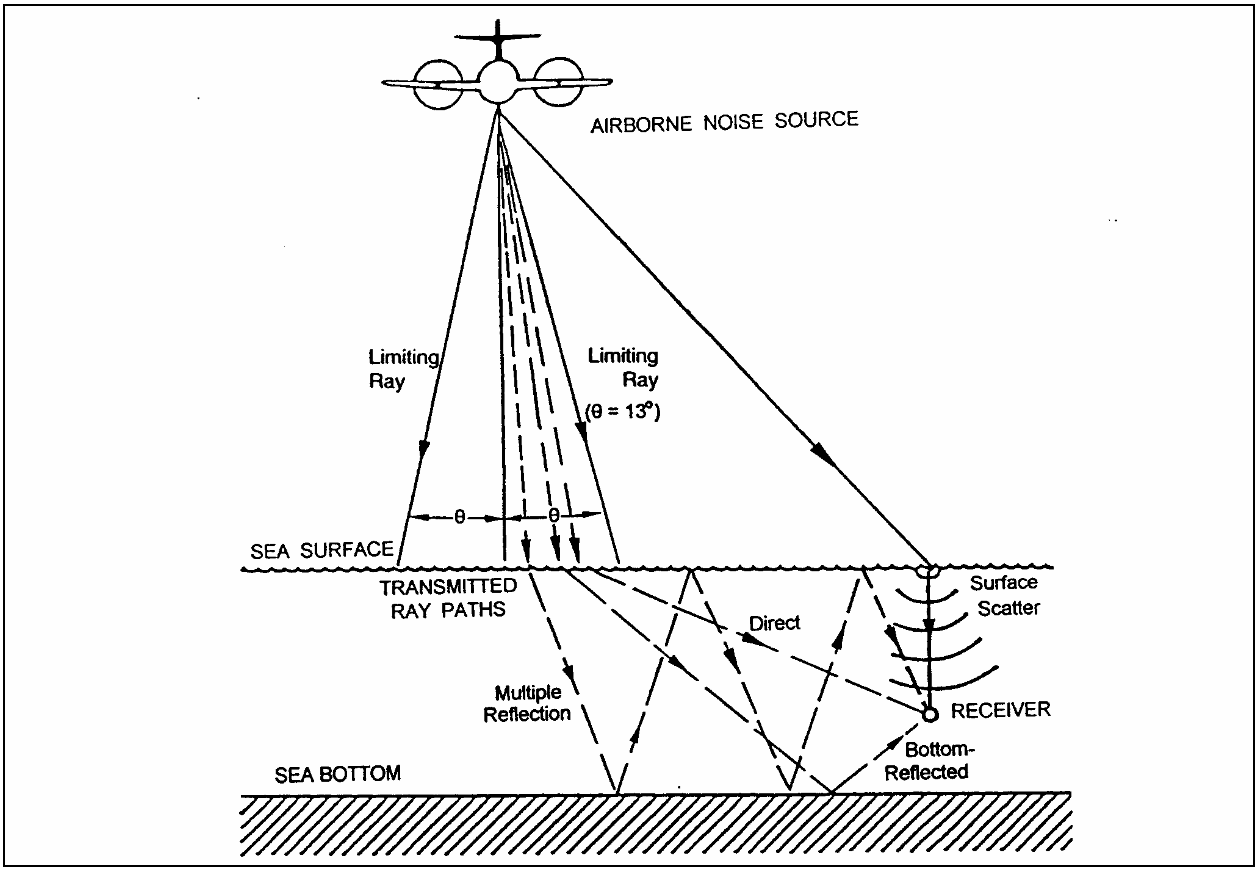

Figure 5-11. Characteristics of sound transmission through air-water interface.

The sound pressure field is actually doubled at the air-to-water interface because the large difference in the acoustic properties of water and air. For example, a sonic boom with a peak pressure of 10 pounds per square foot (psf) at the sea surface becomes an impulsive wave in water with a maximum peak pressure of 20 psf. The pressure and sound levels then decrease with increasing depth.

The effects of sounds from fixed-wing and rotary-wing aircraft are discussed in Richardson et al. (1995), and some of the more relevant information from that report is summarized below.

Spectra of radiated noise from helicopters and propeller-driven aircraft generally show multiple tones related to the rotor- or propeller-blade rate and harmonics, with most of the acoustic energy at frequencies below 500 kHz. As would be expected:

- Helicopters are generally noisier than similarly sized fixed-wing aircraft.
- Large aircraft are generally noisier than smaller ones.
- Aircraft on takeoff or in a climb tend to be noisier than when cruising at a relatively stable speed and altitude.

5.2.10.2 Aircraft Noise Effects on Marine Mammals

Exposure to fixed-wing aircraft noise would be brief (seconds) as an aircraft quickly passes overhead. Exposures would be infrequent based on the transitory and dispersed nature of the overflights; repeated exposure to individual animals over a short period of time (hours or days) is extremely unlikely. Furthermore, the sound exposure levels would be relatively low to marine mammals that spend the majority of their time underwater.

Most observations of cetacean responses to aircraft overflights are from aerial scientific surveys that involve aircraft flying at relatively low altitudes and low airspeeds. Mullin et al. (1991) reported that sperm whale reactions to aerial survey aircraft (standard survey altitude of 750 ft) were not consistent. Some sperm whales remained on or near the surface the entire time the aircraft was in the vicinity, while others dove immediately or a few minutes after the sighting.

Smultea et al. (2008) reviewed multiple observations of sperm whale reactions to aircraft. Based on this review, it was concluded that sperm whales to not react to the presence of aircraft every time and that whether a reaction occurs and what type of reaction a whale exhibits is contigent on multiple factors. Reactions included quick diving in response to a brief overflihgt and a group of sperm whales responding to a circling aircraft (altitude of 800 to 1,100 ft) by moving closer together and forming a fan-shaped semi-circle with their flukes to the center and their heads facing the perimeter. Several sperm whales in the group were observed to turn on their sides, to apparently look up toward the aircraft.

Richter et al. (2003) reported that the number of sperm whale blows per surfacing increased when recreational whale watching aircraft were present, but the changes in ventilation were small and probably of little biological consequence. The presence of whale watching aircraft also apparently caused sperm whales to turn more sharply, but did not affect blow interval, surface time, time to first click, or the frequency of aerial behavior (Richter et al., 2003).

A review of behavioral observations of baleen whales indicates that whales will either demonstrate no behavioral reaction to an aircraft or, occasionally, display avoidance behavior such as diving (Koski et al., 1998). Smaller delphinids also generally display a neutral or startle response (Würsig et al., 1998). Species, such as *Kogia* spp. and beaked whales, that show strong avoidance behaviors with ship traffic, also exhibit disturbance reactions to aircraft (Würsig et al., 1998). Although there is little information regarding reactions to aircraft overflights for other cetacean species, it is expected that reactions would be similar to those described above; either no reaction or quick avoidance behavior.

Marine mammals exposed to a low-altitude fixed-wing aircraft overflights could exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or significantly altered. The studies assessing marine mammal reaction to aircraft generally take place at low altitudes, slow speeds, and involve repeated passes over animals. Aircraft overflights associated with USWTR activities would take place at higher altitudes and would merely pass over any animals in the vicinity, reducing potential exposure. Fixed-wing aircraft overflights are not expected to result in chronic stress because it is extremely unlikely that individual animals would be repeatedly exposed to low altitude overflights.

Helicopter Overflights

Unlike fixed-wing aircraft, helicopter training operations often occur at low altitudes (75 to 100 ft), which increases the likelihood that marine mammals would respond to helicopter overflights. In addition to noise and shadowing effects, helicopters also disturb the surface of the water.

Very little data are available regarding reactions of cetaceans to helicopters. One study observed that sperm whales showed no reaction to a helicopter until the whales encountered the downdrafts from the propellers (Clarke, 1956). Other species such as bowhead whale and beluga whales show a range of reactions to helicopter overflights, including diving, breaching, change in direction or behavior, and alteration of breathing patterns, with belugas exhibiting behavioral reactions more frequently than bowheads (38% and 14% of the time, respectively) (Patenaude et al., 2002). These reactions were less frequent as the altitude of the helicopter increased to 150 m or higher.

Manatees have been shown to exhibit behavioral reactions to helicopters flying below 100 m by abandoning resting behavior and fleeing to deeper water (Rathbun, 1988); manatees are not likely to be in the offshore area where helicopter overflights will occur.

Marine mammals exposed to a low-altitude helicopter overflights could exhibit a short-term behavioral response, but not to the extent where natural behavioral patterns would be abandoned or significantly altered. Helicopter overflights are not expected to result in chronic stress because it is extremely unlikely that individual animals would be repeatedly exposed.

6.0 POTENTIAL IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

Consideration of negligible impact is required for the NMFS to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates). Overall, the conclusions in this analysis find that effects to marine mammal species and stocks would be negligible for the following reasons:

- Most exposures are within the non-injurious TTS or behavioral effects zones (Level B harassment).
- Although the numbers presented in **Table 5-6** represent estimated harassment under the MMPA, as described above, they are conservative estimates. In addition, the model calculates harassment without taking into consideration standard mitigation measures and is not indicative of a likelihood of either injury or harm.
- Additionally, the mitigation measures described in **Chapter 11** are designed to reduce exposure of marine mammals to potential impacts to achieve the least practicable adverse effect on marine mammal species or stocks.

The Navy concludes that exposures to the following marine mammal species due to USWTR activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival:

- North Atlantic right whale
- Humpback whale
- Minke whale
- *Kogia* spp.
- Beaked whale
- Rough-toothed dolphin
- Bottlenose dolphin
- Atlantic spotted dolphin
- Pantropical spotted dolphin
- Clymene dolphin
- Risso's dolphin
- Pilot whale

For species that have predicted MMPA Level A exposures (Atlantic spotted dolphin and bottlenose dolphin), the number of animals impacted is low (and anticipated to be reduced further through implementation of mitigation measures) and even permanent injury to these individuals would not result in any adverse affect to these species or stocks.

The analyses provided below present an estimate of incidental harassment for each species, and describe these estimates in the context of the overall species' population or stock. Overall, the conclusions in this section find that impacts to marine mammals would be negligible for each of the proposed alternatives for the following reasons:

- The overwhelming majority of the acoustic exposures are within the **non-injurious** TTS or behavioral effects zones (see next bullet for clarification on this issue for beaked whales).

  - No exposures to sound levels causing PTS/injury (Level A harassment) are expected to occur.

  - Although the Level B columns of **Table 5-7** estimated harassment incidents under the MMPA, as described above, they are conservative estimates of harassment by behavioral disturbance, and are not indicative of a likelihood of either injury or harm.

    - Additionally, the mitigation measures described in **Chapter 11** are designed to reduce sound exposure of marine mammals to levels below those that may cause "behavioral disruptions." These measures will be discussed with NMFS during the MMPA take authorization process.

- Note that a special case is made to account for all estimated behavioral effects on beaked whales as Level A harassment, although no direct injury to these species is predicted via the acoustic model.

- Consideration of negligible impact is required for NMFS to authorize incidental harassment of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or annual recruitment (i.e. offspring survival, birth rates). Based on each species' life history information, the expected behavioral patterns in the USWTR location, and consideration of the estimated behavioral disturbance levels, an analysis of the potential effects of the proposed action on species recruitment or survival is presented for each species. These species-specific analyses support the conclusion that proposed USWTR installation and operations would have a negligible impact on marine mammals at any of the proposed USWTR alternative sites.

Information on the species population and/or stock is provided for each species. Species are presented in order from greatest predicted number of harassment incidents to the lowest number of harassment incidents (**Table 5-5**). The population estimates for each species were taken from the NMFS stock assessments reports (Waring et al., 2004).

7.0 POTENTIAL IMPACTS ON AVAILABILITY OF SPECIES OR STOCKS FOR SUBSISTENCE USE

Potential impacts resulting from the proposed actions would not affect marine mammals that are harvested for subsistence use. Therefore, the proposed action would not have an unmitigable adverse impact on the availability of marine mammals for subsistence used identified in MMPA Section 101(a)(5)(A)(i).

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8.0 POTENTIAL IMPACTS TO MARINE MAMMAL HABITAT AND LIKELIHOOD OF RESTORATION

The primary source of effects to marine mammal habitat is exposures resulting from USWTR training activities. Sources that may affect marine mammal habitat include changes in water quality, expended materials, introduction of sound into the water column, and transiting vessels. Each of these components was considered in the USWTR EIS/OEIS and was determined to have no effect on marine mammal habitat. A summary of the conclusions are included in subsequent sections.

8.1 WATER QUALITY

The USWTR EIS/OEIS analyzed the potential effects to water quality from construction activities, sonobuoy, ADC, and Expendable Mobile Acoustic Training Target (EMATT) batteries; explosive packages associated with the explosive source sonobuoy (AN/SSQ-110A), and Otto Fuel (OF) II combustion byproducts associated with torpedoes. Expendable Bathythermographs do not have batteries and were not included in the analysis. In addition, sonobuoys were not analyzed since, once scuttled, their electrodes are largely exhausted during operations and residual constituent dissolution occurs more slowly than the releases from activated seawater batteries. As such, only the potential effects of batteries and explosions on marine water quality in and surrounding the sonobuoy operation area were completed. It was determined that there would be no significant effect to water quality from seawater batteries, lithium batteries, and thermal batteries associated with scuttled sonobuoys.

For activities related to construction, there are expected to be minimal, short-term impacts to water quality. During installation of the cable and transducer nodes, bottom sediments would be disturbed, which would result in a temporary increase in turbidity. Best management practices would be used to limit the turbidity associated with installation of the cable and transducer nodes. Long-term impacts to the water quality and currents are expected as the result of installation of the USWTR. Construction of range instrumentation would take place in three increments that would occur over a projected 9-yr period, so that the limited short-term increases in turbidity discussed in the preceding paragraph would be localized and spaced out over time.

ADCs and EMATTs use lithium sulfur dioxide batteries. The constituents in the battery react to form soluble hydrogen gas and lithium dithionite. The hydrogen gas eventually enters the atmosphere and the lithium hydroxide dissociates, forming lithium ions and hydroxide ions. The hydroxide is neutralized by the hydronium formed from hydrolysis of the acidic sulfur dioxide, ultimately forming water. Sulfur dioxide (SO_2), a gas that is highly soluble in water, is the major reactive component in the battery. The SO_2 ionizes in the water, forming bisulfite (HSO_3) that is easily oxidized to sulfate in the slightly alkaline environment of the ocean. Sulfur is present as sulfate in large quantities (i.e., 885 milligrams per liter [mg/L]) in the ocean. Thus, it was determined that there would be no significant effect to water quality from lithium sulfur batteries associated with scuttled ADCs and EMATTs.

Only a very small percentage of the available hydrogen fluoride explosive product in the explosive source sonobuoy (AN/SSQ-110A) is expected to become solubilized prior to reaching the surface and the rapid dilution would occur upon mixing with the ambient water. As such, it was determined that there would be no significant effect to water quality from the explosive product associated with the explosive source sonobuoy (AN/SSQ-110A).

OF II is combusted in the torpedo engine and the combustion byproducts are exhausted into the torpedo wake, which is extremely turbulent and causes rapid mixing and diffusion. Combustion byproducts include carbon dioxide, carbon monoxide, water, hydrogen gas, nitrogen gas, ammonia, hydrogen cyanide, and nitrogen oxides. All of the byproducts, with the exception of hydrogen cyanide, are below the U.S. Environmental Protection Agency (USEPA) water quality criteria. Hydrogen cyanide is highly soluble in seawater and dilutes below the USEPA criterion within 6.3 m (20.7 ft) of the torpedo. Therefore, it was determined there would be no significant effect to water quality as a result of OF II.

8.2 SOUND IN THE ENVIRONMENT

The potential cumulative impact issue associated with active sonar activities is the addition of underwater sound to oceanic ambient noise levels, which in turn could have potential affects on marine animals. Anthropogenic sources of ambient noise that are most likely to have contributed to increases in ambient noise levels are commercial shipping, offshore oil and gas exploration and drilling, and naval and other use of sonar (DoN, 2007h). The potential impact that mid- and high-frequency sonars may have on the overall oceanic ambient noise level are reviewed in the following contexts:

- Recent changes to ambient sound levels in the Atlantic Ocean;
- Operational parameters of the sonar operating during USWTR activities, including proposed mitigation;
- The contribution of active sonar activities to oceanic noise levels relative to other human-generated sources of oceanic noise; and
- Cumulative impacts and synergistic effects.

Sources of oceanic ambient noise, including physical, biological, and anthropogenic, are presented in Chapters 3 and 6 of the USWTR EIS/OEIS. Very few studies have been conducted to determine ambient sound levels in the ocean; however, ambient sound levels for the Eglin Gulf Test and Training Range, located in the Gulf of Mexico, generally range from approximately 40 dB to about 110 dB (USAF, 2002). In a study conducted by Andrew et al. (2002), ocean ambient sound from the 1960s was compared to ocean ambient sound from the 1990s for a receiver off the coast of California (DoN, 2007h). The data showed an increase in ambient noise of approximately 10 dB in the frequency range of 20 to 80 Hz, and 200 to 300 Hz, and about 3 dB at 100 Hz over a 33-yr period (DoN, 2007h).

Anthropogenic sound can be introduced into the ocean by a number of sources, including vessel traffic, industrial operations onshore, seismic profiling for oil exploration, oil drilling, and sonar operation. In open oceans, the primary persistent anthropogenic sound source tends to be commercial shipping, since over 90 percent of global trade depends on transport across the seas (Scowcroft et al., 2006). Moreover, there are approximately 20,000 large commercial vessels at sea worldwide at any given time. The large commercial vessels produce relatively loud and predominately low-frequency sounds. Most of these sounds are produced as a result of propeller cavitation (when air spaces created by the motion of propellers collapse) (Southall, 2005). In 2004, NOAA hosted a symposium entitled, "Shipping Noise and Marine Mammals." During Session I, Trends in the Shipping Industry and Shipping Noise, statistics were presented that indicate foreign waterborne trade into the U.S. has increased 2.45% each year over a 20-yr period (1981 to 2001) (Southall, 2005). International shipping volumes and densities are expected to continually increase in the foreseeable future (Southall, 2005). The increase in shipping volumes and densities will most likely increase overall ambient sound levels in the ocean; however, it is not known whether these increases would have an effect on marine mammals (Southall, 2005).

According to the NRC (2003), the oil and gas industry has five categories of activities which create sound: seismic surveys, drilling, offshore structure emplacement, offshore structure removal, and production and related activities. Seismic surveys are conducted using air guns, sparker sources, sleeve guns, innovative new impulsive sources and sometimes explosives, and are routinely conducted in offshore exploration and production operations in order to define subsurface geological structure. The resultant seismic data are necessary for determining drilling location and currently seismic surveys are the only method to accurately find hydrocarbon reserves. Since the reserves are deep in the earth, the low frequency band (5 to 20 Hz) is of greatest value for seismic surveys, because lower frequency signals are able to travel farther into the seafloor with less attenuation (DoN, 2007h).

The air gun firing rate is dependent on the distance from the array to the substrate. The typical intershot time is 9 to 14 s, but for very deep water surveys, inter-shot times are as high as 42 s. Air gun acoustic signals are broadband and typically measured in peak-to-peak pressures. Peak levels from the air guns are generally higher than continuous sound levels from any other ship or industrial noise. Broadband SLs of 248 to 255 dB from zero-to-peak are typical for a full-scale array. The most powerful arrays have source levels as high as 260 dB, zero-to-peak with air gun volumes of 130 L (7,900 cubic inches [in.^{3}]). Smaller arrays have SLs of 235 to 246 dB, zero-to-peak.

For deeper-water surveys, most emitted energy is around 10 to 120 Hz; however, some pulses contain energy up to 1,000 Hz (Richardson et al., 1995), and higher. Drill ship activities are one of the noisiest at-sea operations because the hull of the ship is a good transmitter of all the ship's internal noises. Also, the ships use thrusters to stay in the same location rather than anchoring. Auxiliary noise is produced during drilling activities, such as helicopter and supply boat noises. Offshore drilling structure emplacement creates some localized noise for brief periods of time, and emplacement activities can last for a few weeks and occur worldwide. Additional noise is created during other oil production activities, such as borehole logging, cementing, pumping, and pile driving. Although sound pressure levels for some of these activities have not yet been calculated, others have (e.g., pile-driving). More activities are occurring in deep water in the Gulf of Mexico and offshore west Africa areas. These oil and gas industry activities occur year-round (not individual surveys, but collectively) and are usually operational 24 hr per day and 7 days per week.

There are both military and commercial sonars: military sonars are used for target detection, localization, and classification; and commercial sonars are typically higher in frequency and lower in power and are used for depth sounding, bottom profiling, fish finding, and detecting obstacles in the water. Commercial sonar use is expected to continue to increase, although it is not believed that the acoustic characteristics will change (DoN, 2007h). Even though an animal's exposure to active sonar may be more than one time, the intermittent nature of the sonar ignal, its low duty cycle, and the fact that both the vessel and animal are moving provide a very small chance that exposure to active sonar for individual animals and stocks would be repeated over extended periods of time, such as those caused by shipping noise.

8.3 CRITICAL HABITAT

The only activity slated to take place in North Atlantic right whale critical habitat (See **Figure 3-1**) is the laying of cable associated with range installation.

The majority of impacts to critical habitat would be extremely short-term and the habitat would return to normal after construction is completed. The use of construction vehicles would add sound into the water in critical habitat. The digging of the trench would increase turbidity by adding sediment to the water; however, after the cable is buried, any disturbed sediment would be expected to settle on the sea floor again.

Disturbance of the sea floor during the installation process may alter the sea floor habitat composition, destroying existing flora and fauna. However, once the construction is complete, the sea floor will be allowed to return to its natural state. Impacts to the sea floor may be longer term in nature; however, they are unlikely to affect the function of the right whale calving ground critical habitat. Therefore, the proposed actions may alter North Atlantic right whale critical habitat, but are not anticipated to displace animals or alter the function of the habitat.

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9.0 POTENTIAL IMPACTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

Based on discussions in **Chapter 8**, marine mammal habitat will not be lost; however, it may be modified. Modifications to the water column would be short-term in nature while modifications to the sea floor may be longer-term. Potential impacts to marine mammal habitat are not anticipated to alter the function of the habitat and, therefore, will have little to no impact of marine mammal species.

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10.0 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Based on the discussion in **Chapter 7**, there are no impacts on the availability of species or stocks for subsistence use.

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11.0 MITIGATION AND PROTECTIVE MEASURES

Mitigation measures to protect marine mammals during Navy operations on the proposed USWTR are addressed in this chapter. **Section 11.1** addresses mitigation with respect to acoustical effects on marine mammals. **Section 11.2** addresses mitigation measures that would be employed during cable installation. **Section 11.3** addresses mitigation related to vessel transits (1) in the vicinity of mid-Atlantic ports during North Atlantic right whale migratory seasons and (2) in the vicinity of NMFS-designated critical habitat off the southeastern U.S. **Section 11.4** presents a discussion of other protective measures that have been considered and rejected because they: (1) are not feasible, (2) present a safety concern, (3) provide no known or ambiguous protective benefit; or (4) impact the effectiveness of the required military readiness activity.

11.1 PROTECTIVE MEASURES RELATED TO ACOUSTIC EFFECTS

Effective training on the proposed USWTR dictates that ship, submarine, and aircraft participants utilize their sensors and exercise weapons to their optimum capabilities. Recognizing that such use may cause harassment of some marine mammal species on the range (see **Chapter 4**), the Navy is seeking an LOA from NMFS pursuant to the MMPA.

In order to make the findings necessary to issue the LOA, it may be necessary for NMFS to require additional mitigation or monitoring measures beyond those addressed here. These could include measures considered but eliminated (**Section 11.4**) or measures yet to be developed.

11.1.1 Personnel Training

Navy shipboard lookout(s) are highly qualified and experienced marine observers. At all times, the shipboard lookouts are required to sight and report all objects found in the water to the OOD. Objects (e.g., trash, periscope) or disturbances (e.g., surface disturbance, discoloration) in the water may indicate a threat to the vessel and its crew. Navy lookouts undergo extensive training to qualify as a watchstander. This training includes on-the-job instruction under the supervision of an experienced watchstander, followed by completion of the PQS program, certifying that they have demonstrated the necessary skills to detect and report partially submerged objects. In addition to these requirements, many watchstanders periodically undergo a two-day refresher training course.

Marine mammal mitigation training for those who would use the proposed USWTR is a key element of the mitigation measures. The goal of this training is twofold:

- That USWTR personnel understand the details of the mitigation measures and be competent to carry out these measures;

- That key personnel onboard Navy platforms exercising in the proposed USWTR understand the mitigation measures and be competent to carry them out.

For the past few years, the Navy has implemented marine mammal spotter training for its bridge lookout personnel on ships and submarines. This training has been revamped and updated as the MSAT and is provided to all applicable units. The lookout training program incorporates MSAT, which addresses the lookout's role in environmental protection, laws governing the protection of marine species, Navy stewardship commitments, and general observation information, including more detailed information for spotting marine mammals. MSAT has been reviewed by NMFS and acknowledged as suitable training. MSAT would also be provided to the following personnel:

- **Bridge personnel on ships and submarines** – Personnel would continue to use the current marine mammal spotting training and any updates.

- **Aviation units** – Pilots and air crew personnel whose airborne duties during ASW operations include searching for submarine periscopes would be trained in marine mammal spotting. These personnel would also be trained on the details of the mitigation measures specific to both their platform and that of the surface combatants with which they are operating.

- **Sonar personnel on ships, submarines, and ASW aircraft** – Sonar operators aboard ships, submarines, and aircraft operating on the proposed USWTR would be trained in the details of the mitigation measures relative to their platform. Training would also target the specific actions to be taken if a marine mammal is observed.

11.1.2 Procedures

The following procedures would be implemented to maximize the ability of operators to recognize instances when marine mammals are in the vicinity.

11.1.2.1 General Maritime Protective Measures: Personnel Training

- All lookouts aboard platforms involved in ASW training activities would review the MSAT material prior to using active sonar.

- All commanding officers, executive officers, and officers standing watch on the bridge would have reviewed the MSAT material prior to a training activity that employs the use of active sonar.

- Navy lookouts would undertake extensive training in order to qualify as a watchstander in accordance with the Lookout Training Handbook (Naval Education and Training Command Manual [NAVEDTRA] 12968-B).

- Lookout training would include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, lookouts would complete the PQS program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects). This does not forbid personnel being trained as lookouts from inclusion in previous measures as long as supervisors monitor their progress and performance.

- Lookouts would be trained to quickly and effectively communicate within the command structure in order to facilitate implementation of mitigation measures if marine mammals are spotted.

11.1.2.2 General Maritime Protective Measures: Lookouts and Watchstander Responsibilities

- On the bridge of surface ships, there would always be at least three personnel on watch whose duties include observing the water surface around the vessel.

- In addition to the three personnel on watch, all surface ships participating in ASW exercises would have at least two additional personnel on watch at all times during the exercises.
- Personnel on lookout and officers on watch on the bridge would have at least one set of binoculars available for each person to aid in the detection of marine mammals.

- On surface vessels equipped with active sonar, pedestal-mounted “Big Eye” (20 x 110) binoculars would be present and would be maintained in good working order to assist in the detection of marine mammals near the vessel.

- Personnel on lookout would follow visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-B).

- Surface lookouts would scan the water from the ship to the horizon and be responsible for all contacts in their sector. In searching the assigned sector, the lookout would always start at the forward part of the sector and search aft (toward the back). To search and scan, the lookout would hold the binoculars steady so the horizon is in the top third of the field of vision and direct their eyes just below the horizon. The lookout would scan for approximately five seconds in as many small steps as possible across the field seen through the binoculars. They would search the entire sector through the binoculars in approximately five-degree steps, pausing between steps for approximately five seconds to scan the field of view. At the end of the sector search, the glasses would be lowered to allow the eyes to rest for a few seconds, and then the lookout would search back across the sector with the naked eye.

- After sunset and prior to sunrise, lookouts would employ Night Lookout Techniques in accordance with the Lookout Training Handbook.

- At night, lookouts would not sweep the horizon with their eyes, because eyes do not see well when they are moving. Lookouts would scan the horizon in a series of movements that would allow their eyes to come to periodic rests as they scan the sector. When visually searching at night, they would look a little to one side and out of the corners of their eyes, paying attention to the things on the outer edges of their field of vision.

- Personnel on lookout would be responsible for informing the OOD of all objects or anomalies sighted in the water (regardless of the distance from the vessel), since any object or disturbance (e.g., trash, periscope, surface disturbance, discoloration) in the water may indicate a threat to the vessel and its crew or the presence of a marine species that may need to be avoided, as warranted.

11.1.2.3 Operating Procedures

- COs would make use of marine species detection cues and information to limit interaction with marine mammals to the maximum extent possible, consistent with the safety of the ship.

- All personnel engaged in passive acoustic sonar operation (including aircraft, surface ships, or submarines) would monitor for marine mammal vocalizations and report the detection of any marine mammal to the appropriate watch station for dissemination and appropriate action. The Navy can detect sounds within the human hearing range due to an operator listening to the incoming sounds. Passive acoustic detection systems are used during all ASW activities.

- Units shall use training lookouts to survey for marine mammals prior to commencement and during the use of active sonar.

- During operations involving active sonar, personnel would use all available sensor and optical systems (such as night vision goggles) to aid in the detection of marine mammals.

- Navy aircraft participating in exercises at sea would conduct and maintain, when operationally feasible and safe, surveillance for marine mammals as long as it does not violate safety constraints or interfere with the accomplishment of primary operational duties.

- Aircraft with deployed sonobuoys would use only the passive capability of sonobuoys when marine mammals are detected within 183 m (200 yd) of the sonobuoy.

- Marine mammal detections by aircraft would be immediately reported to the assigned Aircraft Control Unit (if participating) for further dissemination to ships in the vicinity of the marine species. This action would occur when it is reasonable to conclude that the course of the ship will likely close the distance between the ship and the detected marine mammal.

- Safety zones would prevent exposure to sound levels greater than the lowest mean of the dose-function criteria (**Section 5.2.3**). When marine mammals are detected by any means (aircraft, shipboard lookout, or acoustically) within 914 m (1,000 yd) of the sonar dome (the bow), the ship or submarine would limit active transmission levels to at least 6 dB below normal operating levels.

- Ships and submarines would continue to limit maximum transmission levels by this 6 dB factor until the animal has been seen to leave the area, has not been detected for 30 min, or the vessel has transited more than 1,828 m (2,000 yd) beyond the location of the last detection.

- Should a marine mammal be detected within 457 m (500 yd) of the sonar dome, active sonar transmissions would be limited to at least 10 dB below the equipment's normal operating level. Ships and submarines would continue to limit maximum ping levels by this 10 dB factor until the animal has been seen to leave the area, has not been detected for 30 min, or the vessel has transited more than 1,828 m (2,000 yd) beyond the location of the last detection.

- Should the marine mammal be detected within 183 m (200 yd) of the sonar dome, active sonar transmissions would cease. Sonar would not resume until the animal has been seen to leave the area, has not been detected for 30 min, or the vessel has transited more than 1,828 m (2,000 yd) beyond the location of the last detection.

- If the need for power-down should arise, as detailed above, Navy staff would follow the requirements as though they were operating at 235 dB - the normal operating level (i.e., the first power-down would be to 229 dB, regardless of the level above 235 dB the sonar was being operated).

- Prior to start up or restart of active sonar, operators would check that the safety zone radius around the sound source is clear of marine mammals.

- Sonar levels (generally) – The Navy would operate sonar at the lowest practicable level, not to exceed 235 dB, except as required to meet tactical training objectives.

- Helicopters would observe/survey the vicinity of an ASW exercise for 10 min before the first deployment of active (dipping) sonar in the water.

- Helicopters would not dip their sonar within 183 m (200 yd) of a marine mammal and would cease pinging if a marine mammal closes within 183 m (200 yd) after pinging has begun.

- Submarine sonar operators would review detection indicators of close-aboard marine mammals prior to the commencement of ASW operations involving active sonar.

11.1.2.4 Special Conditions Applicable for Bow-Riding Dolphins

If, after conducting an initial maneuver to avoid close quarters with dolphins, the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel's bow wave, no further mitigation actions are necessary. While in the shallow-wave area of the vessel bow, dolphins are out of the main transmission axis of the active sonar.

11.1.2.5 Potential Protective Measures under Development

The Navy is working to develop the capability to detect and localize vocalizing marine mammals using the installed sensor nodes on the USWTR. Based on the current status of acoustic monitoring science, the Navy is not yet capable of using the system nodes as a mitigation measure; however, as this science develops, it will be incorporated into the USWTR mitigation plan.

The Navy is also actively engaged in acoustic monitoring research involving a variety of methodologies (e.g., underwater gliders); to date, none of the methodologies have been developed to the point where they could be used as an actual mitigation tool. The Navy would continue to coordinate passive monitoring and detection research specific to the proposed USWTR. As technology and methodologies become available, their applicability and viability would be evaluated for incorporation into the mitigation plan.

11.2 PROTECTIVE MEASURES RELATED TO CABLE INSTALLATION AT SEA

The following measures would be taken during cable installation to ensure that no marine mammal or sea turtle would be affected.

- Lookouts would be on all vessels participating in the cable installation process.

- Observers would ensure that the cable installation process does not interfere with or entangle any marine mammal.

11.3 PROTECTIVE MEASURES RELATED TO VESSEL TRANSIT AND NORTH ATLANTIC RIGHT WHALES

The proposed USWTR would involve vessel movements from homeports along the eastern U.S. from Connecticut to Florida. The Navy recognizes the potential for interaction (ship strike) with North Atlantic right whales during vessel transits to and from homeports and the proposed USWTR, as well as during range activities. Therefore, Navy protective measures for both the Mid-Atlantic region and the Southeast region of the U.S. are detailed in this section.

11.3.1 Mid-Atlantic, Offshore of the Eastern United States

For purposes of these measures, the mid-Atlantic is defined broadly to include ports south and east of Block Island Sound southward to South Carolina. The procedure described below would be established as protective measures for Navy vessel transits during North Atlantic right whale migratory seasons near ports located off the western North Atlantic, offshore of the eastern U.S. The mitigation measures would apply to all Navy vessel transits, including those vessels that would transit to and from the proposed USWTR.

Seasonal migration of North Atlantic right whales is generally described by NMFS as occurring from October 15 through April 30, when the whales migrate between feeding grounds farther north and calving grounds farther south. The Navy mitigation measures have been established in accordance with rolling dates identified by NMFS consistent with these seasonal patterns.

NMFS has identified ports located in the western Atlantic Ocean, offshore of the eastern United States, where vessel transit during North Atlantic right whale migration is of highest concern for potential ship strike. The ports include the Hampton Roads entrance to the Chesapeake Bay, which includes the concentration of Atlantic Fleet vessels in Norfolk, Virginia. Navy vessels are required to use extreme caution and operate at a slow, safe speed consistent with mission and safety during the months indicated in **Table 11-1** and within a 37 km (20 nm) arc (except as noted) of the specified reference points.

- During the months indicated in **Table 11-1**, Navy vessels would practice increased vigilance with respect to avoidance of vessel-whale interactions along the mid-Atlantic coast, including transits to and from any mid-Atlantic ports not specifically identified below.

- All surface(d) units transiting within 56 km (30 NM) of the coast in the mid-Atlantic would ensure at least two watchstanders are posted, including at least one lookout that has completed required MSAT training.

- Navy vessels would not knowingly approach any whale head on and would maneuver to keep at least 457 m (500 yd) away from any observed whale, consistent with vessel safety.

Table 11-1
Locations and Time Periods when Navy Vessels are required to Reduce Speeds (Relevant to North Atlantic Right Whales)

Region	Months	Port Reference Points
South and East of Block Island, Rhode Island	Sep-Oct and Mar-Apr	37 km (20 nm) seaward of line between 41-4.49N 071-51.15W and 41-18.58N 070-50.23W
New York/New Jersey	Sep-Oct and Feb-Apr	40-30.64N 073-57.76W
Delaware Bay (Philadelphia)	Oct-Dec and Feb-Mar	38-52.13N 075-1.93W
Chesapeake Bay (Hampton Roads and Baltimore)	Nov-Dec and Feb-Apr	37-1.11N 075-57.56W
North Carolina	Dec-Apr	34-41.54N 076-40.20W
South Carolina	Oct-Apr	33-11.84N 079-8.99W 32-43.39N 079-48.72W

11.3.2 Southeast Atlantic, Offshore of the Eastern United States

For purposes of these measures, the southeast encompasses sea space from Charleston, South Carolina, southward to Sebastian Inlet, Florida, and from the coast seaward to 148 km (80 NM) from shore. The mitigation measures described in this section were developed specifically to protect the North Atlantic right whale during its calving season (typically from December 1 through March 31). During this period, North Atlantic right whales give birth and nurse their calves in and around federally designated critical habitat off the coast of Georgia and Florida. This critical habitat is the area from 31-15 °N to 30-15°N extending from the coast out to 28 km (15 NM), and the area from 28-00°N to 30-15°N from the coast out to 9 km (5 NM). All mitigation measures that apply to the critical habitat also apply to an associated area of concern which extends 9 km (5 NM) seaward of the designated critical habitat boundaries.

Prior to transiting or training in the critical habitat or associated area of concern, ships would contact FACSFAC JAX, to obtain latest whale sighting and other information needed to make informed decisions regarding safe speed and path of intended movement. Subs would contact Commander, Submarine Group Ten for similar information.

Specific mitigation measures related to activities occurring within the critical habitat or associated area of concern include the following:

- When transiting within the critical habitat or associated area of concern, vessels would exercise extreme caution and proceed at a slow safe speed. The speed would be the slowest safe speed that is consistent with mission, training, and operations.

- Speed reductions (adjustments) are required when a whale is sighted by a vessel or when the vessel is within 9 km (5 NM) of a reported sighting less then 12 hr old.

- Additionally, circumstances could arise where, in order to avoid North Atlantic right whale(s), speed reductions could mean vessel must reduce speed to a minimum at which it can safely keep on course or vessels could come to an all stop.

- Vessels would avoid head-on approach to North Atlantic right whale(s) and would maneuver to maintain at least 457 m (500 yd) of separation from any observed whale if deemed safe to do so. These requirements would not apply if a vessel's safety is threatened, such as when change of course would create an imminent and serious threat to person, vessel, or aircraft, and to the extent vessels are restricted in the ability to maneuver.

- Ships would not transit through the critical habitat or associated area of concern in a North-South direction.

- Ship, surfaced subs, and aircraft would report any whale sightings to FACSFAC JAX, by most convenient and fastest means. Sighting report would include the time, latitude/longitude, direction of movement and number and description of whale(s) (i.e., adult/calf).

11.4 ALTERNATIVE PROTECTIVE MEASURES CONSIDERED BUT ELIMINATED

As described in **Chapter 5**, the vast majority of estimated sound exposures of marine mammals on the proposed USWTR would not cause injury. Potential acoustic effects on marine mammals would be further reduced by the protective measures described above. Therefore, the Navy concludes that the proposed protective measures would achieve the least practicable adverse impact on species or stocks of marine mammals.

A determination of “least practicable adverse impacts” includes consideration of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity in consultation with the DoD. Therefore, the following additional mitigation measures were analyzed and eliminated from further consideration:

- Reduction of training.

  - The requirements for training have been developed through many years of iteration to ensure sailors achieve levels of readiness to ensure they are prepared to properly respond to the many contingencies that may occur during an actual mission. These training requirements are designed to provide the experience needed to ensure sailors are properly prepared for operational success.

  - There is no extra training built in to the plan, as this would not be an efficient use of the resources needed to support the training (e.g., fuel, time). Therefore, any reduction of training would not allow sailors to achieve satisfactory levels of readiness needed to accomplish their mission.

- Use of ramp-up to attempt to clear the range prior to the conduct of exercises.

  - Ramp-up procedures, (slowly increasing the sound in the water to necessary levels), are not a viable alternative for training exercises because the ramp-up would alert opponents to the presence of participants. This affects the realism of training in that the target submarine would be able to detect the searching unit prior to themselves being detected, enabling them to take evasive measures. This would insert a significant anomaly to the training, affecting its realism and effectiveness.

  - Though ramp-up procedures have been used in testing, the procedure is not effective in training sailors to react to tactical situations, as it provides an unrealistic advantage by alerting the target. Using these procedures would not allow the Navy to conduct realistic training, or “train as they fight,” thus adversely impacting the effectiveness of the military readiness activity.

- Visual monitoring using third-party observers from air or surface platforms, in addition to the existing Navy-trained lookouts.

  - The use of third-party observers would compromise security due to the requirement to provide advance notification of specific times/locations of Navy platforms.

- Reliance on the availability of third-party personnel would also impact training flexibility, thus adversely affecting training effectiveness. The presence of other aircraft in the vicinity of naval exercises would raise safety concerns for both the commercial observers and naval aircraft.

- Use of Navy observers is the most effective means to ensure quick and effective implementation of mitigation measures if marine species are spotted.

- Navy personnel are extensively trained in spotting items on or near the water surface. Navy spotters receive more hours of training, and use their spotting skills more frequently, than many third-party trained personnel. Another critical skill set of effective Navy training is communication. Navy lookouts are trained to act swiftly and decisively to ensure that the appropriate actions are taken.

- Crew members participating in training activities involving aerial assets have been specifically trained to detect objects in the water. The crew's ability to sight from both surface and aerial platforms provides excellent survey capabilities using the Navy's existing exercise assets.

- Security clearance issues would have to be overcome to allow non-Navy observers onboard exercise participants.

- Some training events will span one or more 24-hr periods, with operations underway continuously in that timeframe. It is not feasible to maintain non-Navy surveillance of these operations, given the number of non-Navy observers that would be required onboard.

- Surface ships having active mid-frequency sonar have limited berthing capacity. As exercise planning includes careful consideration of this limited capacity in the placement of exercise controllers, data collection personnel, and Afloat Training Group personnel on ships involved in the exercise. Inclusion of non-Navy observers onboard these ships would require that in some cases there would be no additional berthing space for essential Navy personnel required to fully evaluate and efficiently use the training opportunity to accomplish the exercise objectives.

- The vast majority (90%) of USWTR training events involves an aerial asset with crews specifically training to hone their detection of objects in the water, and the capability of sighting from both surface and aerial platforms provides excellent survey capabilities using the Navy's existing exercise assets.

● Surveying the USWTR prior to initiating exercises to ensure that the area is devoid of marine mammals.

  - Contiguous ASW events may cover many square miles. The number of civilian ships and/or aircraft required to monitor the area of these events would be considerable. It is not feasible to survey or monitor the large exercise areas in the time required ensuring these areas are devoid of marine mammals. Also, since marine mammals are likely to move freely into or out of an area, surveys done prior to an event could easily become irrelevant.

  - Survey during an event raises safety issues with multiple, slow civilian aircraft operating in the same airspace as military aircraft engaged in combat training activities. In addition, most of the training events take place far from land, limiting both the time available for civilian aircraft to be in the exercise area and presenting a concern should aircraft mechanical problems arise.

  - Scheduling civilian vessels or aircraft to coincide with training events would impact training effectiveness, since exercise event timetables cannot be precisely fixed and are instead based on the free-flow development of tactical situations. Waiting for civilian aircraft or vessels to complete surveys, refuel, or be on station would slow the unceasing progress of the exercise and impact the effectiveness of the military readiness activity.

- Reducing or securing power during the following conditions.

  - Low-visibility/night training: The Navy must train in the same manner as it will fight. Reducing or securing power in low-visibility conditions would affect a commander's ability to develop this tactical picture as well as not provide the needed training realism. Training differently than what would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities.

  - Strong surface duct: The Navy must train in the same manner as it will fight. As described above, the complexity of ASW requires the most realistic training possible for the effectiveness and safety of the sailors. Reducing power in strong surface duct conditions would not provide this training realism because the unit would be operating differently than it would in a combat scenario, reducing training effectiveness and the crew's ability. Additionally, water conditions on USWTR may change rapidly, resulting in continually changing mitigation requirements, resulting in a focus on mitigation versus training.

- Vessel speed: Establish and implement a set vessel speed.

  - Navy personnel are required to use extreme caution and operate at a slow, safe speed consistent with mission and safety. Ships and submarines need to be able to react to changing tactical situations in training as they would in actual combat. Placing arbitrary speed restrictions would not allow them to properly react to these situations.

  - Training differently than what would be needed in an actual combat scenario would decrease training effectiveness and reduce the crew's abilities.

- Increasing power down and shut down zones.

  - The current power down zones of 457 and 914 m (500 and 1,000 yd), as well as the 183 m (200 yd) shut down zone were developed to minimize exposing marine mammals to sound levels that could cause TTS or PTS, levels that are supported by the scientific community. Implementation of the safety zones discussed above will prevent exposure to sound levels greater than 195 dB re 1μPa for animals sighted.

  - The safety range the Navy has developed is also within a range sailors can realistically maintain situational awareness and achieve visually during most conditions at sea.

- Using active sonar with output levels as low as possible consistent with mission requirements and use of active sonar only when necessary.

  - Operators of sonar equipment are always cognizant of the environmental variables affecting sound propagation. In this regard, the sonar equipment power levels are always set consistent with mission requirements.

  - Active sonar is only used when required by the mission since it has the potential to alert opposing forces to the sonar platform's presence. Passive sonar and all other sensors are used in concert with active sonar to the maximum extent practicable when available and when required by the mission.

- Reporting marine mammal sightings to augment scientific data collection.

  - Ships, submarines, aircraft, and personnel engaged in training events are intensively employed throughout the duration of the exercise. Their primary duty is accomplishment of the exercise goals, and they should not be burdened with additional duties unrelated to that task. Any additional workload assigned that is unrelated to their primary duty would adversely impact the effectiveness of the military readiness activity they are undertaking.

12.0 MONITORING AND REPORTING

The Navy is committed to demonstrating environmental stewardship while executing its National Defense mission and is responsible for compliance with a suite of Federal environmental and natural resources laws and regulations that apply to the marine environment. A number of monitoring plans are currently being developed for protected marine species (primarily marine mammals and sea turtles) as part of the environmental planning and regulatory compliance process associated with a variety of training actions and range complexes. The purpose of these monitoring plans is to assess the effects of training activities on marine species. The primary focus of these monitoring plans will be on effects to individuals but data may also support investigation of potential population-level trends in marine species distribution, abundance, and habitat use in various range complexes and geographic locations where Navy training occurs.

The Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species in order to establish the overarching framework and oversight that will facilitate the collection and synthesis of information and data from the various monitoring efforts being implemented. The Program will compile data from range-specific monitoring efforts as well as research and development (R&D) studies that are fully or partially Navy-funded. While the ICMP is not a regulatory requirement, it will facilitate the synthesis of information across multiple monitoring efforts and help to coordinate the most efficient use of limited resources in order to address monitoring concerns navy-wide. Although the ICMP is intended to apply to all Navy training, use of MFA sonar in training, testing, and research, development, test, and evaluation (RDT&E) will comprise a major component of the overall program.
The primary objectives of the ICMP are

- To monitor Navy training exercises, particularly those involving active sonar and underwater detonations, for compliance with the terms and conditions of ESA Section 7 consultations or MMPA authorizations;

- To minimize exposure of protected species to sound levels from active sonar or sound pressure levels from underwater detonations currently considered to result in harassment;

- To collect data to support estimating the number of individuals exposed to sound levels above current regulatory thresholds;

- To document trends in species distribution and abundance in Navy training areas through focused longitudinal monitoring efforts;

- To add to the knowledge base on potential behavioral and physiological effects to marine species from active sonar and underwater detonations;

- To assess the efficacy of the Navy's current marine species mitigation;

- To assess the practicality and effectiveness of potential future mitigation tools and techniques.

The ICMP will provide a comprehensive structure and serve as the basis for establishing monitoring plans for individual range complexes and specific training activities. Specific training exercise plans will be focused on short-term monitoring and mitigation for individual training activities. Each training event taking place at the USWTR will be evaluated to determine if it represents an appropriate monitoring opportunity within the ICMP framework. Due to the scale (spatial, temporal, and operational) of various training activities, not every event will present optimum opportunity for concentrated monitoring and as a result various levels of effort and resources will be associated with individual exercises. The overall approach of the ICMP is to target the majority of available monitoring resources on a limited number of opportunities with best potential for high quality data collection rather than attempting to apply a thin blanket of monitoring over the entirety of Navy training. Despite this variability in monitoring effort, the standard mitigation presented in **Chapter 11** will remain a constant component of all training activities on the USWTR.

Data collection methods will be standardized across the program to the extent possible to provide the best opportunity for pooling data from multiple regions. Some methods may be universally applicable; however, some may be utilized only in specific locations where conditions are most appropriate. For example, in Hawaii, there is significant baseline data on odontocetes from tagging, which can be used to provide context for tagging data collected during training events. The navy's overall monitoring approach will seek to leverage and build upon existing research efforts whenever possible.

By using a combination of monitoring techniques or tools appropriate for the species of concern, the type of training activities conducted, sea state conditions, and the appropriate spatial extent, the detection, localization, and observation of marine species can be optimized and return on the monitoring investment can be maximized in terms of data collection and mitigation effectiveness evaluation. The ICMP will evaluate the range of potential monitoring techniques that can be tailored to any Navy range or exercise and the appropriate species of concern. The primary tools available for monitoring generally include the following:

- Visual Observations – Surface vessel and aerial survey platforms can provide data on both long term population trends (abundance and distribution) as well as occurrence immediately before, during, and after training events. In addition, visual observation has the potential to collect information related to behavioral response of marine species to Navy training activities. Both Navy personnel (watchstanders) and independent visual observers (Navy biologists and/or contractors) will be used from a variety of platforms (both navy and third-party) will be utilized, as appropriate and logistically feasible.

- Passive Acoustic Monitoring – Autonomous Acoustic Recorders (moored buoys), High Frequency Acoustic Recording Packages (HARPS), sonobuoys, passive acoustic towed arrays, shipboard passive sonar, and Navy Instrumented Acoustic Ranges can provide data on presence/absence as well as localization, identification and tracking in some cases. Passive acoustic observations are particularly important for species that are difficult to detect visually or when conditions limit the effectiveness of visual monitoring. The array of passive hydrophones at USWTR presents a relatively unique opportunity to take advantage of infrastructure that would otherwise not be available for monitoring such a large area. The Marine Mammal Monitoring on Navy Ranges (M3R) program takes advantage of this opportunity and may support long-term data collection at specific fixed sites.

- Tagging is an important tool for examining the movement patterns and diving behavior of cetaceans. Sensors can be used that measure location, swim velocity, orientation, vocalizations, as well as record received sound levels. Tagging with sophisticated digital acoustic recording tags (D-tags) may also allow direct monitoring of behaviors not readily apparent to surface observers. D-tags have recently been deployed as part of a behavioral response study (BRS-07) initiated at the Atlantic Undersea Test and Evaluation Center (AUTEC) range in the Bahamas to begin identifying behavioral mechanisms related to anthropogenic sound exposure.

- Photo identification contributes to understanding of movement patterns and stock structure which is important to determine how potential effects may relate to individual stocks or populations.

- Oceanographic and environmental data collection – Physical and environmental data related to habitat parameters is necessary for analyzing distribution patterns, developing predictive habitat and density models, and better understanding habitat use.

In addition, the ICMP framework proposes that the Navy will continue to collaborate with and incorporate data from studies of behavioral response, abundance, distribution, habitat utilization, etc. for species of concern using a variety of methods which may include visual surveys, passive and acoustic monitoring, radar and data logging tags (to record data on acoustics, diving and foraging behavior, and movements). This work will help to build the collective knowledgebase on the geographic and temporal extent of key habitats and provide baseline information to account for natural perturbations such as El Niño or La Niña events as well as establish baseline information to determine the spatial and temporal extent of reactions to Navy operations, or indirect effects from changes in prey availability and distribution. Both the Office of Naval Research and Chief of Naval Operations are heavily involved in supporting a variety of ongoing research efforts (summarized below) including the recent Behavioral Response Study (BRS-07) conducted at AUTEC during the summer of 2007.

12.1 BASELINE MONITORING PROGRAM

The Navy recognizes that shallow water ASW training activities concentrated at the USWTR may have the potential to cause long-term effects to marine mammals. Because data concerning physiological and behavioral effects and long-term modifications of habitat use are extremely limited at this time, the Navy is developing and has begun implementing a longitudinal baseline monitoring program to assess potential effects to marine mammals both at the individual and population level on the USWTR.

In 2005, the Navy contracted with a consortium of researchers from Duke University, the University of North Carolina at Wilmington, the University of St. Andrews, and the NMFS NEFSC to conduct a pilot study analysis and subsequently develop a survey and monitoring plan that prescribes the recommended approach for data collection including surveys (aerial/shipboard, frequency, spatial extent, etc.), passive acoustic monitoring, photo identification and data analysis (standard line-transect, spatial modeling, etc.) necessary to establish a fine-scale seasonal baseline of protected species distribution and abundance. This baseline study will provide the foundation for establishing a monitoring program designed to provide meaningful data on potential long term effects to marine species that may be chronically exposed to training activities on the USWTR.

The researchers initially investigated the use of a Before-After Control-Impact Paired (BACI-P) study design in which monitoring surveys would commence in both the USWTR and a paired control site before training exercises commenced and then continue in both areas after the range became operational. To determine whether this approach could reliably detect an effect of training activities within the proposed USWTR, the movement and behavioral responses of a number of species were simulated over the eastern Atlantic seaboard of the U.S. to determine whether avoidance or fatal exposure (as a worse case scenario) to active sonar in the USWTR could be detected statistically given a realistic level of monitoring.

The results of this simulation modeling (Paxton et al., 2005) indicated that it would be difficult, if not impossible, to detect demographic effects of the USWTR (if any should occur) at realistic sampling intensities. In fact, in the absence of daily sampling, reliable detection of even the worst possible effects of the USWTR was deemed unlikely. Therefore, the initial approach of the program places emphasis on documenting species occurrence, developing more precise density estimates, and establishing residency characteristics so that patterns of use for species inhabiting the USWTR area prior to the commencement of training exercises can be better understood. Only with this improved level of knowledge and understanding can any meaningful assessment of long-term effects be made.

The baseline data collection portion of the program began in June 2007 at the Onslow Bay alternative site and includes coordinated aerial, shipboard, and passive acoustic surveys as well as deployment of HARPs to supplement the traditional visual surveys. A parallel program is currently being initiated at the Jacksonville preferred alternative site. This intensive data collection effort will continue through range construction until ASW training begins. The overall monitoring approach will be reevaluated on an annual basis in order to provide the opportunity for modifications which could potentially increase the overall value of the data being collected. Complete details on the baseline monitoring effort can be found in the monitoring plan technical report (Read et al., 2007).

As the range becomes operational, the data collected through the initial years of baseline effort will be evaluated in order to determine the most effective approach to monitoring individuals and populations for potential effects as a result of ASW training activities on the range. It is anticipated that reliance on dedicated visual surveys would be reduced in favor of passive acoustic methods (M3R) that are currently in development and show significant promise.

12.2 PASSIVE ACOUSTIC MONITORING

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals on instrumented ranges. The workshops brought together acoustic experts and marine biologists from Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods on ranges such as USWTR in the future. Acoustic detection, identification, localization, and tracking of individual animals still requires a significant amount of research effort to be considered a reliable method for marine mammal monitoring.

At present the Navy-supported M3R program represents the most promising effort investigating the utility of passive acoustic monitoring specifically associated with Navy instrumented training ranges. The main objective of the M3R project is to develop a toolset for passive detection, localization, and tracking of marine mammals using existing Navy undersea range infrastructure. The project is funded by the Office of Naval Research (ONR) and Chief of Naval Operations as an effort to provide an effective means of studying marine mammals in natural, open ocean environments.

M3R has successfully developed and tested a suite of signal processing tools that can automatically detect and track marine mammals in real-time using Navy range facilities at both AUTEC and Southern California Offshore Range (SCORE). The M3R toolset allows automated collection of data previously unavailable for the long-term monitoring of the acoustic behavior of marine mammals within their natural environment. Ongoing research applications of the M3R system include the ability to remotely estimate marine mammal abundance, assessment of acoustic behavioral baselines, and evaluation of effectc of anthropogenic noise by comparison to those baselines. As these capabilities continue to be developed and mature they may will integrated into the overall monitoring strategy for the USWTR.

12.3 REPORTING

The Navy will coordinate with the appropriate NMFS stranding network coordinator for any unusual marine mammal behavior and any stranding, beached live/dead or floating marine mammals that may occur at any time during or within 24 hr after completion of active sonar use associated with ASW training activities. The Navy would submit a report to the NMFS-OPR within 120 days of the completion of a Major Exercise. This report would contain a discussion of the nature of the effects, if observed, based on both modeled results of real-time events and sightings of marine mammals.

In combination with previously discussed mitigation and protective measures (**Chapter 11**), exercise-specific implementation plans developed under the ICMP will ensure thorough monitoring and reporting of USWTR training activities. A Letter of Instruction, Mitigation Measures Message, or Environmental Annex to the Operational Order will be issued prior to each exercise to further disseminate the personnel training requirement and general marine mammal protective measures including monitoring and reporting.

13.0 RESEARCH

The Navy provides a significant amount of funding and support to marine research. In 2008 the agency provided over $26 million to universities, research institutions, Federal laboratories, private companies, and independent researchers around the world to study marine mammals. Over the past 5 yr the Navy has provided over $100 million for marine mammal research. The Navy sponsors approximately 70% of all U.S. research concerning the effects of human-generated sound on marine mammals and 50% of such research conducted worldwide. 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 effects of sound on marine mammals, sea turtles, fish, and birds, and
- Developing tools to model and estimate potential effects of sound.

This research is directly applicable to Navy training activities, particularly with respect to the investigations of the potential effects of underwater noise sources on marine mammals and other protected species. Proposed training activities employ sonar and underwater explosives, which introduce sound into the marine environment.

The Marine Life Sciences Division of the ONR currently coordinates six programs that examine the marine environment and are devoted solely to studying the effects of noise and/or the implementation of technology tools that will assist the Navy in studying and tracking marine mammals. The six programs are as follows:

1. Environmental Consequences of Underwater Sound,
2. Non-Auditory Biological Effects of Sound on Marine Mammals,
3. Effects of Sound on the Marine Environment,
4. Sensors and Models for Marine Environmental Monitoring,
5. Effects of Sound on Hearing of Marine Animals, and
6. Passive Acoustic Detection, Classification, and Tracking of Marine Mammals.

The Navy has also developed a suite of technical reports synthesizing data and information on marine resources throughout Navy OPAREA including the MRA and the NODE reports. Furthermore, population assessment cruises by the NMFS and by academic institutions have regularly received funding support from the Navy. For instance, the Navy funded a marine mammal survey in the Marinas Islands to gather information to support an environmental study in that region given there had been no effort undertaken by NMFS.

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods on instrumented ranges. However, acoustic detection, identification, localization, and tracking of individual animals still requires a significant amount of research effort to be considered a reliable method for marine mammal monitoring. The Navy supports research efforts on acoustic monitoring and will continue to investigate the feasibility of passive acoustics as a potential mitigation and monitoring tool.

Overall, the Navy will continue to support and fund ongoing marine mammal research, and is planning to coordinate long-term monitoring/studies of marine mammals on various established ranges and operating areas. The Navy will continue to research and contribute to university/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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