FINAL
REQUEST FOR LETTER OF AUTHORIZATION UNDER SECTION 101(A)(5)(A) OF THE MARINE MAMMAL PROTECTION ACT INCIDENTAL TO ATLANTIC FLEET ACTIVE SONAR TRAINING ACTIVITIES

Submitted to:

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UNITED STATES OF AMERICA

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

°C	Degrees Celsius
°F	Degrees Fahrenheit
ºN	Degrees North
ºS	Degrees South
ADC	Acoustic Device Countermeasures
AFAST	Atlantic Fleet Active Sonar Training
AMCM	Airborne Mine Countermeasures
ASW	Anti-Submarine Warfare
AUTEC	Atlantic Undersea Test & Evaluation Center
CDF	Cumulative Distribution Function
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CG	Cruiser, Guided Missile
CHPT	Cherry Point
CHASN	Charleston
COMPTUEX	Composite Training Unit Exercise
cm	Centimeters
CNO	Chief of Naval Operations
CSG	Carrier Strike Group
dB	Decibels
dB re 1 μPa	Decibels Referenced to 1 Micro-Pascal
dB re 1 μPa^2-s	Decibels Referenced to 1 Micro-Pascal Squared Second
dB re 1 μPa-m	Decibels with a Reference Pressure of 1 Micro-Pascal at 1 Meter
DDG	Guided Missile Destroyer
DoD	Department of Defense
DON	Department of the Navy
EA	Environmental Assessment
ECOUS	Environmental Consequences of Underwater Sound
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EL	Energy Flux Density Level
EMATT	Expendable Mobile Acoustic Training Target
ESA	Endangered Species Act
ESG	Expeditionary Strike Group
ESME	Effects of Sound on the Marine Environment
FAA	Federal Aviation Administration
FFG	Fast Frigate
FRTP	Fleet Response Training Plan
Ft	Feet
FWC	Florida Fish and Wildlife Conservation Commission
GDEMV	Generalized Digital Environmental Model, Variable
GOMEX	Gulf of Mexico
HARP	High Frequency Acoustic Recording Package
Hr	Hours
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
IEER	Improved Extended Echo Ranging
In	Inches
in-lb/in^2	Inch Pounds per Square Inch
IHA	Incidental Harassment Authorization
IP	Implementation Plan
IWC	International Whaling Commission
JAX	Jacksonville

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS, CONT'D

JTFEX	Joint Task Force Exercise
kg	Kilograms
kHz	Kilohertz
km	Kilometers
km^2	Square Kilometers
kPa	Kilo-Pascal
LFA	Low Frequency Active
LOA	Letter of Authorization
Lb	Pounds
LWAD	Littoral Warfare Advanced Development
m	Meters
MAB	Mid-Atlantic Bight
MCM	Mine Countermeasures
MFA	Mid-Frequency Active
Min	Minutes
MIW	Mine Warfare
MMPA	Marine Mammal Protection Act
MPA	Marine Patrol Aircraft
MRA	Marine Resources Assessment
Ms	Microseconds
MSAT	Marine Species Awareness Training
msec	Milliseconds
NAE	Noise Acoustic Emitter
NARWC	North Atlantic Right Whale Consortium
NAVOCEANO	Naval Oceanographic Office
NE	Northeastern
NM	Nautical Miles
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuaries
NOAA	National Oceanic and Atmospheric Administration
NODE	Navy Operating Area Density Estimate
NPAL	North Pacific Acoustic Laboratory
NRL	Naval Research Laboratory
OAML	Oceanographic and Atmospheric Master Library
OPAREA	Operating Area
PBR	Potential Biological Removal
PQS	Personal Qualification Standard
Psi	Pounds per Square Inch
psi-ms	Pounds per Square Inch-Millisecond
PTS	Permanent Threshold Shift
RDT&E	Research, Development, Test, and Evaluation
RIMPAC	Rim of the Pacific Exercise
Rms	Root-Mean-Square
RONEX	Squadron Exercises
SCC	Submarine Command Course
s.d.	Standard Deviations
SEASWITI	South Eastern Integrated Training Initiative
Sec	Seconds
SEL	Sound Exposure Level
SL	Source Level
SPAWAR	Space and Naval Warfare
SPL	Sound Pressure Level
Sp.	Species (singular)

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS, CONT'D

Spp.	Species (plural)
SSC	SPAWAR Systems Center
SSN	Attack Submarine (nuclear powered)
Sub	Submarine
SURTASS	Surveillance Towed Array Sensor System
SWSS	Sperm Whale Seismic Survey
TORPEX	Torpedo Exercise
TS	Threshold Shift
TTS	Temporary Threshold Shift
ULT	Unit Level Training
U.S.	United States
U.S.C.	U.S. Code
USFWS	U.S. Fish and Wildlife Service
USNS	U.S. Naval Ship
USWTR	Undersea Warfare Training Range
UUV	Unmanned Underwater Vehicle
VACAPES	Virginia Capes
Yd	Yards

1. DESCRIPTION OF ACTIVITIES

1.1 INTRODUCTION

The Department of the Navy (DON) has prepared this request for Letter of Authorization (LOA) to analyze the potential environmental effects associated with the use of mid- and high-frequency active sonar technology and the improved extended echo ranging (IEER) system during Atlantic Fleet active sonar training (AFAST) exercises. The IEER system consists of an explosive source sonobuoy (AN/SSQ-110A) and an air deployable active receiver (ADAR) sonobuoy (AN/SSQ-101). During these exercises, surface ships, submarines, and aircraft will utilize active sonar systems during Anti-Submarine Warfare (ASW), Mine Warfare (MIW), object detection/navigational sonar training exercises, and active sonar system maintenance tasks. In addition, this LOA request incorporates research, development, test, and evaluation (RDT&E) activities involving active sonar activities that are similar to, and coincident to, Atlantic Fleet training events. These activities are similar to, and coincident to, Atlantic Fleet training events and have not been previously evaluated in other environmental planning documents. For the purposes of this document, “active sonar activities” refers to training, maintenance, and RDT&E activities involving mid- and high-frequency active sonar and the explosive source sonobuoy (AN/SSQ-110A).

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

This document has been prepared in accordance with the applicable regulations and the MMPA, as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law 108-136). The bases of this LOA are (1) the analysis of spatial and temporal distributions of protected marine mammals in the Atlantic Fleet area of responsibility (Study Area) (Figure 1-1), (2) a review of operational activities that have the potential to affect marine mammals, and (3) a technical risk assessment to determine the likelihood of effects from high-frequency and mid-frequency (MFA) sonar and explosive source sonobuoys (AN/SSQ-110A) during AFAST active sonar activities.

This chapter describes active sonar activities conducted by the United States (U.S.) Navy that could expose marine mammals to levels of sound likely to result in Level B harassment (e.g., temporary threshold shift [TTS] and behavioral effects) and possibly Level A harassment (e.g., mortality or permanent threshold shift [PTS]), under the MMPA of 1972.

1.2 PURPOSE AND NEED OF THE PROPOSED ACTION

The Navy seeks to designate areas where mid- and high-frequency active sonar and IEER system training, maintenance, and RDT&E activities will occur within and adjacent to existing operating areas (OPAREAs), and to conduct these activities. These areas are located in the ocean along the East Coast of the U.S. and within the Gulf of Mexico. Navy OPAREAs include designated ocean areas near fleet concentration areas (i.e., homeports). OPAREAs are where the majority of routine Navy training and RDT&E takes place (DON, 2004a). However, Navy training exercises are not confined to the OPAREAs. Some training exercises or portions of exercises are conducted seaward of the OPAREAs and a limited amount of active sonar use is conducted in water areas shoreward of the OPAREAs.

The purpose of the Proposed Action is to provide mid- and high-frequency active sonar and IEER system training for U.S. Navy Atlantic Fleet ship, submarine, and aircraft crews, as well as to conduct RDT&E activities to support the requirements of the Fleet Readiness Training Plan (FRTP) and stay proficient in ASW and MIW skills. The FRTP is the Navy's training cycle that requires naval forces to build up in preparation for operational deployment and to maintain a high level of proficiency and readiness while deployed. All phases of the FRTP training cycle are needed to meet Title 10 requirements.

The Navy's need for training and RDT&E is found in Title 10 of the United States Code (U.S.C.), Section 5062 (10 U.S.C. 5062). Title 10 U.S.C. 5062 requires the Navy to be "organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea." The current and emerging training and RDT&E activities addressed in the AFAST Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) are conducted in fulfillment of this legal requirement.

Basic combat skills are learned and practiced during Independent Unit Level Training (ULT) activities. These basic skills are then refined at the Coordinated ULT and Strike Group training activities as progressively more difficult, complex, and larger-scale "integrated training" exercises are conducted at an increasing tempo. As a result of this training, the warfighter learns the skills necessary to function as part of a coordinated fighting force in a hostile environment and has developed the capacity to accomplish multiple missions. By conducting this training, the Navy achieves its legal requirement to maintain, train, and equip combat-ready naval forces that are capable of winning wars, deterring aggression, and maintaining freedom of the seas.

Surface ships and submarines participating in the training also must conduct active sonar maintenance pier side and during transit to the training exercise location. Active sonar maintenance is required to ensure that the sonar system is operating properly before engaging in the training exercise or when the sonar systems are suspected of operating at levels below optimal performance.

Additionally, RDT&E provides the Navy the capability of developing new active sonar systems and ensuring their safe and effective implementation for the Atlantic Fleet. The RDT&E sensors

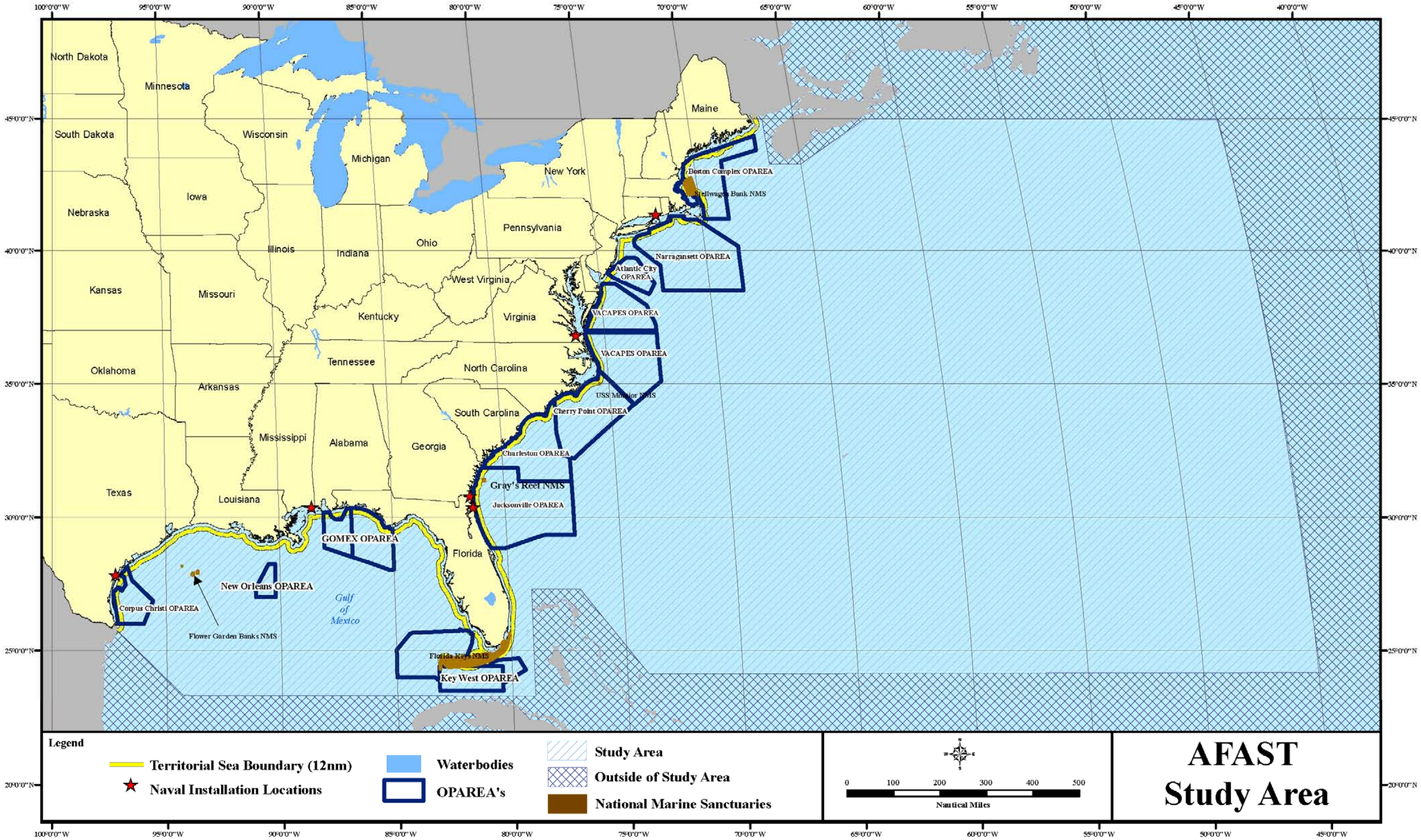

Figure 1-1. Atlantic Fleet Study Area

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analyzed in this document are either existing systems or new systems with similar operating parameters to those used during Atlantic fleet training.

1.2.1 ASW Training

Potential adversary nations are investing heavily in submarine technology, including designs for nuclear attack submarines, strategic ballistic missile submarines, and modern diesel electric submarines. In addition, the modern diesel electric submarine is the most cost-effective platform for the delivery of several types of weapons, including torpedoes, long-range antiship cruise missiles, land attack missiles, and a variety of antiship mines. Since submarines are inherently covert and can operate independently of escort vessels, submarines can be used to conduct intrusive operations in sensitive areas and can be inserted early in the mission without being detected. The inability to detect a hostile submarine before it can launch a missile or a torpedo is a critical vulnerability that puts U.S. forces and merchant mariners at risk and, ultimately, threatens U.S. national security.

Because Navy personnel ultimately fight as trained, a training environment that matches the conditions of actual combat is necessary. Sailors must also train using the combat tools that would be used during a conflict. A complicating factor facing the Navy today is the nature of the littoral waters where submarines can operate. These littoral regions are frequently confined, congested water and air space, which makes identification of allies, adversaries, and neutral parties more challenging than in deeper waters.

When searching for submarines, U.S. naval forces use many sensors. The two broad categories of sensors in use today are acoustic (sound) and nonacoustic. Acoustic tools are currently more effective for searching for submarines because sound travels through water more easily than nonacoustic emissions like light and radio waves. Two types of acoustic devices, passive and active sonar, can be used to detect submarines. Passive sonar devices only receive sound energy; as submarine technology evolves and submarines become significantly quieter, the usefulness of passive sonar continues to diminish. Active sonar devices emit sound energy into the water and receive it after it bounces off the hulls of threat submarines. Modern, quiet submarines can be better detected using active sonar devices, which can detect threat submarines at distances outside the firing range of many modern-day torpedoes. Therefore, active sonar is more useful than passive sonar when searching for submarines in littoral waters or when searching for modern, quiet submarines. Detection of submarines using sound is very difficult, and training is needed to build and hone these skills in order to be prepared in a real threat environment.

Since an adversary equipped with modern, quiet submarines has the potential to deny all Department of Defense (DoD) forces access to strategic areas of the world, the value of active sonar training has broad effects for all DoD forces.

1.2.2 MIW Training

The use of naval mines is one of the simplest ways for enemies to damage ships and disrupt shipping lanes. Over the past 60 years, at least 14 U.S. ships, including two in the last decade alone, have been damaged or sunk by mines as a result of relatively small-scale mining operations. Furthermore, since more than 90 percent of military equipment used in international operations travels by sea, mines have the potential to either delay land and sea military operations by denying access to shallow-water areas, or prevent the delivery of military equipment altogether.

Today, the Navy can expect to encounter a wide spectrum of naval mines, from traditional, low-technology mines, to technologically advanced systems. For instance, mines can have irregular shapes, sound-absorbent coatings, and nonmagnetic material composition, which increase their resistance to countermeasures and reduce their maintenance requirements. This means that mines can stay active in the water longer, are harder to find and are more difficult to neutralize (disarm with the use of countermeasures). More advanced mines are designed with remote controls, improved sensors, and counter-countermeasures that further complicate efforts to identify, classify, and neutralize them. In addition to improved mine technology, the underwater acoustic conditions often present in shallow waters require the use of specialized technology to successfully detect, avoid, and neutralize mines (DON, 2006a).

Training on MIW sonar is crucial because mines are a proven and cost-effective technology that is continually improving to make them more lethal, reliable, and difficult to detect. Because mines do not emit sound, active sonar technology, rather than passive, provides the warfighter with the capability to quickly and accurately detect, classify, and neutralize mines in small, crowded, shallow-water environments. These MIW capabilities are essential to ensuring the U.S.'s maritime dominance and protecting the Navy's ability to operate on both land and sea, including delivering of military equipment.

1.3 DESCRIPTION OF ACTIVE SONAR ACTIVITIES

ASW and MIW training is conducted to meet deployment certification requirements as directed in the FRTP. The U.S. Navy Atlantic Fleet meets these requirements by conducting training activities prior to deployment of forces. The FRTP requires Basic ULT, Intermediate ULT, and Sustainment Training. The Navy meets these requirements during Independent ULT, Coordinated ULT, and Strike Group Training. At the beginning of the cycle, basic combat skills are learned and practiced during basic Independent ULT activities. Basic skills are then refined during Coordinated ULT. Strike Group Training is integrated training using progressively more difficult, complex, and large-scale exercises conducted at an increasing tempo. This training provides the warfighter with the skills necessary to function as part of a coordinated fighting force in a hostile environment with the capacity to accomplish multiple missions.

RDT&E activities are conducted to develop new technologies and to ensure their effectiveness prior to implementation. Maintenance activities are conducted pier side and during transit to training exercise locations. Active sonar maintenance is required to ensure the sonar system is operating properly before engaging in the training exercise or when the sonar systems are suspected of performing below optimal levels.

Because the Navy conducts many different types of Independent ULT, Coordinated ULT, Strike Group training, maintenance, and RDT&E active sonar events, the Navy grouped similar events to form representative scenarios. These representative scenarios describe the scope of activities that are the subject of the LOA request. Note that specific training event names and other details do occasionally change as required to meet the current operational needs. A summary of these scenarios, including information on each sonar system used and its potential effect on marine mammals is shown in Table 1-1. It should be noted that active sonar is rarely used continuously throughout the duration of the list training events. In addition, when sonar is in use, the sonar "pings" occur at intervals, referred to as a duty cycle, and the signals themselves are very short in duration.

1.3.1 Independent Unit Level Training Activities

Independent ULT activities include training and sonar maintenance activities that each individual unit is required to accomplish in order to become certified prior to deploying or to maintain proficiency. Independent ULT activities can include the use of the IEER system, which consists of an explosive source sonobuoy (AN/SSQ-110A) and an air deployable active receiver (ADAR) sonobuoy (AN/SSQ-101). The training requirement is based on the successful completion of the training on a per-unit basis.

The majority of Independent ULT activities involving active sonar components are conducted to meet MIW and ASW training requirements. These activities can be conducted with one or more ships at the same time. ASW Independent ULT activities focus on training sonar operators on the detection, classification, and tracking of underwater targets. Activities include both near shore and open-ocean ASW training activities.

MIW Independent ULT activities focus on training sonar operators to detect, locate, and characterize mine-like objects under various environmental conditions, including those suspended in the water (i.e., moored mines), mines on the ocean floor (i.e., proud mines), and mines buried under the ocean floor. Some guided missile destroyers (DDGs), cruisers (CGs), fast frigates (FFGs), and submarines can operate their hull-mounted sonars, normally used for ASW, in an object detection mode. This mode allows ships to detect mines and other objects in the water as well as to navigate through the area.

1.3.1.1 Surface Ship ASW ULT

One or two surface ships (CG, DDG, or FFG) conduct ASW localization and tracking training using the AN/SQS-53 and/or AN/SQS-56. The AN/SLQ-25 NIXIE may be employed. Additionally, one MK-39 Expendable Mobile Acoustic Training Target (EMATT) or MK-30 target per scenario may be employed as a target. In some Surface Ship ASW ULT events, a MK-1, MK-2, MK-3, or MK-4 acoustic device countermeasure; MK-46 or MK-54 torpedo, and a Noise Acoustic Emitter (NAE) could be used.

1.3.1.2 Surface Ship Object Detection/Navigational Training ULT

Under this scenario, one ship (CG, DDG, or FFG) conducts object detection and navigational training while transiting in and out of port using either the AN/SQS-53 or AN/SQS-56 in the Kingfisher mode.

1.3.1.3 Helicopter ASW ULT

In this scenario, one SH-60 helicopter conducts ASW training using the AN/AQS-13 or 22 dipping sonar, tonal sonobuoys (e.g., AN/SQQ-62), passive sonobuoys (e.g., AN/SSQ-53D/E), and torpedoes. One MK-39 EMATT or MK-30 target may also be employed as a target per scenario.

1.3.1.4 Submarine ASW ULT

This scenario consists of one submarine conducting underwater ASW training using the AN/BQQ-10 active sonar and torpedoes. Additionally, an MK-39 EMATT or MK-30 may be used as a target.

1.3.1.5 Submarine Object Detection/Navigational Training ULT

This scenario consists of one submarine conducting object detection and navigational training while transiting in and out of port using the AN/BQS-15 sonar. In this scenario, the submarine would be operating the sonar to detect obstructions during transit.

1.3.1.6 Maritime Patrol Aircraft ASW ULT

Under this scenario, one maritime patrol aircraft (MPA) conducts ASW localization and tracking training using tonal (AN/SSQ-62), passive (AN/SSQ-53), explosive source sonobuoys (AN/SSQ-110A), or receiver sonobuoys (AN/SSQ-101). Additionally, one MK-39 EMATT or MK-30 target for each training scenario may be used as a target.

1.3.1.7 Surface Ship MIW ULT

During a surface ship MIW ULT, one ship (mine countermeasures [MCM]) would conduct mine localization training using the AN/SQQ-32 and the AN/SLQ-48 sonar systems.

1.3.2 Coordinated Unit Level Training Activities

Coordinated ULT activities concentrate on warfare team training and initial multiunit operations. During this phase, vessels and aircraft begin to develop warfare skills in coordination with other units while continuing to maintain unit proficiency. Coordinated ULT activities involve one or more combined exercises such as South Eastern ASW Integrated Training Initiative (SEASWITI), or specialty training operations such as Submarine Command Course (SCC) Operations and Integrated ASW Course (IAC).

Table 1-1. Summary of Active Sonar Activities

Event Type	Event Name	Training Event Scenarios	Events per Year*	Length of Overall Event	Possible Event Areas***	Typical Event Area Dimensions	Equipment or Action	Equipment Use or Action per Event	Annual Use per Event Type*	Effects Considered
Independent Unit Level Training (including RDT&E)	Surface Ship ASW ULT	One or two surface ships (CG, DDG, and FFG) conducting ASW localization and tracking training.	457	2 to 6 hours	VACAPES, CHPT, JAX/CHASN, and GOMEX OPAREAs	5 NM x 10 NM to 30 NM x 40 NM	Surface ship MFA ASW sonar (AN/SQS-53 or AN/SQS-56)	1 to 2 ships (CG, DDG, or FFG) pinging 1 to 3 hours each	1071 hours AN/SQS-53 and 465 hours AN/SQS-56	MFA sonar exposure
							Acoustic countermeasures (AN/SLQ-25 NIXIE, MK-1, MK-2, MK-3, MK-4, or Noise Acoustic Emitter)	2 hours per NIXIE 20 minutes per MK-1, MK-2, MK-3, or MK-4 Noise Acoustic Emitter	158 NIXIE 225 MK-1, MK-2, MK-3, or MK-4 127 Noise Acoustic Emitter	HFA and MFA sonar exposure and expended materials
							MK-46 or MK-54 Torpedo	Exercise torpedoes could be used for RDT&E	8 MK-46 or MK-54 exercise torpedoes	MFA sonar exposure, direct strike, and expended materials
							MK-39 EMATT or MK-30 target	1 EMATT or MK-30 (recoverable) per exercise may be used as a target	up to 725 EMATTs expended (total annual use for all exercises)	Direct strike and expended materials
							Vessel movement	1 to 2 ships maneuvering	Approximately 54 CG, DDG, and FFG surface ships conducting ULT throughout the year	Vessel strike
	Surface Ship Object Detection ULT	One ship (CG, DDG, and FFG) conducting object detection during transit in/out of port for training and safety during reduced visibility.	108	1 to 2 hours	Sea lanes and Entrance channels to Norfolk, Virginia and Mayport, Florida	5 NM x 10 NM	Surface ship MFA ASW sonar (AN/SQS-53 or AN/SQS-56 Kingfisher) operated in object detection mode	1 ship (CG, DDG, or FFG) pinging for 1 to 2 hours	148 hours AN/SQS-53 and 68 hours AN/SQS-56	MFA sonar exposure
							Vessel movement	1 ship maneuvering	Approximately 54 CG, DDG, and FFG surface ships on the East Coast conducting object avoidance twice a year	Vessel strike
	Helicopter ASW ULT	One helicopter conducting ASW training using dipping sonar or sonobuoys	165	2 to 4 hours	VACAPES, CHPT, and JAX/CHASN OPAREAs	20 NM x 30 NM	Helicopter dipping sonar (AN/AQS-13 or AN/AQS-22)	1 helicopter dipping up to two hours (10 pings per five-minute dip)	160 hours	MFA sonar exposure
							Tonal sonobuoy (DICASS) (AN/SSQ-62)	Up to 4 tonal sonobuoys (DICASS)	549 sonobuoys	MFA sonar exposure, direct strike, and expended materials
							Passive sonobuoy (DIFAR) AN/SSQ-53D/E	Number of sonobuoys deployed can vary	up to 27,500 sonobuoys expended (total annual use for all exercises)	Expended materials and direct strike
							MK-46 or MK-54 Torpedo	exercise torpedoes could be used for RDT&E	8 MK-46 or MK-54 exercise torpedoes	MFA sonar exposure, direct strike, and expended materials
							MK-39 EMATT or MK-30 target	1 EMATT or MK-30 (recoverable) per exercise may be used as a target	up to 725 EMATTs expended (total annual use for all exercises)	Direct strike and expended materials
	Submarine ASW ULT	One submarine conducting ASW and SUW training using passive and active sonar.	100	2 to 3 days	Northeast, VACAPES, CHPT, JAX/CHASN, and GOMEX OPAREAs	30 NM x 40 NM	Submarine MFA sonar (AN/BQQ-10)	1 submarine pinging once per two hours (average 36 pings per event)	3600 pings	MFA sonar exposure
							MK-48 Torpedo	Number of exercise torpedoes could be used in a single RDT&E event could vary	32 MK-48 exercise torpedoes	MFA sonar exposure, direct strike, and expended materials
							Vessel movement	1 submarine maneuvering	Approximately 25 submarines on the East Coast conducting ULT throughout the year	Vessel strike
							MK-39 EMATT or MK-30 target	1 EMATT or MK-30 (recoverable) per exercise may be used as a target	up to 725 EMATTs expended (total annual use for all exercises)	Direct strike and expended materials

Table 1-1. Summary of Active Sonar Activities Cont'd

Event Type	Event Name	Training Event Scenarios	Events per Year*	Length of Overall Event	Possible Event Areas***	Typical Event Area Dimensions	Equipment or Action	Equipment Use or Action per Event	Annual Use per Event Type*	Effects Considered
Independent Unit Level Training (including RDT&E) Cont'd	Submarine Navigational	One submarine operating sonar for navigation and object detection during transit in/out of port during reduced visibility.	300	1 to 2 hours	Sea lanes and entrance channels to Norfolk, Virginia; Groton, Connecticut; and Kings Bay, Georgia	5 NM x 10 NM	Submarine MFA object detection sonar (AN/BQQ-10 or AN/BQS-15)	1 submarine pinging 1 to 2 hours	450 hours	MFA sonar exposure
							Vessel movement	1 submarine maneuvering	Approximately 30 submarines on the East Coast conducting ULT throughout the year	Vessel strike
	MPA ASW ULT (tonal sonobuoy)	One MPA conducting ASW submarine localization and tracking training using tonal sonobuoys.	791	2 to 8 hours	Northeast, VACAPES, CHPT, JAX/CHASN, and GOMEX OPAREAs	30 NM x 30 NM to 60 NM x 60 NM	Tonal sonobuoy (DICASS) (AN/SSQ-62)	Up to 10 tonal sonobuoys (DICASS)	3594 sonobuoys	MFA sonar exposure, direct strike, and expended materials
							Passive sonobuoy (DIFAR) AN/SSQ-53D/E	Number of sonobuoys deployed can vary	up to 27,500 sonobuoys expended (total annual use for all exercises)	Expended materials and direct strike
							MK-46 or MK-54 Torpedo	exercise torpedoes could be used for RDT&E	8 MK-46 or 54 exercise torpedoes	MFA sonar exposure, direct strike, and expended materials
							MK-39 EMATT (repeater) and or MK-30 Target	1 EMATT or MK-30 (recoverable) per exercise may be used as a target	up to 725 EMATTs expended (total annual use for all exercises)	direct strike and expended materials
	MPA ASW ULT (explosive source sonobuoy [AN/SSQ-110A])	One MPA conducting ASW submarine localization and tracking training using explosive source sonobuoy (AN/SSQ-110A).	169	2 to 8 hours	Northeast, VACAPES, CHPT, JAX/CHASN, and GOMEX OPAREAs	60 NM x 60 NM	explosive source sonobuoy (AN/SSQ-110A)	Up to 14 AN/SQ-110A sonobuoys	676 sonobuoys	Explosive byproducts, pressure wave exposure, impulsive sound exposure, direct strike, and expended materials
							receiver (ADAR) sonobuoy (AN/SSQ-101)	Up to 5 AN/SSQ-101 sonobuoys	239 sonobuoys	Direct Strike and expended materials
	Surface Ship MIW ULT	One ship (MCM) conducting mine localization training.	266	Less than 24 hours	GOMEX OPAREA	1 NM x 2 NM	Surface ship HFA MIW sonar (AN/SQQ-32)	1 ship (MCM) pinging for 1 to 15 hours	2074 hours of AN/SQQ-32	HFA sonar exposure
							Vessel movement	1 to 2 ships maneuvering	Approximately 19 MIW surface ships conducting ULT throughout the year	Vessel strike
Coordinated Unit Level Training	Southeastern Anti-Submarine Warfare Integrated Training Initiative (SEASWITI) and similar RDT&E	A combined exercise with two DDGs, one FFG with embarked helicopter, two submarines, and one MPA	4 training events and similar RDT&E	5 to 7 days	JAX/CHASN OPAREA	30 NM x 30 NM	Surface ship MFA ASW sonar (AN/SQS-53 or AN/SQS-56)	2 to 3 ships (CG, DDG, or FFG) pinging daily for several hours	440 hours AN/SQS-53 200 hours AN/SQS-56	MFA sonar exposure
							Helicopter ASW dipping sonar (AN/AQS-13 or AN/AQS-22)	1 helicopter dipping several times daily (10 pings per five-minute dip)	10 hours	MFA sonar exposure
							Submarine MFA sonar (AN/BQQ-5 or AN/BQQ-10)	1 submarine pinging up to four times daily	100 pings	MFA sonar exposure
							Acoustic countermeasures (AN/SLQ-25 NIXIE, MK-2, MK-3, or Noise Acoustic Emitter)	2 hours per NIXIE 20 minutes per MK-2, MK-3, and Noise Acoustic Emitter	ADCs may be used during the event; annual total ADC expenditure shown under ASW Surface ULT	HFA and MFA sonar exposure, direct strike, and expended materials
							Tonal sonobuoy (DICASS) (AN/SSQ-62)	1 MPA dropping up to 8 sonobuoys in one day; 24 sonobuoys for entire SEASWITI	120 tonal sonobuoys (DICASS)	MFA sonar exposure, direct strike, and expended materials
							Passive sonobuoy (DIFAR) AN/SSQ-53D/E	Number of sonobuoys deployed can vary	up to 27,500 sonobuoys expended (total annual use for all exercises)	Expended materials and direct strike
							Vessel movement	3 to 4 ships maneuvering	3 to 4 ships maneuvering over 5-7 days, up to four times a year	Vessel strike

Table 1-1. Summary of Active Sonar Activities Cont'd

Event Type	Event Name	Training Event Scenarios	Events per Year*	Length of Overall Event	Possible Event Areas***	Typical Event Area Dimensions	Equipment or Action	Equipment Use or Action per Event	Annual Use per Event Type*	Effects Considered
Coordinated Unit Level Training Cont'd	Integrated ASW Course (IAC)	A combined exercise with three DDGs, one CG, one FFG, two to three helicopters, one to two submarines, and one MPA	5	2 to 5 days	VACAPES, CHPT, and JAX/CHASN OPAREAs	120NM X 60NM	Surface ship MFA ASW sonar (AN/SQS-53 or AN/SQS-56)	5 ships pinging for up to 10 hours	285 hours AN/SQS-53 100 hours AN/SQS-56	MFA sonar exposure
							Helicopter ASW dipping sonar (AN/AQS-13 or AN/AQS-22)	1 helicopter dipping up to one hour (10 pings per five-minute dip)	5 hours AN/AQS-13 or AN/AQS-22	MFA sonar exposure
							Submarine MFA sonar (AN/BQQ-5 or AN/BQQ-10)	1-2 submarines pinging up to 6 times each	60 pings	MFA sonar exposure
							Acoustic countermeasures (AN/SLQ-25 NIXIE, MK-2, MK-3, or Noise Acoustic Emitter)	2 hours per NIXIE 20 minutes per MK-2, MK-3, and Noise Acoustic Emitter	ADCs may be used during the event; annual total ADCs used shown under ASW Surface ULT	HFA and MFA sonar exposure, direct strike, and expended materials
							Tonal sonobuoy (DICASS) (AN/SSQ-62)	Helicopters and/or MPA dropping up to 36 sonobuoys	180 sonobuoys	MFA sonar exposure, direct strike, and expended materials
							Passive sonobuoy (DIFAR) AN/SSQ-53D/E	Number of sonobuoys deployed can vary	up to 27,500 sonobuoys expended (total annual use for all exercises)	Expended materials and direct strike
	Group Sail	A combined exercise with two DDGs with embarked helicopters, and one submarine.	20	2 to 3 days	VACAPES, CHPT, and JAX/CHASN OPAREAs	30 NM x 30 NM	Surface ship MFA ASW sonar (AN/SQS-53 or AN/SQS-56)	2-3 ships pinging for several hours	240 hours AN/SQS-53 120 hours AN/SQS-56	MFA sonar exposure
							Helicopter ASW dipping sonar (AN/AQS-13 or AN/AQS-22)	1 helicopter dipping up to 6 hours (10 pings per five-minute dip)	60 hours AN/AQS-13 or AN/AQS-22	MFA sonar exposure
							Submarine MFA sonar (AN/BQQ-5 or AN/BQQ-10)	1 submarine pinging up to two times	40 pings	MFA sonar exposure
							Acoustic countermeasures (AN/SLQ-25 NIXIE, MK-2, MK-3, or Noise Acoustic Emitter)	2 hours per NIXIE 20 minutes per MK-2, MK-3, and Noise Acoustic Emitter	ADCs may be used during the event; annual total ADCs used shown under ASW Surface ULT	HFA and MFA sonar exposure, direct strike, and expended materials
							Tonal sonobuoy (DICASS) (AN/SSQ-62)	1 helicopter dropping up to 4 sonobuoys	80 sonobuoys	MFA sonar exposure, direct strike, and expended materials
							Passive sonobuoy (DIFAR) AN/SSQ-53D/E	Number of sonobuoys deployed can vary	up to 27,500 sonobuoys expended (total annual use for all exercises)	Expended materials and direct strike
							Vessel movement	3 ships maneuvering	3 ships maneuvering over 5-7 days, up to 20 times a year	Vessel strike
	Submarine Command Course (SCC) Operations	Two submarines operating against each other as part of the SCC for prospective submarine Commanding Officers.	2	3 to 5 days	NE and JAX/CHASN OPAREAs	30 NM x 50 NM	Submarine MFA sonar (AN/BQQ-5 or AN/BQQ-10)	2 submarines pinging up to 12 times each	48 pings	MFA sonar exposure
							Acoustic countermeasures (AN/SLQ-25 NIXIE, MK-2, MK-3, or Noise Acoustic Emitter)	2 hours per NIXIE 20 minutes per MK-2, MK-3, and Noise Acoustic Emitter	ADCs may be used during the event; annual total ADCs used shown under ASW Surface ULT	HFA and MFA sonar exposure, expended materials
							Vessel movement	2 submarines maneuvering	Maneuvering twice a year for 3-5 days	Vessel strike
	RONEX and GOMEX MIW Exercises	One to five MCM ships conducting mine localization training.	8	10 to 15 days	GOMEX OPAREA	20 NM x 20 NM	Surface ship HFA MIW sonar (AN/SQQ-32 and AN/SLQ-48**)	1 to 5 ships (MCM) 60-90 hours each	2,400 hours AN/SQQ-32	HFA sonar exposure
							Vessel movement	1 to 5 ships (MCM) maneuvering	1 to 5 ships maneuvering up to 100 days a year	Vessel strike

Table 1-1. Summary of Active Sonar Activities Cont'd

Event Type	Event Name	Training Event Scenarios	Events per Year*	Length of Overall Event	Possible Event Areas***	Typical Event Area Dimensions	Equipment or Action	Equipment Use or Action per Event	Annual Use per Event Type*	Effects Considered
Strike Group Training	ESG COMPTUEX and CSG COMPTUEX and similar RDT&E	Intermediate level battle group exercise designed to create a cohesive CSG/ ESG prior to deployment or JTFEX. Three DDGs, one FFG, helicopters, one MPA, and two submarines.	5 training events and similar RDT&E	21 days	VACAPES, CHPT, JAX/CHASN, and GOMEX OPAREAs	60 NM x 120 NM	Surface ship MFA ASW sonar (AN/SQS-53 and AN/SQS-56)	4 ships (CG, DDG, or FFG) pinging approximately 60 hours each over 10 days	740 hours AN/SQS-53 250 hours AN/SQS-56	MFA sonar exposure
							Helicopter ASW dipping sonar (AN/AQS-13 or AN/AQS-22)	1 to 4 helicopters (10 pings per five-minute dip) during CSG COMPTUEX	9 hours	MFA sonar exposure
							Submarine MFA sonar (AN/BQQ-5 or AN/BQQ-10)	2 submarines pinging up to 16 times each	116 pings	MFA sonar exposure
							Acoustic countermeasures (AN/SLQ-25 NIXIE, MK-2, MK-3, or Noise Acoustic Emitter)	2 hours per NIXIE 20 minutes per MK-2, MK-3, and Noise Acoustic Emitter	ADCs may be used during the event; annual total ADCs used shown under ASW Surface ULT	HFA and MFA sonar exposure, direct strike, and expended materials
							Tonal sonobuoy (DICASS) (AN/SSQ-62)	MPA and/or helicopter dropping 3 to 10 sonobuoys for a total of up to 218 sonobuoys over duration of event	982 sonobuoys	MFA sonar exposure, direct strike, and expended materials
							Passive sonobuoy (DIFAR) AN/SSQ-53D/E	Number of sonobuoys deployed can vary	up to 27,500 sonobuoys expended (total annual use for all exercises)	Expended materials and direct strike
							explosive source sonobuoy (AN/SSQ-110A)	2 MPA dropping up to 14 AN/SQ-110A sonobuoys	140 sonobuoys	Explosive byproducts, pressure wave exposure, impulsive sound exposure, direct strike, and expended materials
							receiver (ADAR) sonobuoy (AN/SSQ-101)	Up to 5 AN/SSQ-101 sonobuoys	49 sonobuoys	Direct Strike and expended materials
							Vessel movement	6 ships (CG, DDG, FFG, or submarine) maneuvering	6 ships maneuvering up to 147 days a year	Vessel strike
	JTFEX	Final fleet exercise prior to deployment of the CSG and ESG. Serves as a ready-to-deploy certification for all units. Four DDGs, two FFGs, one helicopter, one MPA, and three submarines.	2	10 days	JAX/CHASN and GOMEX OPAREAs	60 NM x 80 NM up to 180 NM x 180 NM	Surface ship MFA ASW sonar (AN/SQS-53 or AN/SQS-56)	6 ships (CG, DDG, FFG) pinging up to 25 hours each	200 hours AN/SQS-53 100 hours AN/SQS-56	MFA sonar exposure
							Helicopter ASW dipping sonar (AN/AQS-13 or AN/AQS-22)	1 helicopters dipping for up to one hour (10 pings per five-minute dip)	2 hours	MFA sonar exposure
							Submarine MFA sonar (AN/BQQ-5 or AN/BQQ-10)	3 submarines pinging twice each	12 pings	MFA sonar exposure
							Acoustic countermeasures (AN/SLQ-25 NIXIE, MK-2, MK-3, or Noise Acoustic Emitter)	2 hours per NIXIE 20 minutes per MK-2, MK-3, and Noise Acoustic Emitter	ADCs may be used during the event; annual total ADCs used shown under ASW Surface ULT	HFA and MFA sonar exposure, direct strike, and expended materials
							Tonal sonobuoy (DICASS) (AN/SSQ-62)	1 MPA and/or 1 helicopter dropping 3 to 10 sonobuoys for a total of up to 174 sonobuoys over duration of event	348 sonobuoys	MFA sonar , direct srike, and expended materials
							Passive sonobuoy (DIFAR) AN/SSQ-53D/E	Number of sonobuoys deployed can vary	up to 27,500 sonobuoys expended (total annual use for all exercises)	Expended materials and direct strike
							explosive source sonobuoy (AN/SSQ-110A)	2 MPA dropping up to 14 AN/SSQ-110A sonobuoys	56 sonobuoys	Explosive byproducts, pressure wave exposure, impulsive sound exposure, direct strike, and expended materials
							receiver (ADAR) sonobuoy (AN/SSQ-101)	Up to 5 AN/SSQ-101 sonobuoys	20 sonobuoys	Direct Strike and expended materials
							Vessel movement	9 ships (CG, DDG, FFG, or submarine) maneuvering	Up to 9 ships maneuvering for up to 40 days a year	Vessel strike

Table 1-1. Summary of Active Sonar Activities Cont'd

Event Type	Event Name	Training Event Scenarios	Events per Year*	Length of Overall Event	Possible Event Areas***	Typical Event Area Dimensions	Equipment or Action	Equipment Use or Action per Event	Annual Use per Event Type*	Effects Considered
Maintenance	Surface Ship Sonar Maintenance	Pier side and at-sea maintenance to sonar system.	410	.2 to 4 hours	Northeast, VACAPES, CHPT, and JAX/CHASN, OPAREAs		Surface ship MFA ASW sonar (AN/SQS-53 OR AN/SQS-56)	1 ship (CG, DDG, or FFG) pinging	238 hours AN/SQS-53 449 hours AN/SQS-56	MFA sonar exposure
	Submarine Sonar Maintenance	Pier side and at-sea maintenance to sonar system.	200	1 hour	Northeast, VACAPES, CHPT, and JAX/CHASN, OPAREAs		Submarine MFA sonar (AN/BQQ-5 or AN/BQQ-10)	1 submarine pinging for up to one hour (60 pings per hour)	6000 pings (100 total hours of active sonar)	MFA sonar exposure

* Number of events and total hours modeled for acoustic effects analysis.

** The source frequency is greater than 200 kHz, which is above the known hearing range of marine mammals. These sources, therefore, were not modeled for the acoustic effects analysis.

*** OPAREAs also include area seaward of each OPAREA unless otherwise noted.

ADC – Acoustic Device Countermeasure; ASW – Antisubmarine Warfare; CHPT – Cherry Point; CG – Guided Missile Cruiser; COMPTUEX – Composite Training Unit Exercise; CSG – Carrier Strike Group; DDG – Guided Missile Destroyer; DICASS – Directional Command-Activated Sonobuoy System; EMATT – Expendable Mobile Acoustic Training Target; ESG – Expeditionary Strike Group; FFG – Fast Frigate; GOMEX – Gulf of Mexico; HFA – High-Frequency Active; IEER – Improved Extended Echo Ranging; kHz – Kilohertz; JAX/CHASN – Jacksonville/Charleston; JTFEX – Joint Task Force Exercise; MCM – Mine Countermeasures; MFA – Mid-Frequency Active; MIW – Mine Warfare; MPA – Maritime Patrol Aircraft; NM – Nautical Mile; OPAREA – Operating Area; RONEX – Squadron Exercise; SCC OPS – Submarine Command Course Operations; SEASWITI – Southeastern Anti-Submarine Warfare Integrated Training Initiative; SUW – Surface Warfare; TORPEX – Torpedo Exercise; ULT – Unit Level Training; VACAPES – Virginia Capes

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1.3.2.1 Southeastern Anti-Submarine Warfare Integrated Training Initiative

SEASWITI is a combined exercise with up to two submarines and either two DDGs and one FFG or one CG, one DDG, and one FFG. The ships and their embarked helicopters would be conducting ASW localization training using the AN/SQS-53, AN/SQS-56, and AN/AQS-13 or AN/AQS-22 dipping sonar. The submarine also periodically operates the AN/BQQ-10 sonar. Up to 24 tonal sonobuoys (e.g., AN/SQQ-62) and two acoustic device countermeasures (ADCs) are also used per scenario. The number of passive sonobuoys (AN/SSQ-53D/E) deployed can vary.

1.3.2.2 Group Sail

The Group Sail is a coordinated training scenario with one submarine and either two DDGs or one CG, one DDG, and one FFG. The ships and their embarked helicopters conduct ASW localization training using the AN/SQS-53, AN/SQS-56, and AN/AQS-13 or AN/AQS-AN/AQS-22 dipping sonar. The submarine also periodically operates the AN/BQQ-10 sonar. Four tonal sonobuoys and two ADCs may also be used per scenario. The number of passive sonobuoys (AN/SSQ-53D/E) deployed can vary. In addition, up to two MK-48 torpedoes could be fired per exercise.

1.3.2.3 Integrated ASW Course

IAC is a tailored course of instruction designed to improve SCC and Strike Group integrated ASW warfighting skill sets. Key components for this course of instruction include coordinated ASW training for the SCC or ASW Commander and staff, key shipboard decision makers, and ASW watch teams. IAC consists of two phases, IAC Phase I and IAC Phase II. IAC Phase I is an approved Navy course of instruction consisting of five days of basic and intermediate level classroom training. IAC Phase II is intended to leverage the knowledge gained during IAC Phase I and build the basic ASW coordination and integration skills of the Strike Group ASW Team. IAC Phase II is a coordinated training scenario that typically involves three DDGs, one CG and one FFG, two to three embarked helicopters, one submarine, and one MPA aircraft searching for, locating, and attacking one submarine. While the ships are searching for the submarine, the submarine may practice simulated attacks against the ships. The ships and their embarked helicopters conduct ASW localization training using the AN/SQS-53, AN/SQS-56, and AN/AQS-13 or AN/AQS-22 dipping sonar. The submarines also periodically operate the AN/BQQ-10 sonar. Up to 36 tonal sonobuoys (e.g., AN/SQQ-62) may also be used per scenario, in addition to, passive sonobuoys (e.g., AN/SSQ-53) and ADCs. Multiple acoustic sources may be active at one time.

1.3.2.4 Submarine Command Course

This scenario is conducted as training for submarine Executive Officers, and involves two submarines conducting ASW training. The AN/BQQ-10 sonar is used, as well as four ADCs per scenario. In addition, up to 36 MK-48 torpedoes could be fired during the duration of an exercise.

1.3.2.5 Squadron Exercise or Gulf of Mexico Exercise

The scenario employs from one to five MCM ships conducting mine localization training. The AN/SQQ-32 and AN/SLQ-48 sonars are utilized.

1.3.3 Strike Group Training Activities

Strike Group training activities continue to develop and refine integrated Strike Group warfare skills and command and control procedures. The objective of this phase is to ensure that all units in the strike group are prepared to support the group commander's specific mission requirements. Strike Group training activities include exercises such as Carrier Strike Group Composite Training Unit Exercises (CSG COMPTUEXs), Joint Task Force Exercises (JTFEXs), and Expeditionary Strike Group Composite Training Unit Exercises (ESG COMPTUEXs). These training exercises provide realistic training opportunities for the Atlantic Fleet with opposing forces in a battlefield environment that mimics the types of challenges the U.S. Navy could face during deployment.

1.3.3.1 Composite Training Unit Exercise

The COMPTUEX is a training scenario designed to provide coordinated training to the entire ESG and CSG. An ESG COMPTUEX consists of a U.S. Navy ESG and U.S. Marine Corps units conducting integrated maritime and amphibious operations. ESG COMPTUEXs include the insertion of amphibious forces onto a beach, movement of vehicles and troops over land, delivery of troops and equipment from ship to shore via helicopters and fixed-wing MPA, the use of live-fire and blank munitions from ground-based troops and aircraft, and ship operations. In addition, Navy ships provide indirect Naval Surface Fire Support in support of the landing amphibious forces utilizing non-explosive ordnance. A CSG COMPTUEX is a major at-sea training event that represents the first time before deployment that an aircraft carrier and its carrier air wing integrate operations with surface and submarine units in an at-sea environment. The ESG and CSG consist of multiple ships, aircraft and submarines operating as an integrated force. A typical ESG or CSG consists of six surface ships, one to five aircraft, and three submarines, approximately half of which are not equipped with active sonar sensors.

Sonars employed in this scenario include the AN/SQS-53, AN/SQS-56, AN/AQS-13 or AN/AQS-22 dipping sonar, and the AN/BQQ-10 sonar. Up to 218 tonal sonobuoys (e.g., AN/SSQ-62), 28 explosive source sonobuoys (AN/SSQ-110A), five receiver sonobuoys (e.g., AN/SSQ-101), and four ADCs are used per scenario. The number of passive sonobuoys (AN/SSQ-53D/E) deployed can vary.

1.3.3.2 Joint Task Force Exercise

The JTFEX is the final fleet exercise prior to the deployment of the combined CSG and ESG. Specifically, a JTFEX would be scheduled after a CSG COMPTUEX to certify that the Strike Group is ready for deployment. The focus of a JTFEX is on mission planning and strategy and on the orchestration of integrated maneuvers, communication, and coordination. The activity is a non-scripted scenario-driven exercise that requires adaptive mission planning by participating naval forces and operational staff, and typically includes other DoD services and/or Allied forces. Often a CSG COMPTUEX and a JTFEX take place concurrently, in which case the exercise is called a Combined CSG COMPTUEX/JTFEX.

Typically, four DDGs, two FFGs, and three submarines participate in a JTFEX. Sonars employed in this scenario include the AN/SQS-53, AN/SQS-56, AN/AQS-13 or AN/AQS-22 dipping sonar, and the AN/BQQ-10 sonars. Up to 174 tonal sonobuoys (e.g., AN/SSQ-62), 28 explosive source sonobuoys (AN/SSQ-110A), 5 receiver sonobuoys (AN/SSQ-101), and 2 ADCs are used per JTFEX. The number of passive sonobuoys (AN/SSQ-53D/E) deployed can vary.

1.3.4 Active Sonar Maintenance

Active sonar maintenance includes both pier side and at sea activities. These activities are required before deployment, after major sonar array maintenance, and when the systems are suspected of not operating at optimal levels.

1.3.4.1 Surface Ship Sonar Maintenance

This scenario consists of surface ships performing periodic maintenance to the AN/SQS-53 or AN/SQS-56 sonar while in port or at sea.

1.3.4.2 Submarine Sonar Maintenance

A submarine performs periodic maintenance on the AN/BQQ-10 and AN/BQS-15 sonar systems while in port or at sea.

1.3.5 RDT&E

RDT&E activities associated with ASW and MIW systems are typically conducted to ensure that the ASW and MIW active sonar and IEER systems being developed function properly and meet the operational requirements set forth in the test plan. The sensors tested in conjunction with RDT&E activities are either existing systems or new systems with similar operating parameters. RDT&E activities addressed in this document are substantially similar to AFAST activities. A separate environmental analysis would be conducted for new sensors that do not have similar operating parameters to the active sonar systems addressed in this LOA request and the AFAST Draft EIS/OEIS. For the effects analysis, RDT&E activities similar to ULT, Coordinated ULT, and Strike Group Exercises are distributed and accounted for in the related training category (see Table 1-1).

1.4 SONAR SYSTEMS

There are two basic types of sonar, passive and active.

- ***Passive sonars*** are only used to listen to incoming sounds. Passive sonars do not emit sound energy into the water and cannot acoustically affect the environment.

- ***Active sonars*** emit acoustic energy to obtain information concerning a distant object from the reflected sound energy. Active sonars are the most effective detection systems against modern ultraquiet submarines and sea mines in shallow water.

1.4.1 Sonars Modeled for Acoustic Effects Analysis

Table 1-2 identifies all of the acoustic systems used during Atlantic Fleet active sonar activities. The acoustic systems presented in Table 1-2 have been separated out into systems that were analyzed and systems that were not analyzed in the effects analysis. The systems that were not analyzed in the effects analysis were systems that are typically operated at frequencies greater than 200 kHz.

Table 1-2. Acoustic Systems Analyzed and Not Analyzed

Systems That Were Analyzed			
System	***Frequency***	***Associated Platform***	***System Description***
AN/SQS-53	MF	DDG and CG hull-mounted sonar	Utilized 70% in search mode and 30% track mode
AN/AQS-13 or AN/AQS-22*	MF	Helicopter dipping sonar	AN/AQS-22: 10 pings/dip, 30 seconds between pings)- also used to represent AN/AQS-13
Explosive source sonobuoy (AN/SSQ-110A)	Impulsive	Helicopter and MPA deployed	Contains two 4.1 lb charges
AN/SQQ-32	HF	MCM over the side system	Used during MIW training events detect, classify, and localize bottom and moored mines
AN/BQS-15	HF	Submarine navigational sonar	Only used when entering and leaving port
AN/SQS-56	MF	FFG hull-mounted sonar	Utilized 70% in search mode and 30% track mode
MK-48 Torpedo	HF	Submarine fired exercise torpedo	Active for 15 min per torpedo run
MK-46 Torpedo	HF	Surface ship and aircraft fired exercise torpedo	(15 min per torpedo run), modeling also used to represent MK-54
AN/SLQ-25 (NIXIE)	MF	DDG, CG, and FFG towed array	20 mins per use
AN/SQS-53 and AN/SQS-56 (Kingfisher)	MF	DDG, CG, and FFG hull-mounted sonar (object detection)	only modeled 53 Kingfisher, used to represent 56
AN/BQQ-10	MF	Submarine hull-mounted sonar	2 pings per hour
Tonal sonobuoy (DICASS) (AN/SSQ-62)	MF	Helicopter and MPA deployed	12 pings, 30 secs between pings
MK-1, MK-2, MK-3 and MK-4 ADCs**	MF	Submarine fired countermeasure	20 mins
Submarine fired countermeasure	MF	Submarine fired countermeasure	20 mins per use

Table 1-2. Acoustic Systems Analyzed and Not Analyzed

Systems That Were Not Analyzed			
System	***Frequency***	***Reason not Analyzed***	***System Description***
Surface Ship Fathometer	12 kHz	System is not unique to military and operates identically to any commercially available bottom sounder.	Depth finder on surface ships
Submarine Fathometer	12 kHz	System is not unique to military and operates identically to any commercially available bottom sounder.	Depth finder on submarine
SQR-19	Passive	System is a passive towed array emitting no active sonar.	A listening device towed behind a surface ship
TB-16/23/29/33	Passive	System is a passive towed array emitting no active sonar.	A listening device towed behind a submarine
Passive Sonobuoy (DIFAR) (AN/SSQ-53)	Passive	Sonobuoys are passive and emit no active sonar	Passive listening buoys deployed from helicopter or MPA
AN/AQS-14	>200 kHz	System frequency outside the upper frequency limit for marine mammals	Helicopter towed array used in MIW for the detection of mines
AN/AQS-24	>200 kHz	System frequency outside the upper frequency limit for marine mammals	Helicopter towed array used in MIW for the detection of mines
AN/AQS-20	>200 kHz	System frequency outside the upper frequency limit for marine mammals	Helicopter towed array used in MIW for the detection of mines
AN/SLQ-48	>200 kHz	System frequency outside the upper frequency limit for marine mammals	A system that uses a remote-controlled submersible vehicle to identify underwater objects.

*AN/AQS-22 modeling is representative of all helicopter dipping sonar

**MK-3 modeling is representative of all ADCs

ADC – Acoustic Device Countermeasure; CG – Guided Missile Cruiser; DDG – Guided Missile Destroyer; DICASS – Directional Command-Activated Sonobuoy System; DIFAR – Directional Frequency Analysis and Recording; FFG – Fast Frigate; HF – High-Frequency; IEER – Improved Extended Echo Ranging; kHz – Kilohertz; MCM – Mine Countermeasures; MF – Mid-Frequency; MIW – Mine Warfare; MPA – Maritime Patrol Aircraft

As a group, marine mammals have functional hearing ranging from 10 hertz (Hz) to 200 kHz; however, their best hearing sensitivities are well below that level. Since active sonar sources operating at 200 kHz or higher attenuate rapidly and are at or outside the upper frequency limit of even the ultrasonic species of marine mammals, further consideration and modeling of these higher frequency acoustic sources are not warranted. As such, high-frequency active sonar systems in excess of 200 kHz are not included in this LOA.

In addition, systems that were found to have similar acoustic output parameters (i.e. frequency, power, deflection angles) were compared. The system with the largest acoustic footprint was modeled as representative of those similar systems that have a smaller footprint. An example of this representative modeling is the AN/AQS-22 for the AN/AQS-13.

Based on individual sonar parameters and the acoustic modeling, the AN/SQS-53 hull-mounted sonar was noted as being the most powerful of all the sonar systems analyzed. The AN/SQS-53 has a nominal source level of 235 decibels with a reference pressure of 1 micro-Pascal at 1 meter (dB re 1 µPa-m) and transmits at center frequency range of 3.5 kHz. As a result, this sonar system has the largest acoustic footprint.

Modern sonar technology includes a multitude of sonar sensor and processing systems. In concept, the simplest active sonar emits sound waves, or "pings," sent out in multiple directions (i.e., is omnidirectional). Sound waves reflect off the target object and move in multiple directions. The time it takes for some of these sound waves to return to the sonar source is calculated to provide a variety of information, including the distance to the target object. More sophisticated active sonars emit an omnidirectional ping and then rapidly scan a steered receiving beam to provide directional as well as range information. Even more advanced sonars use multiple pre-formed beams to listen to echoes from several directions simultaneously and provide efficient detection of both direction and range.

1.4.2 ASW Sonar Systems

ASW sonar systems are deployed from certain classes of surface ships, submarines, helicopters, and fixed-wing MPA. The surface ships used are typically equipped with hull-mounted sonars (passive and active) for the detection of submarines. Helicopters equipped with dipping sonar or sonobuoys are utilized to locate suspect submarines or submarine targets within the training area. In addition, fixed-wing MPA are used to deploy both active and passive sonobuoys to assist in locating and tracking submarines during the duration of the exercise. Submarines involved in the exercises are equipped with hull-mounted and sail-mounted sonars sometimes used to locate and prosecute other submarines and/or surface ships during the exercise. Mid-frequency active (MFA) (i.e., 1 to 10 kHz) sonar is predominately used in ASW activities. The types of tactical acoustic sources employed during ASW sonar training exercises are included in this section.

- **Surface Ship Sonars.** A variety of surface ships operate the AN/SQS-53 and AN/SQS-56 hull-mounted MFA sonar during ASW sonar training exercises, including 11 CGs, 26 DDGs (AN/SQS-53), and 17 FFGs (AN/SQS-56). About half of the U.S. Navy ships do not have any onboard tactical sonar systems.
- **Submarine Sonars.** Tactical military submarines (i.e., 25 SSNs and 6 SSBNs) equipped with BQQ-5 or BQQ-10 hull-mounted MFA sonars, are used to detect and target enemy submarines and surface ships. A submarine's mission revolves around its stealth; therefore, MFA sonars are used very infrequently since the pinging of the MFA sonar also gives away the location of the submarine. Note that the BQQ-10 is the more predominant system, and that the system is identified throughout the remainder of this document with the understanding that the BQQ-5 and BQQ-10 are similar in those operational parameters with a potential to affect marine mammals. In addition, Seawolf Class attack submarines, Virginia Class attack submarines, Los Angeles Class attack submarines, and Ohio Class nuclear guided missile submarines also have the AN/BQS-15, a sonar that uses both mid- and high-frequency for under-ice navigation and mine-hunting.

- **Aircraft Sonar Systems.** Aircraft sonar systems that operate during ASW sonar training exercises include sonobuoys and dipping sonars.
    - **Sonobuoys**. Sonobuoys, deployed by both helicopter and fixed-wing MPA, are expendable devices that are either tonal (active), impulsive (explosive), or listening (passive). The Navy uses a tonal sonobuoy called a Directional Command-Activated sonobuoy System (DICASS) and a sonobuoy system called an IEER system, which consists of an explosive source sonobuoy (AN/SSQ-110A) and a passive receiver sonobuoy (AN/SSQ-101). The Navy also uses a passive sonobuoy called a Directional Frequency Analysis and Recording (DIFAR). Passive listening sonobuoys such as DIFAR (AN/SSQ-53) are deployed from helicopters or maritime patrol aircraft and do not emit active sonar. These systems are used for the detection and tracking of submarine threats.
    - **Dipping Sonars**. Dipping active/passive sonars, present on helicopters, are recoverable devices that are lowered via a cable to detect or maintain contact with underwater targets. The Navy uses the AN/AQS-13 and AN/AQS-22 dipping sonars. Helicopters can be based ashore or aboard a ship.
- **Torpedoes.** Torpedoes are the primary ASW weapons used by surface ships, aircraft, and submarines. The guidance systems of these weapons can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively by listening for sound generated by the target, or actively by pinging the target and using the echoes for guidance. All torpedoes to be used during ASW activities are recoverable and non-explosive. The majority of torpedo firings occurring during AFAST activities are air slugs (dry fire) or shapes (i.e., solid masses resembling the weight and shape of a torpedo).
- **Acoustic Device Countermeasures.** Several types of counter measure devices could be deployed during Fleet training exercises, including the Acoustic Device Countermeasure MK-1, MK-2, MK- 3, MK-4, and the AN/SLQ-25A (NIXIE). Counter measure devices are submarine simulators and act as decoys to avert localization and torpedo attacks. Countermeasures may be towed or free floating sources.
- **Training Targets.** ASW training targets are used to simulate target submarines. They are equipped with one or more 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, and (3) magnetic sources to trigger magnetic detectors. The Navy uses the Expendable Mobile Acoustic Training Target (EMATT) and the MK-30 acoustic training targets (recovered) during ASW sonar training exercises.

Logistic support ships and aircraft are sometimes used in active sonar training activities to deliver and recover targets. However, the logistical support platforms that are used for recovery either are not equipped with sonar capabilities or do not utilize their sonar system during the recovery effort.

1.4.3 MIW Sonar Systems

There are a variety of different sonar systems that could be used during MIW sonar training exercises. These systems are typically high-frequency sonars (i.e., greater than 10 kHz) used to detect, locate, and characterize mines suspended in the water (i.e., moored mines) and mines buried under the ocean floor. In addition, the majority of the MIW sonar sensors used can be deployed by more than one platform (i.e., helicopter-towed body, unmanned underwater vehicle [UUV], surf zone crawler, or surface ship) and may be interchangeable. The majority of MIW systems are deployed by helicopters and typically operate at high frequencies (greater than 200kHz).

The types of tactical acoustic sources used during MIW sonar training exercises include the following:

- **Surface Ship Sonars.** DDGs, FFGs, and CGs can utilize their hull-mounted sonars (AN/SQS-53 and AN/SQS-56) in the object detection (Kingfisher) mode. These ships, as well as mine hunters, may utilize over-the-side UUV systems containing sonar sensor packages to detect and classify mine shapes. Navy minesweepers use the AN/SQQ-32, a variable depth mine detection and classification high-frequency active sonar system. In addition, mine hunters are equipped with underwater acoustic communication systems.
- **Submarine Sonars.** Submarines use a sail-mounted sonar, the AN/BQS-15, to detect mines and objects.

1.5 DESCRIPTION OF ALTERNATIVES INCLUDING PREFERRED ALTERNATIVE

Four alternatives, including the No Action Alternative, were included for analysis in the AFAST EIS/OEIS. Under all four Alternatives, the Navy would conduct active sonar activities at current tempo and intensity.

Under Alternative 1, Designated Active Sonar Areas, fixed active sonar areas would be designated using an environmental analysis to determine locations that would minimize environmental effects to biological resources while still meeting operational requirements. These areas would be available for use year-round. Under Alternative 2, Designated Seasonal Active Sonar Areas, active sonar training areas would be designated using the same environmental analysis conducted under Alternative 1. The areas would be adjusted seasonally to minimize effects to marine resources while still meeting minimum operational requirements. Under Alternative 3, the results of the environmental analysis conducted for Alternative 1 and 2 were utilized in conjunction with a qualitative environmental analysis of sensitive habitats to identify areas of increased awareness. Active sonar would not be conducted within these areas of increased awareness. Under the No Action Alternative, the Navy would continue conducting active sonar activities within and adjacent to existing OPAREAs rather than designate active sonar areas or areas of increased awareness.

Through careful consideration of the data developed in the AFAST Draft EIS/OEIS, and the necessity to conduct realistic ASW training today and in the future, the U.S. Fleet Forces has selected the No Action Alternative as the operationally preferred alternative. The world today is a rapidly changing and extremely complex place. This is especially true in the arena of ASW and the scientific advances in submarine quieting technology. Not only is this technology rapidly improving, the availability of these quiet submarines has also significantly increased. Since these submarines typically operate in coastal regions, which are the most difficult acoustically to conduct ASW, the Navy needs to ensure it has the ability to train in areas that are environmentally similar to where these submarines currently operate, as well as areas that may arise in the future. Limiting where naval forces can train will eliminate this critical option of training flexibility to respond to future crises.

As the biological science continues to evolve, the areas identified in the AFAST Draft EIS/OEIS could evolve and change as well, again potentially restricting access to areas that would be critical to training. Not only would Alternatives 1 and 2 severely limit the necessity to train in areas similar to where potential threats operate, it would require the relocation of approximately 30 percent of Navy's current training. Furthermore, independent of the geographic limitations that would be imposed by Alternative 3; there is not a difference in the environmental effects analysis between Alternative 3 and the No Action Alternative. Due to the relatively insignificant difference between Alternative 3 and the No Action Alternative and the importance of the geographic flexibility required to conduct realistic training, the No Action Alternative was selected as the operationally preferred option. As such, this LOA request is for the conduct of activities in accordance with the No Action Alternative as described in the AFAST Draft EIS/OEIS.

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2. DATES, DURATION AND LOCATION OF ACTIVE SONAR ACTIVITIES

The Navy is requesting a five-year authorization to cover the period of December 2008 through December 2013. The anticipated active sonar use was distributed based on actual reported active sonar usage. The Navy's Atlantic Fleet trains in a series of Operating Areas (OPAREAs) along the U.S. East Coast and in the Gulf of Mexico. Due to the size of the battle space needed for effective conduct of activities, training and testing also occur seaward of these OPAREAs. The OPAREAs include the Northeast OPAREA, the Virginia Capes (VACAPES) OPAREA, the Cherry Point (CHPT) OPAREA, the Jacksonville/Charleston (JAX/CHASN) OPAREA, and the Gulf of Mexico (GOMEX) OPAREA. The locations of the OPAREAs and the shoreward/seaward boundary of the Study Area are depicted in Figure 1-1. Note that the Northeast and Gulf of Mexico OPAREAs encompass a series of OPAREAs. The Northeast OPAREA includes the Boston, Atlantic City, and Narragansett Bay OPAREAs. The GOMEX OPAREAs includes the Pensacola, Panama City, Corpus Christi, New Orleans, and Key West OPAREAs. For the purposes of this document, the OPAREA includes the existing OPAREA, as well as adjacent shoreward and seaward areas. Table 2-1 summarizes the number of events per year by OPAREA.

For the purposes of the Preferred Alternative that is the subject of this Letter of Authorization (LOA) request, active sonar activities would occur year-round throughout the Study Area. These areas are depicted in Figure 2-1. Active sonar activities would occur in locations that maximize active sonar opportunities and meet applicable operational requirements associated with a specific active sonar activity. The text and figures in subsequent sections describe where active sonar training, research, development, test, and evaluation (RDT&E), and maintenance activities would occur.

The following sections describe each of the identified ULT events, Coordinated ULT events, Strike Group exercises and maintenance events. The sonar use data presented in these sections and within Table 2-1 was gathered from the operational community and represents the required training to meet the Purpose and Need of the Proposed Action. Please refer to Appendix C of the Atlantic Fleet Active Sonar Training (AFAST) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) for detailed descriptions of sonar use for individual training events.

2.1 LOCATION OF ACTIVE SONAR ACTIVITIES

The No Action Alternative is to continue conducting active sonar activities within and adjacent to existing OPAREAs rather than designate active sonar areas or areas of increased awareness. The No Action alternative can be regarded as continuing with the present course of action. Under the No Action Alternative, active sonar activities occur in locations that maximize active sonar opportunities and meet applicable operational requirements associated with a specific active sonar activity. Currently active sonar training does not occur in North Atlantic right whale critical habitat with the exception of object detection and navigation off shore Mayport, Florida and Kings Bay, Georgia; helicopter ASW offshore Mayport, Florida; and TORPEXs in the northeast during August, September, and October. Additionally, active sonar training does not currently occur in National Marine Sanctuaries along the East coast and Gulf of Mexico.

2.1.1 ASW Training Areas

ASW activities for all platforms could occur within and adjacent to existing East Coast OPAREAS beyond 22.2 km (12 NM) with the exception of sonar dipping activities, however, most ASW training involving submarines or submarine targets would occur in waters greater than 183 m (600 ft) deep due to safety concerns about running aground at shallower depths. ASW active sonar activities occurring in specific locations are discussed below.

Table 2-1. Events per Year by Operating Area

Scenario	**OPAREA**					
	NE	**VACAPES**	**CHPT**	**JAX/ CHASN**	**GOMEX**	**TOTAL**
Independent ULT						
Surface Ship ASW		69	91	292	5	457
Surface Ship Object Detection/Navigational Sonar		68		40		108
Helicopter ASW		25	25	115		165
Submarine ASW	30	10	14	45	1	100
Submarine Object Detection/Navigational Sonar	165	78		57		300
MPA ASW (tonal sonobuoy)	238	79	111	356	7	791
MPA ASW (explosive source sonobuoy)	34	34	34	34	34	170
Surface Ship MIW					266	266
Coordinated ULT						
SEASWITI				5		5
IAC		0.2	1.4	2.4	1	5
Group Sail		3	4	13		20
SCC Operations	0.4			1.6		2
RONEX and GOMEX Exercises					8	8
Strike Group Training						
ESG COMPTUEX and CSG COMPTUEX*		0.2	1.4	2.4	1**	5
JTFEX		0.2	0.6	1.2	0	2
Maintenance						
Surface Ship Sonar Maintenance		61	82	263	4	410
Submarine Sonar Maintenance	30	10	14	45	1	100

* COMPTUEX distribution reflects the typical distribution of COMPTUEXs across OPAREA boundaries.

**All events are considered equally likely to occur at any time during the year, except for strike group exercises, which would not occur in the GOMEX OPAREA during hurricane season (summer and fall).

ASW – Antisubmarine Warfare; CHPT – Cherry Point; COMPTUEX – Composite Training Unit Exercise; GOMEX – Gulf of Mexico; JAX/CHASN – Jacksonville/Charleston; JTFEX – Joint Task Force Exercise; MIW – Mine Warfare; MPA – Maritime Patrol Aircraft; NE – Northeast; OPAREA – Operating Area; RONEX – Squadron Exercise; SCC OPS – Submarine Command Course Operations; SEASWITI – Southeastern Antisubmarine Warfare Integrated Training Initiative; TORPEX – Torpedo Exercise; ULT – Unit Level Training; VAC – Virginia Capes

2.1.1.1 Helicopter ASW ULT Areas

The helicopter ASW ULT events are the only ASW activity that could occur within 22 km (12 NM) of shore. This activity would be conducted in the waters of the East Coast OPAREAs typically near fleet concentration areas while embarked on a surface ship. Helicopter ASW ULT events are also conducted by helicopters deployed from shore-based Jacksonville, Florida, units. These helicopter units use established sonar dipping areas offshore Mayport (Jacksonville), Florida, which are located in territorial waters and within the southeast North Atlantic right whale critical habitat.

2.1.1.2 SEASWITI Areas

SEASWITIs continue over a 5 to 7 day period and occur up to four times per year. This training exercise generally occurs in deep water off the coast of Jacksonville, Florida.

2.1.1.3 Group Sail Areas

This exercise lasts from 2 to 3 days and occurs up to 20 times per year. These events typically take place within and seaward of the VACAPES, CHPT, and JAX/CHASN OPAREAs.

2.1.1.4 Integrated ASW Course

An IAC exercise consists of two, back-to-back, 12-hour events that could occur up to five times per year. These events typically take place within and seaward of the VACAPES, CHPT, and JAX/CHASN OPAREAs.

2.1.1.5 Submarine Command Course Operations Areas

The submarine command course (SCC) operations last from 3 to 5 days and occur up to two times per year. This training exercise typically occurs in the JAX/CHASN and Northeast OPAREAs in deep ocean areas.

2.1.1.6 Torpedo Exercise Areas

Torpedo firing exercises (TORPEX) can occur anywhere within and adjacent to East Coast and GOMEX OPAREAs. The exception is in the Northeast OPAREA where the North Atlantic right whale critical habitat is located. TORPEX areas that meet current operational requirements for proximity to torpedo and target recovery support facilities were established during previous consultations. Therefore, TORPEX activities in the northeast North Atlantic right whale critical habitat are limited to these established areas.

2.1.2 MIW Training Areas

MIW Training could occur in territorial or non-territorial waters. Independent and Coordinated MIW ULT activities would be conducted within and adjacent to the Pensacola and Panama City OPAREAs in the northern Gulf of Mexico and off the east coast of Texas in the Corpus Christi OPAREA.

Coordinated ULT scenarios are 10 to 15 days in length and occur up to four times per year. The Squadron Exercise (RONEX) or GOMEX Exercise would be conducted in both deep and shallow water training areas.

2.1.3 Object Detection/Navigational Training Areas

Surface Ship training would be conducted primarily in the shallow water port entrance and exit lanes for Norfolk, Virginia, and Mayport, Florida. The transit lane servicing Mayport, Florida crosses through the southeast North Atlantic right whale critical habitat.

Submarine training would occur primarily in the established submarine transit lanes entering/exiting Groton, Connecticut; Norfolk, Virginia; and Kings Bay, Georgia. The transit lane servicing Kings Bay, Georgia crosses through the southeast North Atlantic right whale critical habitat.

2.1.4 Maintenance Areas

Maintenance activities could occur in homeports located in territorial waters, or in the open ocean during transit in non-territorial waters.

2.1.4.1 Surface Ship Sonar Maintenance Areas

This maintenance takes up to 4 hours. Surface ships would be operating their active sonar systems for maintenance while pier side within their homeport, located in either Norfolk, Virginia or Mayport, Florida. Additionally, open ocean sonar maintenance could occur anywhere within the non-territorial waters of the AFAST Study Area as the system’s performance may warrant.

2.1.4.2 Submarine Sonar Maintenance Areas

This maintenance takes from 45 minutes to 1 hour. Submarines would conduct maintenance to their sonar systems pier side in their homeports of either Groton, Connecticut; Norfolk, Virginia; or Kings Bay, Georgia. Additionally, sonar maintenance could occur anywhere within the non-territorial waters of the AFAST Study Area as the system’s performance may warrant.

2.1.5 RDT&E Areas

For RDT&E activities included in this analysis, active sonar activities occur in similar locations as representative training events.

2.2 NATIONAL MARINE SANCTUARIES

At present, the Navy does not conduct active sonar activities in the Stellwagen Bank, USS Monitor, Gray's Reef, Flower Garden, and Florida Keys National Marine Sanctuaries. If it is determined that an active sonar activity may occur in the Gray's Reef, Flower Garden, or Florida Keys National Marine Sanctuaries, naval activities will be carried out in a manner that avoids to the maximum extent practicable any adverse impacts on sanctuary resources and qualities. If necessary, the Navy would consult with the Director, Office of Ocean and Coastal Resource Management in accordance with 15 CFR 922.

Stellwagen Bank and USS Monitor National Marine Sanctuary regulations specifically preclude the Navy from conducting operations in this area without first entering consultation. If it is determined that an active sonar activity or vessel transit may occur in the Stellwagen Bank or USS Monitor National Marine Sanctuaries the Navy would consult with the Director, Office of Ocean and Coastal Resource Management in accordance with 15 CFR 922.

2.3 CRITICAL HABITAT

NMFS designated three areas in June 1994 as critical habitat for the western North Atlantic population of the North Atlantic right whale. They include the following:

1. Coastal Florida and Georgia (Sebastian Inlet, FL to the Altamaha River, GA),
2. Great South Channel (east of Cape Cod), and
3. Massachusetts Bay and Cape Cod Bay

In the southeastern critical habitat, the Navy would conduct helicopter sonar dipping in the designated training area. In addition, the Navy would conduct ship object detection/navigational sonar training while entering/exiting port. These two activities could occur year round. No other active sonar activities will occur in the critical habitat.

In the northeastern critical habitat, the Navy would conduct TORPEX activities. These activities would be conducted in August, September, and October per the Navy consultation with NMFS. Water depths in this area are less than the optimal depth for most ASW activities. The limited ASW active sonar activities that could occur year round would only involve submarines, which have minimal active sonar usage.

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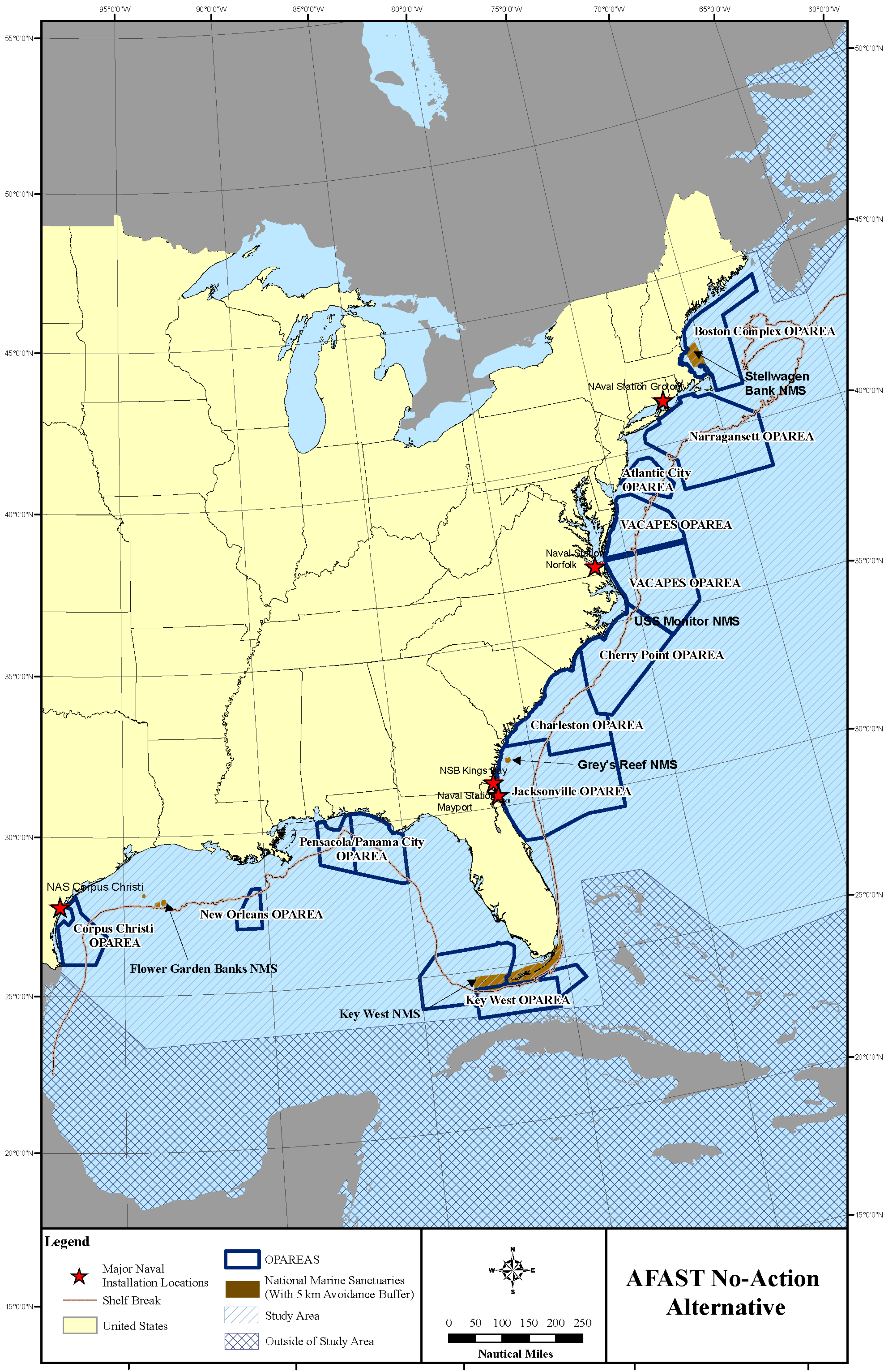

Figure 2-1. No Action Alternative – Active Sonar Activities could occur Anywhere in the Study Area

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3. MARINE MAMMAL SPECIES AND NUMBERS

The information contained in this Chapter relies heavily on the data gathered in the Marine Resource Assessments (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 Operating Areas (OPAREAs). Specifically, the goal of the MRA program is to describe and document the marine resources present in each of the Navy's OPAREAs. MRAs have been completed for the Northeast (DON, 2005a), Virginia Capes (VACAPES) (DON, 2007a), Cherry Point (CHPT) (DON, 2007b), Jacksonville/Charleston (JAX/CHASN) (DON, 2007c), and the Gulf of Mexico (GOMEX) OPAREAs (2007d). As shown in Table 3-1, 43 marine mammal species have possible or confirmed occurrence along the East Coast of the United States (U.S.) or in the Gulf of Mexico. The species include cetaceans, pinnipeds, and a sirenian.

Table 3-1. Marine Mammals with Possible or Confirmed Occurrence Along the U.S. East Coast and in the Gulf of Mexico

Common Name	Scientific Name	ESA Status	Possible Location
Suborder Mysticeti (baleen whales)			
Family Balaenidae (right whales)			
North Atlantic Right Whale	*Eubalaena glacialis*	Endangered	East Coast
Family Balaenopteridae (rorquals)			
Humpback whale	*Megaptera novaeangliae*	Endangered	East Coast
Minke whale	*Balaenoptera acutorostrata*		East Coast
Bryde's whale	*Balaenoptera edeni*		East Coast and Gulf of Mexico
Sei whale	*Balaenoptera borealis*	Endangered	East Coast
Fin whale	*Balaenoptera physalus*	Endangered	East Coast and Gulf of Mexico
Blue whale	*Balaenoptera musculus*	Endangered	East Coast
Suborder Odontoceti (toothed whales)			
Family Physeteridae (sperm whale)			
Sperm whale	*Physeter macrocephalus*	Endangered	East Coast and Gulf of Mexico
Family Kogiidae			
Pygmy sperm whale	*Kogia breviceps*		East Coast and Gulf of Mexico
Dwarf sperm whale	*Kogia sima*		East Coast and Gulf of Mexico
Family Monodontidae (buluga and narwhal whales)			
Beluga whale	*Delphinapterus leucas*		East Coast
Family Ziphiidae (beaked whales)			
Cuvier's beaked whale	*Ziphius cavirostris*		East Coast and Gulf of Mexico
True's beaked whale	*Mesoplodon mirus*		East Coast
Gervais' beaked whale	*Mesoplodon europaeus*		East Coast and Gulf of Mexico
Sowerby's beaked whale	*Mesoplodon bidens*		East Coast
Blainville's beaked whale	*Mesoplodon densirostris*		East Coast and Gulf of Mexico
Northern bottlenose whale	*Hyperoodon ampullatus*		East Coast
Family Delphinidae (dolphins)			
Rough-toothed dolphin	*Steno bredanensis*		East Coast and Gulf of Mexico
Common bottlenose dolphin	*Tursiops truncatus*		East Coast and Gulf of Mexico
Pantropical spotted dolphin	*Stenella attenuate*		East Coast and Gulf of Mexico
Atlantic spotted dolphin	*Stenella frontalis*		East Coast and Gulf of Mexico
Spinner dolphin	*Stenella longirostris*		East Coast and Gulf of Mexico

Table 3-1. Marine Mammals with Possible or Confirmed Occurrence Along the U.S. East Coast and in the Gulf of Mexico Cont'd

Common Name	Scientific Name	ESA Status	Possible Location
Clymene dolphin	*Stenella clymene*		East Coast and Gulf of Mexico
Striped dolphin	*Stenella coeruleoalba*		East Coast and Gulf of Mexico
Common dolphin	*Delphinus* spp.		East Coast
Fraser's dolphin	*Lagenodelphis hosei*		East Coast and Gulf of Mexico
Risso's dolphin	*Grampus griseus*		East Coast and Gulf of Mexico
Atlantic white-sided dolphin	*Lagenorhynchus acutus*		East Coast and Gulf of Mexico
White-beaked dolphin	*Lagenorhynchus albirostris*		East Coast and Gulf of Mexico
Melon-headed whale	*Peponocephala electra*		East Coast and Gulf of Mexico
Pygmy killer whale	*Feresa attenuate*		East Coast and Gulf of Mexico
False killer whale	*Pseudorca crassidens*		East Coast
Killer whale	*Orcinus orca*		East Coast and Gulf of Mexico
Long-finned pilot whale	*Globicephala melas*		East Coast and Gulf of Mexico
Short-finned pilot whale	*Globicephala macrorhynchus*		East Coast and Gulf of Mexico
Family Phocoenidae			
Harbor porpoise	*Phocoena phocoena*		East Coast
Order Carnivora			
Suborder Pinnipedia			
Family Phocidae (true seals)			
Hooded seal	*Cystophora cristata*		East Coast
Harp seal	*Pagophilus groenlandica*		East Coast
Gray seal	*Halichoerus grypus*		East Coast
Harbor seal	*Phoca vitulina*		East Coast
Ringed seal	*Pusa hispida*		East Coast
Walrus	*Odobenus rosmarus*		East Coast
Order Sirenia			
Family Trichechidae (manatees)			
West Indian manatee	*Trichechus manatus*	Endangered	East Coast and Gulf of Mexico

Source: DON, 2005a, 2007a, 2007b, 2007c, and 2007d

3.1 MARINE MAMMAL OCCURRENCE

The MRA data were used to provide a regional context for each species. These MRAs represent 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, recovery plans, and survey reports.

Of the marine mammals that may occur along the East Coast of the U.S. and Gulf of Mexico, six species of cetaceans—five mysticete whales and one odontocete whale—and one sirenian species are currently listed as federally endangered. These species include the North Atlantic right whale, humpback whale, sei whale, fin whale, blue whale, sperm whale, and West Indian manatee. A separate consultation is underway with NMFS to evaluate potential effects to these species. The Navy has requested NMFS initiate Endangered Species Act (ESA) consultation in support of this Letter of Authorization (LOA) request.

3.2 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 in the Northeast, Southeast, and GOMEX OPAREAs. The updated density estimates presented in this LOA are derived from the *Navy OPAREA Density Estimates (NODE) for the Northeast OPAREAS* report (DON, 2007e*)*, the *NODE for the Southeast OPAREAS* report (DON, 2007f), and the *NODE for the GOMEX OPAREA* report (DON 2007g).

Density estimates for cetaceans were either modeled for each region (Northeast, Southeast, and GOMEX) using available line-transect survey data or derived in order of preference: 1) through spatial models using line-transect survey data provided by NMFS; 2) using abundance estimates from Mullin and Fulling (2003), Fulling et al. (2003), and/or Mullin and Fulling (2004); 3) or based on the cetacean abundance estimates found in the most current NOAA stock assessment report (SAR) (Waring et al. 2007). In the AFAST Study Area, density estimates were derived as follows:

1. Northeast OPAREAs: The traditional line-transect methods used in the preliminary Northeast NODE (DON, 2006c) and abundance estimates from the North Atlantic Right Whale Consortium (NARWC, 2006). Density estimates for pinnipeds in these OPAREAs were derived from abundance estimates found in the NOAA stock assessment report (Waring et al., 2007) or from the scientific literature (Barlas, 1999).
2. Southeast OPAREAs: Abundance estimates found in the National Oceanic and Atmospheric Administration (NOAA) stock assessment report (Waring et al., 2007) or in Mullin and Fulling, (2003).
3. Gulf of Mexico OPAREAs: Abundance estimates found in the NOAA stock assessment report (Waring et al., 2007) based on Mullin and Fulling (2004).

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 Northeast, all analyses for cetaceans were based on data collected through the National Marine Fisheries Service’s (NMFS) Northeast Fisheries Science Center (NMFS-NEFSC) aerial surveys conducted between 1998 and 2005. For the Southeast, all analyses for cetaceans were based on sighting data collected through shipboard surveys conducted by NMFS-NEFSC and Southeast Fisheries Science Center (NMFS-SEFSC) between 1998 and 2005. For the GOMEX, all analyses for cetaceans were based on data collected through NMFS-SEFSC shipboard surveys conducted between 1996 and 2004. Species-specific density estimates derived through spatial modeling were compared with abundance estimates found in the most current NOAA SAR to ensure consistency. All spatial models and density estimates were reviewed by NMFS technical staff. For each region, a list of each species and how their density was derived is shown in Tables 3-2 through 3-4. For a more detailed description of the methodology involved in calculating the density estimates provided in this LOA, please refer to each of the NODE reports (DON 2007e, 2007f, and 2007g).

Table 3-2. Method of Density Estimation for each Species/Species Group in the Northeast OPAREA

Species/Species Group
Model-Derived Density Estimates
Humpback whale (*Megaptera novaeangliae*)
Fin whale (*Balaenoptera physalus*)
Minke whale (*Balaenoptera acutorostrata*)
Common dolphin (*Delphinus delphis*)
Atlantic White-sided dolphin (*Lagenorhynchus acutus*)
Harbor porpoise (*Phocoena phocoena*)
Density Estimates from Preliminary NE NODE Report
Sei whale (*Balaenoptera borealis*)
Sperm whale (*Physeter macrocephalus*)
Beaked whales (Family Ziphiidae)
Bottlenose dolphin (*Tursiops truncatus*)
Spotted dolphins (*Stenella attenuata and Stenella frontalis*)
Striped dolphin (*Stenella coeruleoalba*)
Risso's dolphin (*Grampus griseus*)
Pilot whales (*Globicephala* spp.)
Gray seal (*Halichoerus grypus*)
Harbor seal (*Phoca vitulina*)
Literature Derived Density Estimates
North Atlantic Right Whale (*Eubalaena glacialis*)
Species for Which Density Estimates Are Not Available
Blue whale (*Balaenoptera musculus*)
Spinner dolphin (*Stenella longirostris*)
White-Beaked Dolphin (*Lagenorhynchus albirostris*)
Pygmy killer whale (*Feresa attenuata*)
Killer whale (*Orcinus orca*)
Harp seal (*Pagophilus groenlandicus*)
Hooded seal *(Cystophora cristata)*

Source: DON, 2007e

Table 3-3. Method of Density Estimation for each Species/Species Group in the Southeast OPAREAs

Species/Species Group
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
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
Source: DON, 2007f.

Table 3-4. Method of Density Estimation for each Species/Species Group in the Gulf of Mexico OPAREA

Species/Species Group
Model-Derived Density Estimates
Sperm whale (*Physeter macrocephalus*)
Kogia spp.
Beaked Whales (Family Ziphiidae)
Rough-toothed dolphin (*Steno bredanensis*)
Bottlenose dolphin (*Tursiops truncatus*)
Pantropical spotted dolphin (*Stenella attenuata*)
Atlantic spotted dolphin (*Stenella frontalis*)
Striped dolphin (*Stenella coeruleoalba*)
Spinner dolphin (*Stenella longirostris*)
Risso's dolphin (*Grampus griseus*)
SAR or Literature-Derived Density Estimates
Bryde's whale (*Balaenoptera brydei/edeni*)
Clymene dolphin (*Stenella clymene*)
Fraser's dolphin (*Lagenodelphis hosei*)
Killer whale (*Orcinus orca*)
False killer whale (*Pseudorca crassidens*)
Pygmy killer whale (*Feresa attenuata*)
Melon-headed Whale (*Peponocephala electra*)
Short-finned pilot whale *(Globicephala macrorhynchus)*

Source: DON, 2007g

4. AFFECTED SPECIES STATUS AND DISTRIBUTION

More than 120 species of marine mammals occur worldwide (Rice, 1998). The term "marine mammal" is purely descriptive and refers to mammals that carry out all or a substantial part of their foraging in marine or, in some cases, freshwater environments. Marine mammals as a group are comprised of various species from three orders (Cetacea, Carnivora, and Sirenia).

Cetaceans are divided into two major suborders: Mysticeti (baleen whales) and Odontoceti (toothed whales). Toothed whales are generally smaller and have teeth that are used to capture prey. Baleen whales use baleen to filter their prey from the water. In addition to contrasts in feeding methods, there are life history and social organization differences (see Tyack, 1986). Pinnipeds are divided into three families: *Phocidae* (the "true" or earless seals); *Otariidae* (sea lions and fur seals); and *Odobenidae* (walruses). Four living sirenian species are classified into two families: *Trichechidae*, with three species of manatees, and *Dugongidae*, the dugong. Sirenians are the only completely herbivorous marine mammals. Of the sirenians, only the West Indian manatee occurs along the U.S. Atlantic coast.

Cetaceans have undergone numerous anatomical and physiological adaptations to the marine environment that are discussed in detail by Pabst et al. (1999). These include significant changes from terrestrial mammalian sensory systems to accommodate the unique challenges that a marine environment imposes. Cetaceans have well-developed senses of touch and sight, with highly innervated skin and an eye structure that allows them to see well in air, as well as in water (Van der Pol et al., 1995; Wartzok and Ketten, 1999). Due to increased density, sound travels farther and faster in water than in air (Wartzok and Ketten, 1999). This physical property can allow for more effective communication and echolocation but requires drastic changes in auditory and sound production structures (Wartzok and Ketten, 1999). Marine mammal vocalizations often extend both above and below the range of human hearing. Sound frequencies lower than 18 hertz (Hz) are termed infrasonic and those higher than 20 kilohertz (kHz) are ultrasonic. Baleen whales generally utilize lower frequencies. Depending upon the species, mysticetes produce tonal sounds between 20 and 3,000 Hz. Clark and Ellison (2004) suggested that baleen whales use low-frequency sounds not only for long-range communication but also as a simple form of echo-ranging, using echoes to navigate and orient relative to physical features of the ocean. However, additional research is needed to determine whether these animals actually use sound for echolocation. Toothed whales also produce a wide variety of sounds (Wartzok and Ketten, 1999). Species-specific broadband "clicks" with peak energies between 10 and 200 kHz are used for echolocation. Tonal vocalizations (whistles), ranging from 4 to 16 kHz, are important to communication. Individually variable burst-pulse click trains have also been identified. However, not all toothed whales fully utilize this repertoire. Sperm whales only produce clicks which presumably function in both communication and echolocation (Whitehead, 2003).

Empirical data on cetacean hearing are sparse, particularly for baleen whales. However, auditory thresholds of some smaller odontocetes have been determined. It is generally believed that cetaceans should at least be sensitive to the frequencies of their own vocalizations. Indications of sensitivity ranges at various frequencies have been developed from comparisons of cetacean inner ear anatomy and structural models of ear responses to vibrations. The ears of small toothed whales are specialized for receiving high-frequency sound, while baleen whale inner ears are best suited to low or infrasonic frequencies (Ketten 1992, 1997).

Sounds produced by pinnipeds include airborne and underwater vocalizations (Thomson and Richardson, 1995). Calls include grunts, barks, and growls in addition to the more conventional whistles, clicks, and pulses. The majority of pinniped sounds are in the sonic range (20 Hz to 20 kHz; Ketten, 1998; Wartzok and Ketten, 1999). In general, phocids are far more vocal underwater than are otariids. Phocid calls are commonly between 100 Hz and 15 kHz, with peak spectra less than 5 kHz, but can range as high as 40 kHz (Ketten, 1998; Wartzok and Ketten, 1999). There is no evidence that pinnipeds echolocate (Schusterman et al., 2000).

General reviews of cetacean and pinniped sound production and hearing may be found in Richardson et al. (1995), Edds-Walton (1997), Wartzok and Ketten (1999), Au et al. (2000), and Hildebrand (2005). For a discussion of acoustic concepts, terminology, and measurement procedures, as well as underwater sound propagation, Urick (1983) and Richardson et al. (1995) are recommended.

4.1 MYSTICETES

4.1.1 North Atlantic Right Whale (*Eubalaena glacialis*)

Description – Until recently, right whales in the North Atlantic and North Pacific were classified together as a single species referred to as the “northern right whale.” Genetic data indicate that these two populations represent separate species: the North Atlantic right whale (*Eubalaena glacialis*) and the North Pacific right whale (*Eubalaena japonica*) (Rosenbaum et al., 2000). In this report, the naming convention matches that used in the NOAA stock assessment reports; therefore, “northern right whale” refers to the North Atlantic right whale species.

Adults are robust and may reach 18 meters (m) (59 feet [ft]) in length (Jefferson et al., 1993). There is no dorsal fin on the broad back. The head is nearly one-third of its total body length. The jaw line is arched and the upper jaw is very narrow in dorsal view. Right whales are overall black in color although many individuals also have irregular white patches on their undersides (Reeves and Kenney, 2003). The head is covered with irregular, whitish patches called “callosities” that assist researchers in individual identification (Kraus et al., 1986b).

Status – The northern right whale is one of the world’s most endangered large whale species (Clapham et al., 1999; Perry et al., 1999; IWC, 2001b). Northern right whales are classified as endangered under the ESA (Waring et al., 2007).

Approximately 350 individuals, including about 70 mature females, are thought to occur in the western North Atlantic (Kraus et al., 2005). The most recent NOAA Stock Assessment Report states that in a review of the photo-id recapture database for October 2005, 306 individually recognized whales were known to be alive during 2001 (Waring et al., 2007). This represents a minimum population size, and no estimate of abundance with an associated coefficient of variation has been calculated for this population (Waring et al., 2007).

This species is presently declining in number (Caswell et al., 1999; Kraus et al., 2005) and is considered to be reproductively dysfunctional, which means even if human induced mortality is eliminated, the species still likely faces extinction (Reeves et al., 2001). Kraus et al. (2005) noted that the recent increases in birth rate are too small to overcome this decline.

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., 2003b). 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 kilometers (km) (1,040 Nautical Miles [NM]) in 23 days (mean=3.5 kilometers per hour [km/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, 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 dB root-mean-square (rms) re: 1 μPa-m (decibels at the reference level of one micropascal at one meter) (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).

Distribution – Right whales occur in sub-polar to temperate waters. The northern right whale was historically widely distributed, ranging from latitudes of 60°N to 20° N, prior to serious declines in abundance due to intensive whaling (e.g., NMFS, 2006b; Reeves et al., 2007). Northern 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 United States (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; Silber and Clapham, 2001). There are documented records for this species in the Gulf of Mexico; mother/calf pairs have been sighted as far west as Texas (Zoodsma, 2006).

Most northern 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 (there may be a regular offshore component). The population migrates as two separate components, although some whales may remain in the feeding grounds throughout the winter (Winn et al., 1986; Kenney et al., 2001). Pregnant females and some juveniles migrate from the feeding grounds to the calving grounds off the southeastern United States in late fall to winter. The cow-calf pairs return northward in late winter to early spring. The majority of the right whale population leaves the feeding grounds for unknown habitats in the winter but returns to the feeding grounds coinciding with the return of the cow-calf pairs. Some individuals as well as cow-calf pairs can be seen through the fall and winter on the feeding grounds with feeding observed (e.g., Sardi et al., 2005).

During the spring through early summer, northern right whales are found on feeding grounds off the northeastern United States and Canada. Individuals may be found in Cape Cod Bay in February through April (Winn et al., 1986; Hamilton and Mayo, 1990) and in the Great South Channel east of Cape Cod in April through June (Winn et al., 1986; Kenney et al., 1995). Right whales are found throughout the remainder of summer and into fall (June through November) on two feeding grounds in Canadian waters (Gaskin, 1987 and 1991). The peak abundance is in August, September, and early October. The majority of summer/fall sightings of mother/calf pairs occur east of Grand Manan Island (Bay of Fundy), although some pairs might move to other unknown locations (Schaeff et al., 1993). Jeffreys Ledge appears to be important habitat for right whales, with extended whale residences; this area appears to be an important fall feeding area for right whales and an important nursery area during summer (Weinrich et al., 2000). The second feeding area is off the southern tip of Nova Scotia in the Roseway Basin between Browns, Baccaro, and Roseway banks (Mitchell et al., 1986; Gaskin, 1987; Stone et al., 1988; Gaskin, 1991). The Cape Cod Bay and Great South Channel feeding grounds are formally designated as critical habitats under the ESA (Silber and Clapham, 2001).

During the winter (as early as November and through March), northern right whales may be found in coastal waters off North Carolina, Georgia, and northern Florida (Winn et al., 1986). The waters off Georgia and northern Florida are the only known calving ground for western northern right whales; it is formally designated as a critical habitat under the ESA (Figure 4-1). Calving occurs from December through March (Silber and Clapham, 2001). On 1 January 2005, the first observed birth on the calving grounds was reported (Zani et al., 2005). The majority of the population is not accounted for on the calving grounds, and not all reproductively active females return to this area each year (Kraus et al., 1986a).

The coastal waters of the Carolinas are suggested to be a migratory corridor for the right whale (Winn et al., 1986). The Southeast U.S. Coast Ground, consisting of coastal waters between North Carolina and northern Florida, was mainly a winter and early spring (January-March) right whaling ground during the late 1800s (Reeves and Mitchell, 1986). The whaling ground was centered along the coasts of South Carolina and Georgia (Reeves and Mitchell, 1986). An examination of sighting records from all sources between 1950 and 1992 found that wintering right whales were observed widely along the coast from Cape Hatteras, North Carolina, to Miami, Florida (Kraus et al., 1993). Sightings off the Carolinas were comprised of single individuals that appeared to be transients (Kraus et al., 1993). These observations are consistent with the hypothesis that the coastal waters of the Carolinas are part of a migratory corridor for the right whale (Winn et al., 1986). Knowlton et al. (2002) analyzed sightings data collected in the mid-Atlantic from northern Georgia to southern New England and found that the majority of right whale sightings occurred within approximately 56 km (30 NM) from shore. Until better information is available on the right whale's migratory corridor, it has been recommended that management considerations are needed for the coastal areas along the mid-Atlantic migratory corridor within 65 km (35 NM) from shore (Knowlton, 1997).

Radio-tagged animals have made extensive movements, sometimes traveling from the Gulf of Maine into deeper waters off the continental shelf (Mate et al., 1997). Mate et al. (1997) tagged one male that traveled into waters with a bottom depth of 4,200 m (13,780 ft). Long-distance movements as far north as Newfoundland, the Labrador Basin, southeast of Greenland, Iceland, and Arctic Norway have been documented (Knowlton et al., 1992; IWC, 2001a; Waring et al., 2007). One individually identified right whale was documented to make a two-way trans-Atlantic migration from the eastern coast of the United States to a location in northern Norway (Jacobsen et al., 2004). A female northern right whale was tagged with a satellite transmitter and tracked to nearly the middle of the Atlantic where she remained for a period of months (WhaleNet, 1998).

Critical habitat for the north Atlantic population of the North Atlantic right whale exists in portions of the JAX/CHASN and Northeast OPAREAs (Figures 4-1 and 4-2). The following three areas occur in U.S. waters and were designated by NMFS as critical habitat in June 1994 (NMFS, 2005):

(1) Coastal Florida and Georgia (Sebastian Inlet, Florida, to the Altamaha River, Georgia),

(2) The Great South Channel, east of Cape Cod, and

(3) Cape Cod and Massachusetts Bays.

The northern critical habitat areas serve as feeding and nursery grounds, while the southern area from the mid-Georgia coast extending southward along the Florida serves as calving grounds. The waters off Georgia and northern Florida are the only known calving ground for western North Atlantic right whales. A large portion of this habitat lies within the coastal waters of the JAX/CHASN OPAREA. The physical features correlated with the distribution of right whales in the southern critical habitat area provide an optimum environment for calving. For example, the bathymetry of the inner and nearshore-middle shelf area minimizes the effect of strong winds and offshore waves, limiting the formation of large waves and rough water. The average

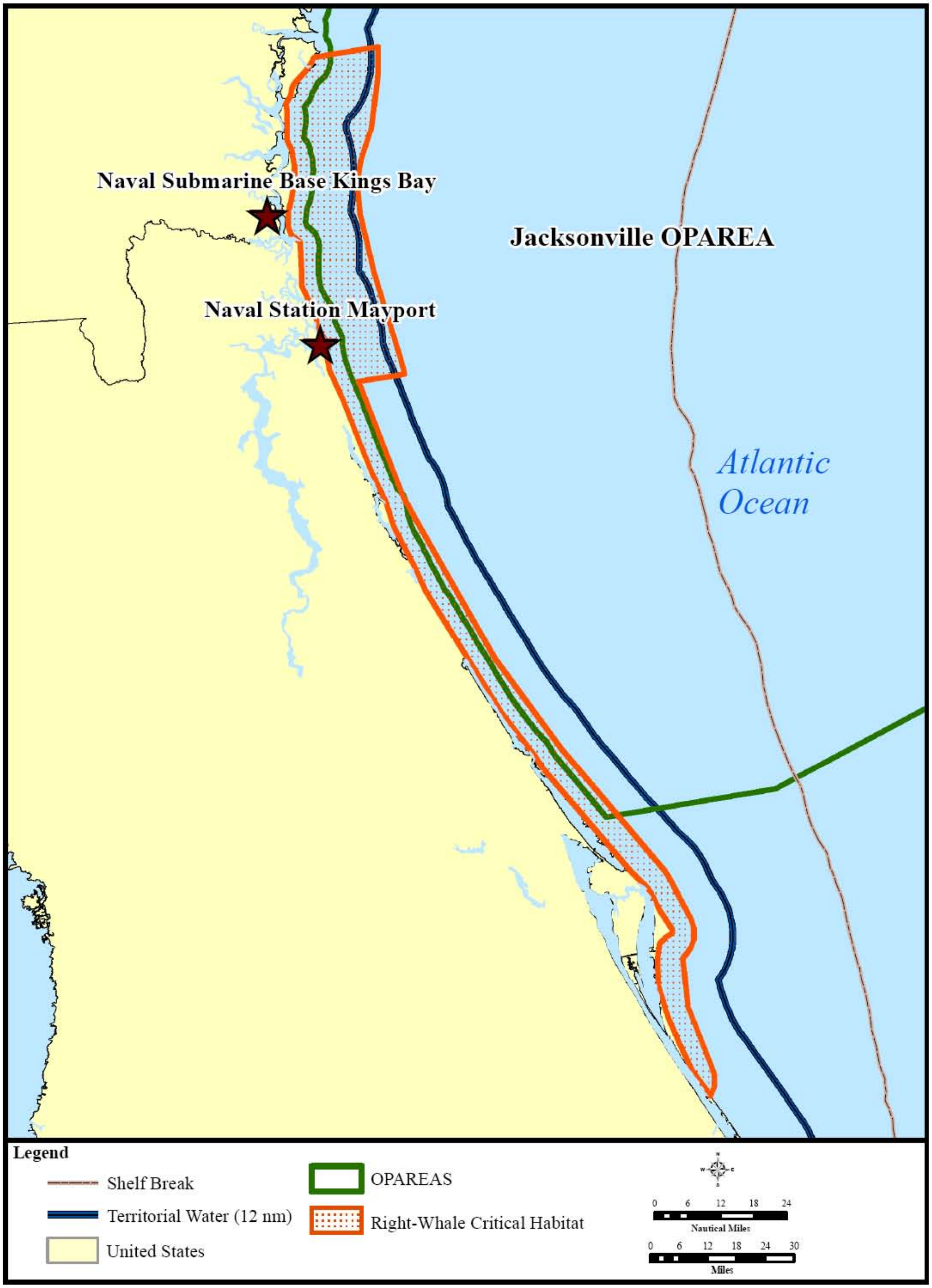

Figure 4-1. Southeast North Atlantic Right Whale Critical Habitat

1

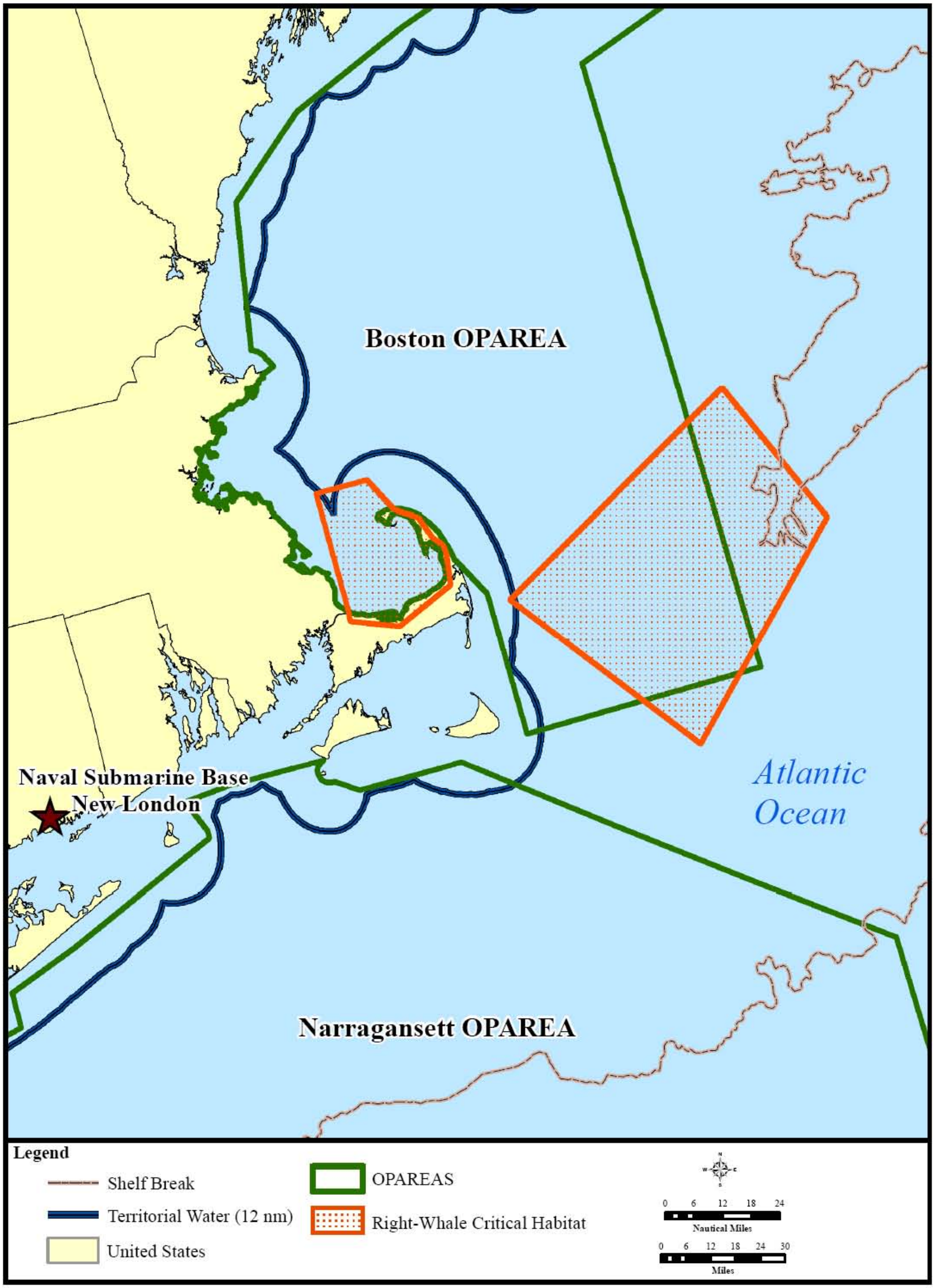

Figure 4-2. Northeast North Atlantic Right Whale Critical Habitat

temperature of critical habitat waters is cooler during the time right whales are present due to a lack of influence by the Gulf Stream and cool freshwater runoff from coastal areas. NMFS theorizes the water temperatures provide an optimal balance between offshore waters that are too warm for nursing mothers to tolerate, yet not too cool for calves that may only have minimal fatty insulation (NMFS, 1994). On the calving grounds, the reproductive females and calves are expected to be concentrated near the critical habitat in the JAX/CHASN OPAREA from December through April.

Atlantic Ocean, Offshore of the Southeastern United States

Right whales generally occur in the VACAPES and CHPT OPAREAs between November and April, when these whales transit the area on their migrations to and from breeding grounds in the south and the feeding grounds in the north. Because not all of the known North Atlantic right whales winter in the south in any particular year, the number of whales passing through the area can fluctuate from year to year. Based on sighting data, the North Atlantic right whales are most likely to occur in shallower waters (shore to the 200-m [656-ft] isobath). Because the population of the North Atlantic right whale is so low, it is expected to be found only rarely along the migratory corridor.

The coastal waters off Georgia and Florida are the only known calving ground for the North Atlantic right whale. During the winter (as early as November and through April), right whales may be found in coastal waters off North Carolina, Georgia, and northern Florida, and calving occurs December through March. Right whales on the winter calving grounds are primarily limited to coastal waters.

Atlantic Ocean, Offshore of the Northeastern United States

North Atlantic right whales occur primarily in Cape Cod Bay, Jeffreys Ledge and Bank, Georges Basin, Roseway Basin, and the Bay of Fundy, with increasing occurrences at Roseway Basin and Bay of Fundy. The two feeding areas adjacent to Massachusetts Bay in the Boston OPAREA are designated as critical habitat for North Atlantic right whales under the ESA.

During the wintertime, North Atlantic right whales can be expected in inner continental shelf waters from the western Gulf of Maine, Cape Cod and Massachusetts Bay, the Great South Channel, and off southern New England, in the Narragansett Bay OPAREA, with some occurrences further south off Maryland and Virginia. The occurrences in the Mid-Atlantic Bight (MAB) may represent whales migrating between the calving grounds off Florida and the feeding grounds in the northern New England. Cape Cod Bay is a known high-use area and the right whale occurrence peaks in the bay in late March (Hamilton and Mayo, 1990).

During the springtime, the general occurrence of right whales extends from waters over the continental shelf from the Bay of Fundy to Nantucket Shoals. Cape Cod Bay and the Great South Channel are known right whale feeding areas (CETAP, 1982; Hamilton and Mayo, 1990). Locations of preferred habitat may change based on the variance in temporal and spatial formations of zooplankton concentrations responding to annual fluctuations in oceanic conditions (Kenney, 2001). For example, during 1992, there were no right whales seen in the

Great South Channel, and the only right whales seen in this region were in the central Gulf of Maine (Kenney, 2001).

In the summertime, right whales generally occur in the continental shelf waters from the Bay of Fundy and the Scotian Shelf to the southern tip of New Jersey. The highest occurrences of right whales are found in the Bay of Fundy. Known high abundance areas are in the Grand Manan Basin (east of Grand Manan Island in the lower Bay of Fundy) and in the Roseway Basin.

In the fall, right whales are generally found in the continental shelf waters from the Bay of Fundy and Roseway Basin to Maryland. Right whales are present through at least mid-October on their feeding grounds located in Northeast.

In 1999, a Mandatory Ship Reporting System was implemented by the U.S. Coast Guard, which requires specified vessels (DON ships are exempt) to report their location, course, speed, and destination upon entering the nursery and feeding areas of the right whale. At the same time, ships receive information on locations of right whale sightings, in order to avoid collisions with the animals. In the northeastern United States, 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; it includes all of Stellwagen Bank National Marine Sanctuary. A portion of the Boston OPAREA falls within these boundaries.

Gulf of Mexico

There are five confirmed records of the North Atlantic right whale in the Gulf of Mexico; all of them occurred in winter and spring, including one stranding on the Texas coast in 1972 (Schmidly et al., 1972; Zoodsma, 2006). Three of the sightings were of cow-calf pairs. One pair seen in late January 2004 off Miami, Florida, and in mid-March to early April off the Florida Panhandle was later resighted in June in waters off Cape Cod (Anonymous, 2004). More recently, a cow-calf pair was photographed in Corpus Christi Bay off southern Texas and sighted a few weeks later off Long Boat Key, Florida (NOAA and FWC, 2006; Zoodsma, 2006). These records likely represent individuals wandering from the wintering grounds or might even reflect a more extensive historic range beyond the known calving and wintering ground in the waters of the southeastern U.S. (Jefferson and Schiro, 1997; Waring et al., 2006). The North Atlantic right whale occurs very rarely in the Gulf of Mexico.

4.1.2 Humpback Whale (*Megaptera novaeangliae*)

Description – Adult humpback whales are 11 to 16 m (36 to 52 ft) 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). The head is larger than in other rorquals. The flukes have a concave, serrated trailing edge; the ventral side is variably patterned in black and white. Individual humpback whales may be identified using these patterns (Katona et al., 1979). The dorsal fin is set far back on the body and is triangular or falcate in shape, with a long hump cranially tapering to a pointed apex.

Status – Humpback whales are classified as endangered under the ESA (NMFS, 1991). An estimated 11,570 humpback whales occur in the entire North Atlantic (Stevick et al., 2003a). The International Whaling Commission (IWC) considers the "feeding stock" to be the appropriate unit for management of humpback whales in the North Atlantic (COSEWIC, 2003). 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. 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 902 individuals (Waring et al., 2007); this number is based on line-transect surveys conducted in 1999 (Clapham et al., 2003). There is no designated critical habitat for this species.

Diving Behavior – Humpback whale diving behavior depends on the time of year (Clapham and Mead, 1999). In summer, most dives last less than five 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 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 sec 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).

While no measured data on hearing ability is available for this species, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. Houser et al. (2001) produced the first humpback whale audiogram (using a mathematical model). The predicted audiogram indicates sensitivity to frequencies from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz. Au et al. (2006) noted that if the popular notion that animals generally hear the totality of the sounds they produce is applied to humpback whales, this suggests that its upper frequency limit of hearing is as high as 24 kHz.

***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 deepwater 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). The Gulf of Maine is one of the principal summer feeding grounds for humpback whales in the North Atlantic. The largest numbers of humpback whales are present from mid-April to mid-November. Feeding locations off the northeastern United States include Stellwagen Bank, Jeffreys Ledge, the Great South Channel, the edges and shoals of Georges Bank, Cashes Ledge, Grand Manan Banks, the banks on the Scotian Shelf, the Gulf of St. Lawrence, and the Newfoundland Grand Banks (CETAP, 1982; Whitehead, 1982; Kenney and Winn, 1986; Weinrich et al., 1997). Distribution in this region has been largely correlated to prey species and abundance, although behavior and bottom topography are factors in foraging strategy (Payne et al., 1986; Payne et al., 1990b). Humpbacks typically return to the same feeding areas each year.

The distribution and abundance of sand lance are important factors underlying the distribution patterns of the humpback whale (Kenney and Winn, 1986). Changes in diets and feeding preferences are likely caused by changes in prey distribution and/or in the relative abundance of different prey species (sand lance and herring) (Payne et al., 1986; Payne et al., 1990b; Kenney et al., 1996; Weinrich et al., 1997). Feeding most often occurs in relatively shallow waters over the inner continental shelf and sometimes in deeper waters. Large multi-species feeding aggregations (including humpback whales) have been observed over the shelf break on the southern edge of Georges Bank (CETAP, 1982; Kenney and Winn, 1987) and in shelf break waters off the U.S. mid-Atlantic coast (Smith et al., 1996).

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). Due to the temporal difference in occupancy of the West Indies between individuals from different feeding areas, coupled with sexual differences in migratory patterns, Stevick et al. (2003b) suggested the possibility that there are reduced mating opportunities between individuals from different high-latitude feeding areas. The calving peak is

January through March, with some animals arriving as early as December and a few not leaving until June. The mean sighting date in the West Indies for individuals from the United States and Canada is February 16 and 15, respectively (Stevick et al., 2003b).

Apparently, not all Atlantic humpback whales migrate to the calving grounds, since some sightings (believed to be only a very small proportion of the population) are made during the winter in northern habitats (CETAP, 1982; Whitehead, 1982; Clapham et al., 1993; Swingle et al., 1993). The sex/age class of nonmigratory animals remains unclear. A small number of individuals remain in the Gulf of Maine during winter (CETAP, 1982; Clapham et al., 1993); however, it is not known whether these few sightings represent winter residents or either late-departing or early-arriving migrants (Mitchell et al., 2002).

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). Strandings of humpbacks (mainly juveniles) in this area have also increased in recent years (Wiley et al., 1995). Recently, winter humpback whale sightings have occurred in coastal southeastern U.S. waters during northern right whale surveys (Waring et al., 2006). A humpback whale was also sighted in the Tongue of the Ocean (Bahamas) during marine mammal surveys (Mobley, 2004). There are also reports of humpback whales in the Gulf of Mexico, particularly near the Panhandle region of Florida, during this time of year (Weller et al., 1996a; MMS, 2001; Pitchford, 2006). None of these occurrences are fully understood. They might be due to shifts in distribution, increases in sighting effort, or habitat that is becoming increasingly important for juveniles (Wiley et al., 1995). Sighting histories of mature humpback whales suggest that the mid-Atlantic area contains a greater percentage of mature animals than is represented by strandings (Barco et al., 2002). 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).

The routes taken during the southbound and northbound migrations are not known. Examination of whaling catches revealed that both northward and southward migrations are characterized by a staggering of sexual and maturational classes; lactating females are among the first to leave summer feeding grounds in the fall, followed by subadult males, mature males, non-pregnant females, and pregnant females (Clapham, 1996). On the northward migration, this order is broadly reversed, with newly pregnant females among the first to begin the return migration to high latitudes. Stevick et al. (2003b) reported sighting males 6.63 days earlier in the West Indies than females. Individuals identified on feeding grounds in the Gulf of Maine and eastern Canada arrived significantly earlier (9.97 days) than those animals identified in Greenland, Iceland, and Norway (Stevick et al., 2003b). During the northward migration, the whales are not believed to separate into discrete feeding groups until north of Bermuda (Katona and Beard, 1990).

Atlantic Ocean, Offshore of the Southeastern United States

Along the southeastern United States, most humpback whale sightings are generally in nearshore and continental shelf waters, though it is likely that at least some part of the migration is through the open ocean.

There has been an increasing occurrence of (primarily juvenile) humpback whales during the winter along the U.S. Atlantic coast from Florida north to Virginia. Strandings of humpbacks (mainly juveniles) in this area have also increased in recent years. It has recently been proposed that the mid-Atlantic region may represent a supplemental winter feeding ground, which is also an area of mixing of humpback whales from different feeding stocks (Barco et al., 2002).

The humpback whales may occur in the VACAPES OPAREA in all seasons, although they are least likely to be found there in the summer, when they are generally located at their feeding grounds to the north. Sighting data in the VACAPES OPAREA indicate that these whales are mainly distributed in nearshore and continental shelf waters, but are found as well as open-ocean waters on and outside the shelf edge (the 200-m [656-ft] isobath). The majority of offshore sightings occurred in the spring and fall. Humpbacks are presumed to make their seasonal north/south migrations in the more direct route through deeper offshore waters, and this is the most likely explanation for sightings in deep water during the fall and spring.

Based on sighting data for the CHPT OPAREA and the nearby vicinity, humpback whales may occur on the continental shelf, as well as farther offshore, during fall, winter, and spring, which takes into consideration humpbacks migrating to calving grounds in the Caribbean during the fall and making return migrations to the feeding grounds much farther north during the spring. Humpback whales most likely do not occur in the CHPT OPAREA during summer, since they should occur farther north, at their feeding grounds.

Based on sightings and strandings, the humpback whale may occur throughout the JAX/CHASN OPAREA during fall, winter, and spring. Humpback whales are not expected in the JAX/CHASN OPAREA during the summer; instead, they are expected to be on their feeding grounds further north.

Atlantic Ocean, Offshore of the Northeastern United States

Humpback whales occur in the Gulf of Maine, in the continental shelf waters from the Bay of Fundy and the Scotian Shelf to the southern map extent. Overall, spring and summer have the highest occurrences of whales, while winter has the lowest.

In the winter, humpback whales generally occur in continental shelf waters from the southern region of the Gulf of Maine to Virginia. There occurrences of humpback whales have been recorded primarily over the continental shelf in the Gulf of Maine, in Cape Cod and Massachusetts Bays, Great South Channel, over Stellwagen Bank, Jeffreys Ledge, and Georges Bank (CETAP, 1982; Clapham et al., 1993). The occurrences south of the Gulf of Maine may represent whales in transit.

In the spring, humpback whales primarily occur in the continental shelf waters from the Bay of Fundy and the Scotian Shelf to New Jersey. The greatest concentrations may occur in the western and southern perimeter of Gulf of Maine, just northeast of the Narragansett Bay OPAREA. The occurrences south of the Gulf of Maine may represent whales in transit.

During the summertime, humpback whales can be expected in the continental shelf waters, from the Bay of Fundy and the Scotian Shelf to the southern tip of New Jersey. Humpback whales may be found in increased concentrations during the summer on the eastern, southern, and western perimeter of the Gulf of Maine, with the greatest concentration occurring east of Cape Cod. Occurrence records also show that humpback whales may occur in the northern region of the Narragansett Bay OPAREA, and near the coast from Long Island to northern Virginia.

In fall, the general occurrence of humpback whales extends from the Bay of Fundy and the Scotian shelf to the northwestern region of the Narragansett Bay OPAREA, in the continental shelf waters. During this season, humpback whales may be found in greater concentrations in the southern and western region of the Gulf of Maine, including Cape Cod Bay.

Gulf of Mexico

Any occurrences of the humpback whale in the Gulf of Mexico are considered to be extralimital. The western-most sighting of a humpback whale in the GOMEX was made in February 1992 off Galveston, Texas (Weller et al., 1996a). There are at least 19 additional reports of humpback whales in the Gulf, mostly from the Florida Panhandle region. Reports include a stranding east of Destin in mid-April 1998, a confirmed sighting of six humpback whales in May 1998 near DeSoto Canyon, and a handful of sightings during spring 2006 (MMS, 2001; Pitchford, 2006). In February 2004, an individual was sighted off the west coast of Florida. This individual was identified as “Fingerpaint,” a humpback whale known to inhabit the Gulf of Maine. Fingerpaint was resighted in September later that year in the Gulf of Maine (Guinta, 2006). Weller et al. (1996a) speculated that humpbacks sighted in the GOMEX are likely juveniles that have wandered into the GOMEX from the nearby Caribbean Sea and Atlantic Ocean during the breeding season or on their migration northward (Weller et al., 1996a; Jefferson and Schiro, 1997). However, a review of the available records suggests that such occurrences could actually occur during any time of the year.

4.1.3 Minke Whale (*Balaenoptera acutorostrata*)

Description – Minke whales are small rorquals; adults reach lengths of just over 9 m (30 ft) (Jefferson et al., 1993). The head is pointed, and the median head ridge is prominent. The dorsal fin is tall (for a baleen whale), falcate, and located about two-thirds of the way back from the snout tip (Jefferson et al., 1993). The minke whale is dark gray dorsally, white beneath, with streaks of intermediate shades on the sides (Stewart and Leatherwood, 1985). The most distinctive light marking is a brilliant white band across each flipper of Northern Hemisphere minke whales (Stewart and Leatherwood, 1985).

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; Waring et al., 2007). Minke whales off the eastern United States are considered to be part of the Canadian East Coast stock which inhabits the area from the eastern half of the Davis Strait to 45ºW and south to the Gulf of Mexico (Waring et al., 2007). The best estimate of abundance for the Canadian East Coast stock is 2,998 individuals (Waring et al., 2007).

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 seconds (sec) 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 sec (S.D.=±0.3 sec) (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 sec. 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: 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 msec, and a less common “slow-down” pulse train (dominant frequency range: 50 to 0.35 kHz) lasting for 70 to 140 msec. 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 sec (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.

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 rather than 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 (11,401 ft) (Mullin and Fulling, 2003).

There appears to be a strong seasonal component to minke whale distribution (Horwood, 1990). Spring and summer are periods of relatively widespread distribution, and when they are most abundant off the northeastern United States. During fall in New England waters, there are fewer minke whales, and during early winter (January and February), the species appears to be largely absent from this area (Waring et al., 2006). Minke whales off the U.S. Atlantic Coast apparently migrate offshore and southward in winter (Mitchell, 1991; Mellinger et al., 2000). Clark and Gagnon (2004) reported that based on acoustics data, minke whales move clockwise through the Caribbean from winter into spring. 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).

Atlantic Ocean, Offshore of the Southeastern United States

The minke whale is only occasionally found in the mid-Atlantic area and only on a widely scattered basis. Most minke whale sightings in the VACAPES OPAREA were on the continental shelf, with only a few sightings past the shelf break. It appears that minke whale could occur during any season.

In the CHPT OPAREA, there has been only one reported minke whale sighting, which occurred along the northern edge of the OPAREA. There have also been a few strandings reported north of Cape Hatteras. During the winter, minke whales are sighted both north and south of the CHPT OPAREA. During spring and fall, the minke whales are most likely found north of the CHPT OPAREA. During the summer, minke whales are expected to occur at higher latitudes, on their feeding grounds. The minke whale is most likely to occur in the CHPT OPAREA during the winter.

Winter is the only season with recorded minke whale sightings in the JAX/CHASN OPAREA. During the summer, these whales, like other large baleen whales, are expected to occur at their feeding grounds in higher latitudes.

Atlantic Ocean, Offshore of the Northeastern United States

Minke whales may occur throughout the NE OPAREAs in the continental shelf and slope waters. Overall, spring and summer have the greatest occurrences of minke whales, while winter has the lowest.

In the spring, the general occurrence of minke whales extends from waters over the continental shelf to the continental slope, from the Bay of Fundy and Browns Bank south to the VACAPES OPAREA. Minke whales may also occur in the deeper waters of the southern region of the Northeastern United States. During this season, minke whales may be found in greater concentration in the western, southern, and eastern perimeter of the Gulf of Maine, Browns Bank; with the greatest concentrations found in the Bay of Fundy. The western North Atlantic is important feeding habitat for this species during this season (Murphy, 1995; Waring et al., 2004).

During summer, minke whales are thought to occur primarily over the continental shelf and slope in waters from the Bay of Fundy and the Scotian Shelf south to the VACAPES OPAREA. Minke whales may occur in greater concentrations in the western, northern, and eastern perimeter of the Gulf of Maine, the Bay of Fundy and along the southern Nova Scotian coast.

In the fall, minke whales should occur in the NE OPAREAs in lower numbers (Waring et al., 2007), primarily over the continental shelf and slope in waters from the Bay of Fundy and the Scotian Shelf to Georges Bank.

Gulf of Mexico

There are only confirmed stranding records available to indicate minke whale occurrence in the GOMEX; these are mostly around the Florida Keys (Jefferson and Schiro, 1997; Würsig et al., 2000). Based on their known habitat preferences, minke whales might occur anywhere from nearshore waters (but not up to the shoreline) out into deeper waters in the eastern Gulf but would be considered extralimital to the western Gulf. Minke whales are not expected in the eastern Gulf during the summer, when these whales should occur further north on feeding grounds. Due to the timing of the strandings, these individuals may represent strays moving into the Gulf during their migrations (Würsig et al., 2000; Jefferson, 2006), or the normal migratory route of the species (which appears dispersed at best) might extend into the Florida Strait (Jefferson, 2006). Given the recent lack of records, the former hypothesis may be more accurate (Jefferson, 2006).

4.1.4 Bryde's Whale (*Balaenoptera edeni*)

Description – Bryde's whales can be easily confused with sei whales. Bryde's whales usually have three prominent ridges on the rostrum (other rorquals generally have only one) (Jefferson et al., 1993). The Bryde's whale's dorsal fin is tall and falcate and generally rises abruptly out of the back. Adults can be up to 15.5 m (50.9 ft) in length (Jefferson et al., 1993), but there is a smaller "dwarf" species that rarely reaches over 10 m (33 ft) in length (Jefferson, 2006).

It is not clear how many species of Bryde's whales exist but genetic analyses suggest at least two species (Rice, 1998; Kato, 2002). The taxonomy of the baleen whale group formerly known as sei and Bryde's whales is currently confused and highly controversial (see Reeves et al., 2004 for a recent review). It is clear that there are at least three species in this group, the antitropically distributed sei whale, the tropically distributed standard form Bryde's whale (probably referable to *Balaenoptera brydei*), and the "dwarf Bryde's whale" (probably referable to *Balaenoptera edeni*), which inhabits tropical waters of the Indo-Pacific (Yoshida and Kato, 1999). However, the nomenclature is still not resolved due to questions about the affinities of the type specimens of *Balaenoptera brydei* and *Balaenoptera edeni*.

Status – No abundance information is currently available for Bryde's whales in the western North Atlantic. The best estimate of abundance for the Bryde's whale in the northern GOMEX is 40 individuals (Mullin and Fulling, 2004; Waring et al., 2006). It has been suggested that the Bryde's whales found in the GOMEX may represent a resident stock (Schmidly, 1981), but there is no information on stock differentiation (Waring et al., 2006). The NOAA Stock Assessment Report provisionally considers the GOMEX population a separate stock from the Atlantic Ocean stock(s) (Waring et al., 2006).

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 has 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.

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). In the Atlantic, Bryde's whales are distributed in the Gulf of Mexico and Caribbean Sea south to Cabo Frio, Brazil (Cummings, 1985; Mullin et al., 1994c). Most sightings in the GOMEX have been made in the DeSoto Canyon region and off western Florida (Davis et al., 2000). Mead (1977) speculated that the GOMEX represents at least a portion of the range of a dispersed, resident population of Bryde's whale. There is a known concentration of this species in Venezuelan waters (Notarbartolo di Sciara, 1982). There are occasional reported sightings of this species in the rest of the Caribbean (Erdman, 1970; Mignucci-Giannoni, 1989 and 1996). Long migrations are not typical of Bryde's whales although limited shifts in distribution toward and away from the equator in winter and summer, respectively, have been observed (Cummings, 1985).

Atlantic Ocean, Offshore of the Southeastern United States

The Bryde's whale is difficult to differentiate from the sei whale, and there are no confirmed sightings for this species in the southeastern Atlantic Coast OPAREAs. The Bryde's whale is a tropical species and is, therefore, not expected to occur in the VACAPES or CHPT OPAREAs during any season. There is only one record of this species near the VACAPES OPAREA—a stranding of an immature individual in the winter of 1927 within the Chesapeake Bay. This record is considered extralimital. There are no confirmed sightings of Bryde's whale in the JAX/CHASN OPAREA, although strandings have occurred throughout the year. Bryde's whales could occur in any season from the shore continuing beyond the eastern boundary of the JAX/CHASN OPAREA, but is expected to be unlikely.

Atlantic Ocean, Offshore of the Northeastern United States

The Bryde's whale is a tropical species and is, therefore, not expected to occur in the Northeastern OPAREAs during any season.

Gulf of Mexico

Bryde's whales are not often sighted in the GOMEX, though they are observed more frequently than any other species of baleen whale in this region. Sightings have primarily been recorded in the region of the DeSoto Canyon and over the Florida Escarpment, near the 100-m (328-ft) isobath (Mullin et al., 1994a; Davis and Fargion, 1996; Davis et al., 2000). This species may occur in the area during any season (Würsig et al., 2000).

During the winter, the greatest likelihood for encountering Bryde's whales is over the Florida Escarpment. In the springtime, Bryde's whales are predicted to occur in the area of the shelf break in a region that includes DeSoto Canyon and part of the Florida Escarpment. The highest

Bryde’s whale concentrations are thought to be discrete areas in the DeSoto Canyon and over the Florida Escarpment. In the summer, the greatest likelihood for encountering Bryde’s whales is in a small region over the Florida Escarpment. During the fall, there are few stranding records which reveal that the species is occasionally present during this season. Weather conditions (i.e., inclement weather increasing) could make sighting this species during this time of the year difficult and could explain why there are no recorded sightings.

4.1.5 Sei Whale (*Balaenoptera borealis*)

Description – Adult sei whales are up to 18 m (59 ft) in length and are mostly dark gray in color with a lighter belly, often with mottling on the back (Jefferson et al., 1993). There is a single prominent ridge on the rostrum and a slightly arched rostrum with a downturned tip (Jefferson et al., 1993). The dorsal fin is prominent and very falcate. Sei whales are extremely similar in appearance to Bryde’s whales, and it is difficult to differentiate them at sea and, in some cases, on the beach (Mead, 1977).

Status – Sei whales are listed as endangered under the ESA. The International Whaling Commission 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., 2007). There are no recent abundance estimates for the Nova Scotia stock (Waring et al., 2007). There is no designated critical habitat for this species.

The taxonomy of the baleen whale group formerly known as sei and Bryde’s whales is currently confused and highly controversial. It clearly consists of three or more species; however, the final determination awaits additional studies. Reeves et al. (2004) provides a recent review; see the Bryde’s whale species account above for further explanation.

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 sec, separated by 0.4 to 1.0 sec) of 10 to 20 short (4 milliseconds [msec]) frequency-modulated (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 sec, 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.

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 are also known for occasional irruptive occurrences in areas followed by disappearances for sometimes decades (Horwood, 1987; Schilling et al., 1992; Clapham et al., 1997; Gregr et al., 2005).

Sei whales spend the summer months feeding in the subpolar higher latitudes and return to the lower latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males (Horwood, 1987; Perry et al., 1999; Gregr et al., 2000). For the most part, the location of winter breeding areas remains a mystery (Rice, 1998; Perry et al., 1999), but the winter range of most rorquals is hypothesized to be in offshore waters (Kellogg, 1928; Gaskin, 1982) and acoustic data support this hypothesis of an offshore wintering habitat (Clark, 1995).

In the western North Atlantic Ocean, sei whales occur primarily from Georges Bank north to Davis Strait (northeast Canada, between Greenland and Baffin Island) (Perry et al., 1999). Sei whales are not known to be common in most U.S. Atlantic waters (NMFS, 1998a). 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, 1998a). 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).

As noted by Reeves et al. (1999a), reports in the literature from any time before the mid-1970s are suspect because of the frequent failure to distinguish sei from Bryde’s whales, particularly in tropical to warm-temperate waters where Bryde’s whales are generally more common than sei whales.

Atlantic Ocean, Offshore of the Southeastern United States

Sei whales are not common in U.S. Atlantic waters. Peak abundance in U.S. waters occurs in spring, primarily around the edges of Georges Bank. The distribution of the Nova Scotia stock may extend south along the U.S. coast to at least North Carolina.

Sightings and strandings have been documented in and around the VACAPES OPAREA throughout the year in continental shelf and slope waters, as well as further offshore.

There are several sei whale records for the North Carolina area. This species is probably a relatively common migrant there (Lee and Socci, 1989). This whale is difficult to distinguish from Bryde’s whale at sea and is frequently grouped with Bryde’s whale in the sighting data. There is only one recorded sighting of a sei whale in the CHPT OPAREA. Two other individuals were recorded during the Oregon II marine mammal survey near the Onslow Bay area in January 1992, but they were not positively identified as either sei or Bryde’s whales. January through April is the time of year when this species is most likely to be present in the OPAREA.

There are only two documented sightings—a fall stranding and a spring stranding—in the JAX/CHASN OPAREA. In the summer, sei whales are expected to be in northerly feeding grounds (e.g., the Grand Banks) or in offshore waters. During the fall, winter, and spring, the likelihood of encountering this species is not known.

Atlantic Ocean, Offshore of the Northeastern United States

Sei whales occur primarily in the northern region of the Northeast in continental shelf and slope waters, and winter has the lowest reported occurrence of sei whales.

In the spring, sei whales occur primarily over the continental shelf and slope, in waters from the Bay of Fundy to the northern region of the Narragansett Bay OPAREA. The greatest concentrations of sei whales in spring may be found along the northern flank and eastern tip of Georges Bank. Occurrence records also indicated the sei whales may occur along the shelf break on southern Georges Bank. This is consistent with what is known about sei whale distribution in the western North Atlantic Ocean (CETAP, 1982; Stimpert et al., 2003).

In the summer, the general occurrence of sei whales extends from the Bay of Fundy and the Scotian Shelf to the northern region of Narragansett Bay OPAREA. Occurrence records indicate that sei whales are primarily distributed in the Bay of Fundy, Roseway Basin, and Northeast Channel. Occurrences in these areas of complex bottom topography that may concentrate prey species with the known habitat associations of the sei whale (Nishiwaki, 1966; Kenney and Winn, 1987; Schilling et al., 1992; Best and Lockyer, 2002).

During the fall, sei whales may be found in limited areas of the continental shelf waters, in the Northeast Channel and in the western Gulf of Maine, which are both located in the Boston OPAREA.

Gulf of Mexico

The sei whale is represented by only three reliable records in the northern Gulf: two strandings near Louisiana and one stranding in the Florida Panhandle (Jefferson and Schiro, 1997). Based on the scarcity of records for this species in the Gulf, the sei whale is not expected to occur in the GOMEX. Any sightings are considered extralimital for this species as sei whales are uncommon in most tropical regions (Jefferson and Schiro, 1997).

4.1.6 Fin Whale (*Balaenoptera physalus*)

Description – The fin whale is the second-largest whale species, with adults reaching 24 m (79 ft) in length (Jefferson et al., 1993). Fin whales have a very sleek body with a pale, V-shaped chevron on the back just behind the head. The dorsal fin is prominent but with a shallow leading edge and is set back two-thirds of the body length from the head (Jefferson et al., 1993). The head color is asymmetrical, with a lower jaw that is white on the right and black or dark gray on the left. Fin and sei whales are very similar in appearance and size which has resulted in confusion about the distribution of both species (NMFS, 2006c).

Status – Fin whales are classified as endangered under the ESA (NMFS, 2006c). The NOAA Stock Assessment Report estimates that there are 2,814 individual fin whales in the U.S. Atlantic waters (Waring et al., 2007); this is probably an underestimate, however, as the data were not corrected for animals missed while diving. Incorporation of a dive correction factor brings the estimate to 5,000 to 6,000 fin whales in the waters of the U.S. Atlantic (CETAP, 1982; Kenney et al., 1997). No critical habitat is designated for this species.

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 sec 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.]=±32.59 m [106.92 ft]) with a duration of 6.3 min (S.D.=±1.53 min) when foraging and to 59.3 m (194.6 ft) (S.D.=±29.67 m [97.34 ft]) with a duration of 4.2 min (S.D.=±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 sec 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.

Distribution – Fin whales are broadly distributed throughout the world's oceans, usually in temperate to polar latitudes and less commonly in the tropics (Reeves et al., 2002). In general, fin whales are more common north of about 30ºN than they are in tropical zones (NMFS, 1998a). The overall range of fin whales in the North Atlantic extends from the Gulf of Mexico/Caribbean and Mediterranean north to Greenland, Iceland, and Norway (Gambell, 1985a; NMFS, 1998a). 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 United States to eastern Canada (CETAP, 1982; Hain et al., 1992; Waring et al., 2004). Fin whales are the dominant large cetacean species in all seasons in the North Atlantic and have the largest standing stock and food requirements (Hain et al., 1992; Kenney et al., 1997). The fin whale is also the most common whale species acoustically detected with Navy deepwater hydrophone arrays in the North Atlantic (Clark, 1995).

Fin whales are believed to follow the typical baleen whale migratory pattern, with a population shift north into summer feeding grounds and south for the winter. However, the location and extent of the wintering grounds are poorly known (Aguilar, 2002). Peak acoustic detections of fin whales occurred in winter throughout the deepwater of the North Atlantic, supporting the widely held hypothesis about their migration. A definite southward movement of the species was detected in the fall with a northward shift in spring; the endpoints of most of the migration routes in the northwestern Atlantic were areas around Newfoundland and Labrador to the north and Bermuda through the West Indies to the south (Clark, 1995). Migration routes are otherwise unknown.

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. This is the most likely large whale species to be sighted off the eastern U.S. coast in winter. Perhaps a fifth to a quarter of the spring/summer peak population remains in this area year-round (CETAP, 1982; Hain et al., 1992).

Atlantic Ocean, Offshore of the Southeastern United States

Fin whales follow the typical baleen whale migratory pattern of feeding at the high latitudes in summer and fasting at low latitudes in winter. It is thought that fin whales migrate north nearshore along the coast during spring and south offshore during winter. They are common in waters of the U. S. Atlantic, principally from Cape Hatteras northward (Waring et al., 2007).

Fin whales may occur in the VACAPES OPAREA year-round. Sighting data show that these whales are distributed over the continental shelf and into waters over the continental slope, although the majority of sightings occurred on the continental shelf. Acoustic data indicate there is a substantial deep-ocean component to fin whale distribution (Clark, 1995; Waring et al., 2007).

During the winter, the fin whale may occur in the entire CHPT OPAREA. During the spring, and fall they should occur north of the CHPT OPAREA and during summer, it is expected that fin whales would be on their feeding grounds further north off the northeastern U.S. coast.

During winter, the fin whale may be found in the JAX/CHASN OPAREA. Since fin whales are expected to be on their feeding grounds at higher latitudes off the northeastern U.S. coast during the summer, and migrating to/from the feeding grounds during spring and fall this species is not expected to occur in the JAX/CHASN OPAREA during those seasons.

Atlantic Ocean, Offshore of the Northeastern United States

Fin whales occur year round throughout the study area in continental shelf and rise waters. During winter, the general distribution of whales seems to shift towards the southern region of the NE OPAREAs.

In winter, fin whales are the most common large whale species occurring in U.S. Atlantic continental shelf waters (Mitchell et al., 2002). Greater occurrences of fin whales may be found in Georges Basin, southwestern region of the Narragansett Bay OPAREA and Atlantic City OPAREAS.

During the spring, fin whales primarily occur on the continental shelf and slope, in waters extending from the Bay of Fundy and the Scotian Shelf south to the VACAPES OPAREA. Fin whales may occur in greater numbers along the perimeter of the Gulf of Maine and on the eastern edge of the study area, with the greatest occurrences found near the southern flank of Georges Bank, just east of Narragansett Bay OPAREA. An important habitat for fin whales is located in the western Gulf of Maine, including Jeffreys Ledge and Stellwagen Bank, to the Great South Channel, in waters with a bottom depth of approximately 90 m (295 ft) (Hain et al., 1992).

In the summer, fin whales generally occur from the Bay of Fundy and the Scotian Shelf south to the VACAPES OPAREA. Fin whales may occur in greater numbers in the Bay of Fundy, east of Crowell Basin, the waters over Browns Bank and the southern flank of Georges Bank, and the western region of the Gulf of Maine. Most fin whale sightings occur during July to August in the Gulf of Maine (Agler et al., 1993).

In the fall, fin whales may occur primarily over the continental shelf and slope, in waters from the Bay of Fundy and the Scotian Shelf to the southern map extent. Fin whales may occur in greater concentrations in the Bay of Fundy and the Great South Channel.

Gulf of Mexico

There are only four recorded strandings (Jefferson and Schiro, 1997) and two confirmed sightings of fin whales in the Gulf of Mexico (Jefferson and Schiro, 1997). All other sightings records for the fin whale in the GOMEX are not verified.

Jefferson and Schiro (1997) suggested that the Gulf of Mexico might represent a part of the range of a low-latitude fin whale population in the northwestern Atlantic or that possibly a small relict population is resident in the Gulf. It is more likely that the occurrences of this species in the Gulf might be extralimital and that these fin whale individuals are simply accidental occurrences (Jefferson and Schiro, 1997; Würsig et al., 2000).

4.1.7 Blue Whale (*Balaenoptera musculus*)

Description – Blue whales are the largest living animals. Blue whale adults in the northern hemisphere reach 22.9 to 28 m (75 to 92 ft) in length (Jefferson et al., 1993). The rostrum of a blue whale is broad and U-shaped, with a single prominent ridge down the center (Jefferson et al., 1993). The tiny dorsal fin is set far back on the body and appears well after the blowholes when the whale surfaces (Reeves et al., 2002). This species is blue-gray with light (or sometimes dark) mottling.

Status – Blue whales are classified as endangered under the ESA. The blue whale was severely depleted by commercial whaling in the twentieth century (NMFS, 1998b). 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. However, the photo-identified individuals from the Gulf of St.

Lawrence area are considered to be a minimum population estimate for the western North Atlantic stock (Waring et al., 2007); there are nearly 400 individuals based on research efforts by Sears et al. (2005). There is no designated critical habitat for this species in the North Atlantic.

Diving Behavior – Blue whales spend greater than 94 percent of their time below the water's surface (Lagerquist et al., 2000). Croll et al. (2001) determined that blue whales dived to an average of 140.0 m (459.3 ft) (S.D.=±46.01 m [151.95 ft]) and for 7.8 min (S.D.=±1.89 min) when foraging and to 67.6 m (221.8 ft) (S.D.=±51.46 m [168.83 ft]) and for 4.9 min (S.D.=±2.53 min) when not foraging. However, dives deeper than 300 m have been recorded from tagged individuals (Calambokidis et al., 2003).

Acoustics and Hearing – Blue and fin whales produce calls with the lowest frequency and highest source levels of all cetaceans. Sounds are divided into two categories: short-duration or long duration. Blue whale vocalizations are typically long, patterned low-frequency sounds with durations up to 36 sec (Thomson and Richardson, 1995) repeated every 1 to 2 min (Mellinger and Clark, 2003). Their frequency range is 12 to 400 Hz, with dominant energy in the infrasonic range at 12 to 25 Hz (Ketten, 1998; Mellinger and Clark, 2003). These long, patterned, infrasonic call series are sometimes referred to as "songs." The short-duration sounds are transient, frequency-modulated calls having a higher frequency range and shorter duration than song notes and often sweeping down in frequency (Di Iorio et al., 2005; Rankin et al., 2005). Short-duration sounds appear to be common; however, they are underrepresented in the literature (Rankin et al., 2005). These short-duration sounds are less than 5 sec in duration (Di Iorio et al., 2005; Rankin et al., 2005) and are high-intensity, broadband (858±148 Hz) pulses (Di Iorio et al., 2005). Source levels of blue whale vocalizations are up to 188 dB re 1 μPa-m (Ketten, 1998; Moore, 1999; McDonald et al., 2001). During the Magellan II Sea Test (at-sea exercises designed to test systems for antisubmarine warfare) off the coast of California in 1994, blue whale vocalization source levels at 17 Hz were estimated in the range of 195 dB re 1 μPa-m (Aburto et al., 1997). Vocalizations of blue whales appear to vary among geographic areas (Rivers, 1997), with clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific (Stafford et al., 2001). Blue whale sounds in the North Atlantic have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark, 2003; Berchok et al., 2006). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing.

Distribution **–** Blue whales are distributed from the ice edge to the tropics and subtropics in both hemispheres (Jefferson et al., 1993). The longest documented migration for this species is between Iceland and Mauritania at an estimated 5,200 km (Sears et al., 2005). Stranding and sighting data suggest that the blue whale's original range in the Atlantic extended south to Florida, the Gulf of Mexico, the Cape Verde Islands, and the Caribbean Sea (Yochem and Leatherwood, 1985). Blue whales rarely occur in the U.S. Atlantic Exclusive Economic Zone (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). Sightings in the Gulf of Maine and U.S. EEZ have been made in late summer and early fall (August and October) (CETAP, 1982; Wenzel et al., 1988). Researchers using the Navy-integrated undersea surveillance system (IUSS) resources detected blue whales throughout the open Atlantic south to at least the Bahamas (Clark, 1995), suggesting that all North Atlantic blue whales may comprise a single stock (NMFS, 1998b).

Atlantic Ocean, Offshore of the Southeastern United States

There is only one record of a blue whale in the VACAPES OPAREA, a sighting made between the 3,000-m (9,840-ft) and 4,000-m (13,120-ft) isobaths during the Cetacean and Turtle Assessment Program (CETAP) surveys in April 1969. There are no records of the blue whale in the CHPT or JAX/CHASN OPAREAs.

The absence of records of blue whales may indicate that blue whales are often difficult to distinguish from other large baleen whales. This whale is primarily a deep-water species, and the winter range of most large baleen whales is thought to be in offshore waters. Acoustic data support the hypothesis of an offshore wintering habitat (Clark, 1995). The likelihood of encountering this species in the VACAPES, CHPT, and JAX/CHASN OPAREAS is unknown, but believed to be extremely low.

Atlantic Ocean, Offshore of the Northeastern United States

There are a few occurrence records of blue whales scattered throughout the northeast from the Bay of Fundy and the Scotian Shelf to just outside the southern region of the NE OPAREAs. It is possible that the northeastern EEZ represents the southern limits of blue whale feeding grounds (CETAP, 1982; Wenzel et al., 1988; Mitchell et al., 2002).

Gulf of Mexico

This is one of the rarest cetacean species in the GOMEX (Würsig et al., 2000). There are only two reliable records for blue whales in the GOMEX; both records are strandings (Jefferson and Schiro, 1997). Any records for this species should be considered extralimital in the GOMEX.

4.2 ODONTOCETES

The following Odontocetes have possible or confirmed occurrence along the East Coast of the U.S. and in the Gulf of Mexico.

4.2.1 Sperm Whale (*Physeter macrocephalus*)

Description – The sperm whale is the largest toothed whale species. Adult females can reach 12 m (39 ft) in length, while adult males measure as much as 18 m (59 ft) in length (Jefferson et al., 1993). The head is large (comprising about one-third of the body length) and squarish. The lower jaw is narrow and underslung. The blowhole is located at the front of the head and is offset to the left (Rice, 1989). Sperm whales are brownish gray to black in color with white areas around the mouth and often on the belly. The flippers are relatively short, wide, and paddle-shaped. There is a low rounded dorsal hump and a series of bumps on the dorsal ridge of the tailstock (Rice, 1989). The surface of the body behind the head tends to be wrinkled (Rice, 1989).

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 best estimate of sperm whale abundance in the western North Atlantic Ocean is 4,804 individuals (Waring et al., 2007). The current best estimate of abundance for sperm whales in the northern GOMEX is 1,349 individuals (Mullin and Fulling, 2004). Based on mark-recapture analyses of photo-identified individuals, 398 individuals are suggested to utilize the region south of the Mississippi River Delta between the Mississippi Canyon and DeSoto Canyon along and about the 1,000-m (3,281-ft) isobath (Jochens et al., 2006). NMFS provisionally considers the sperm whale population in the northern GOMEX as a stock distinct from the U.S. Atlantic stock (Waring et al., 2006). 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). There is no designated critical habitat for this species.

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 percent 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 hrs 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 0.7 m/sec (1.4 knots[kn]) (Watkins et al., 2002). Dive descents for tagged individuals average 11 min at a rate of 1.52 m/sec (2.95 kn), and ascents average 11.8 min at a rate of 1.4 m/sec (2.7 kn) (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 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 percent of their dive period, specifically 64 percent 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).

***Distribution* –** Sperm whales are found from tropical to polar waters in all oceans of the world between approximately 70°N and 70°S (Rice, 1998). Females use a subset of the waters where males are regularly found. 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 on female distribution correspond approximately to the 40° parallels (50° in the North Pacific; Whitehead, 2003). Photo-identification data analyzed by Jaquet et al. (2003) revealed that seven female sperm whales moved into the Gulf of California from the Galápagos Islands, traveling up to 3,803 km (2,052 NM); these are among the longest documented movements for female sperm whales.

Sperm whales are the most-frequently sighted whale seaward of the continental shelf off the eastern United States (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). In winter, sperm whales are primarily concentrated east and northeast of Cape Hatteras. However, in spring, the center of concentration shifts northward to off Delaware and Virginia and is generally widespread throughout the central MAB and southern Georges Bank. Summer distribution is similar to spring but also includes the area northeast of Georges Bank and into the Northeast Channel region as well as shelf waters south of New England. Fall sperm whale occurrence is generally south of New England over the continental shelf, with a remaining contingent over the continental shelf break in the MAB. Despite these seasonal shifts in concentration, no movement patterns affect the entire stock (CETAP, 1982). Although concentrations shift depending on the season, sperm whales are generally distributed in Atlantic EEZ waters year-round.

The region of the Mississippi River Delta has been recognized for high densities of sperm whales and appears to represent an important calving and nursery area for these animals (Townsend, 1935; Collum and Fritts, 1985; Mullin et al., 1994a; Würsig et al., 2000;

Baumgartner et al., 2001; Davis et al., 2002; Mullin et al., 2004; Jochens et al., 2006). Body sizes for most of the sperm whales seen off the mouth of the Mississippi River range from 7 to 10 m (23 to 33 ft), which is the typical size for females and younger animals (Weller et al., 2000; Jochens et al., 2006). On the basis of photo-identification of sperm whale flukes and acoustic analyses, it is likely that some sperm whales are resident to the GOMEX (Weller et al., 2000; Jochens et al., 2006). Tagging data demonstrated that some individuals spend several months at a time in the Mississippi River Delta and the Mississippi Canyon for several months, while other individuals move to other locations the rest of the year (Jochens et al., 2006). Spatial segregation between the sexes was noted one year by Jochens et al. (2006); females and immatures showed high site fidelity to the region south of the Mississippi River Delta and Mississippi Canyon and in the western Gulf, while males were mainly found in the DeSoto Canyon and along the Florida slope.

Atlantic Ocean, Offshore of the Southeastern United States

In the VACAPES OPAREA, sperm whales are distributed along the continental shelf edge and over the continental slope. There have also been occasional sightings on the continental shelf. During the winter, spring, and fall, their occurrence in the VACAPES OPAREA is expected in the area of the continental shelf edge between the 200-m (656-ft) and the 4000-m (13,120-ft) isobaths. In the summer, the highest likelihood of encountering this species, begins at the 200-m (656-ft) isobath and extends past the eastern boundary of the VACAPES OPAREA (DON, 2001a).

In the CHPT OPAREA, sperm whales are most likely to occur in waters seaward of the continental shelf edge (the 200-m [656-ft] isobath) throughout the year. During winter, there is an area of concentrated sperm whale occurrence records that extend into the northern portion of the OPAREA between the 200-m (656-ft) and 2,000-m (6,560-ft) isobaths.
In the JAX/CHASN OPAREA, sperm whales are most likely to occur from the vicinity of the continental shelf break continuing beyond the eastern boundary of the OPAREA throughout the year.

Atlantic Ocean, Offshore of the Northeastern United States

Sperm whales may occur year-round throughout the NE OPAREAs in continental slope waters extending out to deeper waters of the southern region of the study area. Overall, summer seems to have the greatest occurrence of sperm whales.

During the summer months, sperm whales occur primarily in continental slope waters out to deeper waters of the southern region of the NE OPAREAs, extending from the Scotian Shelf south to the VACAPES OPAREA. In this season, sperm whales may occur in greatest concentrations in the southwestern regions of Narragansett Bay OPAREA, with the greatest concentrations occurring off the southern flank of Georges Bank.

Gulf of Mexico

Worldwide, sperm whales exhibit a strong affinity for deep waters beyond the continental shelf break (Rice, 1989). The recorded observations of sperm whales in the GOMEX support this trend, with sightings consistently recorded in waters beyond the 200-m (656-ft) isobath. Overall, sperm whales may occur year-round in the deepest waters of the northern GOMEX and the outer continental shelf waters in the region off the Mississippi River Delta, which may represent a significant calving and nursery area for the species in the northern GOMEX (Mullin et al., 2004). Sperm whales tend to be observed most often near the 1,000-m (3,281-ft) isobath (Jochens et al., 2006). They have been recorded (visually and acoustically) in sufficient numbers during all seasons to provide additional support to the belief that the Gulf of Mexico supports a resident population (Weller et al., 2000; Jochens et al., 2006). There is a consistent aggregation of sperm whales in the southeastern Gulf west of the Dry Tortugas (Mullin and Fulling, 2004). The Florida Straits represent a probable corridor for movements of individuals between the GOMEX and Caribbean Sea (or even western North Atlantic waters). These aggregations are thought to result from primary productivity associated with the Mississippi River plume and periodic formation of the cyclonic Tortugas Gyre near the Dry Tortugas.

In the winter, the occurrence of sperm whales is patchy, with all sighting records located in deep water. Survey effort during this season, especially in the deep waters of the Gulf, is low and may explain the paucity of sighting records. There may be a very small area of high concentration in deep waters over the Rio Grande Slope. Stranding records along western Florida and the Keys support the likelihood of sperm whale occurrence in waters off of Florida during this season.

During spring, there is the greatest intensity and distribution of survey effort which explains the large number of sightings during this time of year. The occurrence of sperm whales during this season is the most spatially extensive in the Gulf, with all sightings recorded in waters beyond the 200-m (656-ft) isobath. Sperm whales may occur in the deepest waters throughout the northern GOMEX and in all OPAREAs.

During summer, sperm whales may occur in the deepest Gulf waters west of the DeSoto Canyon, including the Corpus Christi, New Orleans, and Pensacola OPAREAs. There are stranding records in southern Florida, including the Florida Keys, as well as one sighting near the Florida Straits. Of interest is a report of a sperm whale giving birth on 15 July 2006, 88 NM (163 km) offshore of south Texas (no further details on the exact location were provided) (Christenson, 2006).

In the fall, occurrence records are relatively sparse and patchy in waters seaward of the shelf break. Whether the lower number of sighting records during this season is due to reduced survey effort or the movement of sperm whales out of the Gulf or into more southerly waters cannot be detailed without further seasonal survey effort.

4.2.2 Pygmy and Dwarf Sperm Whales (*Kogia breviceps* and *Kogia sima*)

Description – There are two species of *Kogia*: the pygmy sperm whale and the dwarf sperm whale. Recent genetic evidence suggests that there might be an Atlantic and a Pacific species of dwarf sperm whales; however, more data are needed to make such a determination (Chivers et al., 2005).

Pygmy sperm whales have a shark-like head with a narrow, underslung lower jaw (Jefferson et al., 1993). The flippers are set high on the sides near the head. The small falcate dorsal fin of the pygmy sperm whale is usually set well behind the midpoint of the back (Jefferson et al., 1993). The dwarf sperm whale is similar in appearance to the pygmy sperm whale, but it has a larger dorsal fin that is generally set nearer the middle of the back (Jefferson et al., 1993). The dwarf sperm whale also has a shark-like profile but with a more pointed snout than the pygmy sperm whale. Pygmy and dwarf sperm whales reach body lengths of around 3 and 2.5 m (10 to 8 ft), respectively (Plön and Bernard, 1999).

Pygmy and dwarf 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). Based on the cryptic behavior of these species and their small group sizes (much like that of beaked whales), as well as similarity in appearance, it is difficult to identify these whales to species in sightings at sea.

Status – There is currently no information to differentiate Atlantic stock(s) (Waring et al., 2007). The best estimate of abundance for both species combined in the western North Atlantic is 395 individuals (Waring et al., 2007). Species-level abundance estimates cannot be calculated due to uncertainty of species identification at sea (Waring et al., 2007).

There is currently no information to differentiate the Northern GOMEX stock from the Atlantic stock(s) (Waring et al., 2006). The best estimate of abundance for *Kogia* spp. in the GOMEX is 742 individuals (Mullin and Fulling, 2004; Waring et al., 2006). A separate estimate of abundance for the pygmy sperm whale or the dwarf sperm whale cannot be calculated due to uncertainty of species identification at sea (Waring et al., 2006).

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 Martinque (Lesser Antilles) were recorded producing clicks at 13 to

33 kHz with durations of 0.3 to 0.5 sec (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 μsec, interclick intervals between 40 and 70 msec, 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).

Distribution – *Kogia* species apparently have a worldwide distribution in tropical and temperate waters (Jefferson et al., 1993). In the western Atlantic Ocean, *Kogia* spp. (specifically, the pygmy sperm whale) are documented as far north as the northern Gulf of St. Lawrence (Measures et al., 2004) and as far south as Colombia (dwarf sperm whale) (Muñoz-Hincapié et al., 1998). *Kogia* spp. generally occur along the continental shelf break and over the continental slope in the GOMEX (Baumgartner et al., 2001; Fulling and Fertl, 2003).

Atlantic Ocean, Offshore of the Southeastern United States

Western North Atlantic sightings of the physically similar pygmy and dwarf sperm whales occur primarily along the continental shelf and over the deeper waters off the continental shelf. There are limited sighting data for these species in the VACAPES OPAREA, and all recorded sightings are from the summer. The pygmy and dwarf sperm whales may occur in the VACAPES OPAREA during any season.

Pygmy and dwarf sperm whales are generally found along the outside of the continental shelf edge (the 200-m [656-ft] isobath) in warm-temperate to tropical waters in the North Atlantic. In the CHPT and JAX/CHASN OPAREAs, these whales are most likely to occur from the continental shelf edge to beyond the eastern boundary of the OPAREA. The distribution is assumed to be the same for all four seasons.

Atlantic Ocean, Offshore of the Northeastern United States

There is only a single sighting for each of the pygmy and dwarf sperm whales in the NE OPAREAs, both of which occurred in the summer when the majority of the remaining *Kogia* spp. sightings also occurred. With one exception, all of the sightings of Kogia spp. are located in continental slope and deeper waters from Georges Bank south. A large number of pygmy sperm whale stranding records occur as far north as Cape Cod while one dwarf sperm whale stranding was recorded in southernmost Maine. Based on these limited data, Kogia spp., including the dwarf sperm whale, may occur in waters from southern Maine to the deep waters in southern region of the NE OPAREAs. It is likely that the cryptic behavior of this species is responsible for so few sighting records.

Gulf of Mexico

Kogia spp. generally occur along the continental shelf break and over the continental slope in the GOMEX (Baumgartner et al., 2001; Fulling and Fertl, 2003).

In the winter, *Kogia* spp. are found throughout the northern Gulf, seaward of the shelf break. This is a time of year that is typically data deficient for deep water cetaceans in the Gulf because there is little survey effort. It is also the time when inclement weather conditions occur, and since *Kogia* spp. are low to the water, they can be difficult to sight in rough seas.

During the spring and summer, *Kogia* spp. may occur throughout most of the deep water sections of the Gulf. There is a concentration of records near the south-central edge of the GOMEX based on sighting records in the spring and two sites of concentrated occurrence records near the south-central edge of the study area and directly south of Louisiana over the continental slope in the summer.

In the fall, there are sightings within the Mississippi Canyon and DeSoto Canyon regions which indicate that, as expected, this region is important habitat for this species.

4.2.3 Beluga Whale (*Delphinapterus leucas*)

Description – The beluga or white whale, is a medium-sized whale, robust in body shape. Sexual dimorphism is apparent, with females attaining a maximum body length of 4.1 m (13.5 ft), while most adult males are less than 5.5 m (18.0 ft) and weigh upwards of 1,500 kg (3,307 lb) (Jefferson et al., 1993). The beluga has a small bulbous head and a very short beak. Instead of a dorsal fin, this species has a prominent dorsal ridge (1 to 3 cm in height) that runs along the midline of the back. The beluga has more head and neck flexibility than other cetaceans since the cervical (neck) vertebrae are not fused. At birth, the calf is a dark slate gray to brownish gray, whitening as they age, reaching the pure white stage between 5 and 12 years of age (Brodie, 1989). Belugas could be confused with narwhals (*Monodon monoceros*), which overlap with their range, and adult Risso’s dolphins, which are superficially similar in appearance (Reeves and Katona, 1980).

Status – There are well over 100,000 belugas in the circumpolar Arctic (Reeves et al., 2002b). Stocks are defined primarily on the basis of summering grounds, most of which are centered on estuaries where animals molt (Reeves et al., 2002b). There are approximately 12 North American beluga management units (Brown Gladden et al., 1999). In stock assessment reports, NMFS does not include beluga whales among those species having populations or stocks in the Western North Atlantic Ocean or in the Gulf of Mexico.

Diving Behavior – Belugas are not generally thought of as deep-diving marine mammals, with typical dives to approximately 20 m (66 ft). However, they are capable of diving to extreme depths; free-ranging belugas have been documented to dive to maximum depths of 350 m (1,148 ft) (Martin and Smith, 1992). Under experimental conditions, a trained beluga repeatedly dove to 400 m with ease, and even dove to a depth of 647 m (2,123 ft) (Ridgway, 1986). The maximum dive duration recorded for the beluga is 25 min (Martin et al., 1998).

***Acoustics and Hearing* –** Belugas make such an array of sounds that nineteenth century sailors and explorers of the high Arctic named them "sea canaries." Scientists have documented as many as 50 call types (O'Corry-Crowe, 2002). Whistle and pulsed calls are typically made at frequencies between 0.4 and 20 kHz (Thomson and Richardson, 1995). Belugas have demonstrated echolocation abilities with frequencies of 40 to 60 kHz, but has been known to go up to 100 to 120 kHz (Au et al., 1985); the source level is 206 to 225 dB re 1 μPa-m, peak-to-peak (Thomson and Richardson, 1995).

This species has good high-frequency hearing, with high sensitivities from 32 kHz to 108 kHz (Klishin et al., 2000). Hearing extends at least as low as 40 to 75 Hz, however, sensitivity at these low frequencies appears to be poor (Awbrey et al., 1988; Klishin et al., 2000). Ridgway et al. (2001) determined that beluga hearing is not attenuated at depth (which means that zones of audibility occur throughout the depths to which these whales dive). Temporary threshold shifts (TTS) of 6 to 7 dB were observed in the beluga after exposure to single impulses with peak pressure of 160 kilopascal (kPa) (23 psi) and total energy flux of 186 dB re 1 μPa^2-s (Finneran et al., 2002). After exposures to intense tones (0.4, 3, 10, 20, and 75 kHz), belugas exhibited altered behavior at 180 to 196 dB re 1 μPa-m; TTS was induced at source levels generally between 192 and 201 dB re 1 μPa-m (Schlundt et al., 2000).

***Distribution* –** The beluga has a nearly circumpolar distribution, being found in arctic and subarctic waters along the northern coasts of Canada, Alaska, Russia, Norway, and Greenland (Gurevich, 1980). Distribution is centered mainly between 50ºN and 80ºN (Reeves et al., 2002b). The St. Lawrence estuary is at the southern limit of the distribution of this species (Lesage and Kingsley, 1998). Long migrations (thousands of kilometers) are a normal part of beluga behavior in some locales (Reeves, 1990). These movements are probably a response to a combination of coastal ice formations, offshore feeding opportunities, and the affinity for estuarine conditions during the summer calving period (Brodie, 1989).

Atlantic Ocean, Offshore of the Southeastern United States

The beluga whale is not expected to occur within the western North Atlantic Ocean offshore of the southeastern U.S.

Atlantic Ocean, Offshore of the Northeastern United States

The beluga is extralimital in the Northeast OPAREAs at all times of the year. The southernmost record is from Cape May, New Jersey (Reeves and Katona, 1980; CETAP, 1982; Reeves, 1990). Overstrom et al. (1991) documented the occurrence and activities of a solitary beluga that inhabited Long Island Sound from February 1985 until its death in May 1986. Most of the individuals found off the northeastern United States probably originate from the St. Lawrence River population, which winters in the Gulf of St. Lawrence or along the open coasts of Labrador and Newfoundland (Reeves and Katona, 1980). There is no direct evidence, however, to support this assumption regarding the origination of these stray individuals (Reeves, 1990; Lesage and Kingsley, 1998).

Gulf of Mexico

The beluga whale is not expected to occur in the Gulf of Mexico.

4.2.4 Beaked Whales (various species)

Description – Based upon available data, six beaked whales are known to occur in the western North Atlantic Ocean: Cuvier's beaked whales, northern bottlenose whales, and four members of the genus *Mesoplodon* (True’s, Gervais', Blainville's, and Sowerby's beaked whales), which, with the exception of *Ziphius* and *Hyperoodon*, are nearly indistinguishable at sea (Coles, 2001). Four have documented occurrence in the GOMEX, including Cuvier's beaked whale and three members of the genus *Mesoplodon* (Gervais', Blainville's, and Sowerby's beaked whales). The Smithsonian Institution is currently developing an online system to facilitate species-level identification of stranded individuals (Allen et al., 2005). They are presented in one summary due to the paucity of biological information available for each species and the difficulty of species-level identifications for *Mesoplodon* species. *Mesoplodon* spp. are also often termed ”mesoplodonts.“

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 (24.6 and 23.0 ft) in length, respectively (Jefferson et al., 1993). This species has a relatively short beak, which along with the curved jaw, resembles a goose beak. The body is spindle shaped, and the dorsal fin and flippers are small which is typical for beaked whales. A useful diagnostic feature is a concavity on the top of the head, which becomes more prominent in older individuals. Cuvier’s beaked whales are dark gray to light rusty brown in color, often with lighter color around the head. In adult males, the head and much of the back can be light gray to white in color, and they also often have many light scratches and circular scars on the body (Jefferson et al., 1993).

Northern bottlenose whales are 7 to 9 m (23 to 30 ft) in length with rotund bodies, large bulbous heads, and small, well-defined beaks (Mead, 1989a). These whales range in color from green-brown to gray with lighter gray-white markings on the body and lighter coloring on the lower part of the flanks and ventral surface (Jefferson et al., 1993). Diatoms are known to grow on some individuals, giving them an added brownish appearance. The head and face are gray and may even appear white. White or yellow blemishes or scars can be present, especially in older animals. Only mature males have erupted teeth. There is marked sexual dimorphism in the melon of northern bottlenose whales, which is enlarged, flattened, and squared off in males (Mead, 1989a). Gowans and Rendell (1999) observed head-butting by males and speculated that differences in head shape may be significant in male contests for mates.

All mesoplodonts have a relatively small head, large thorax and abdomen, and short tail. Mesoplodonts all have a pair of throat grooves on the ventral side of the head on the lower jaw. Mesoplodonts are characterized by the presence of a single pair of sexually dimorphic tusks, which erupt only in adult males. MacLeod (2000b) suggested that the variation in tusk position and shape acts as a species recognition signal for these whales.

Blainville's beaked whales are documented to reach a maximum length of around 4.7 m (15.4 ft) (Jefferson et al., 1993). Adults are blue-gray on their dorsal side and white below (Jefferson et al., 1993). The lower jaw of the Blainville's beaked whale is highly arched, and massive flattened tusks extend above the upper jaw in adult males (Jefferson et al., 1993).

Gervais' beaked whale males reach lengths of at least 4.5 m, while females reach at least 5.2 m (17.1 ft) (Jefferson et al., 1993). These beaked whales are dark gray dorsally with a light-gray belly. Adult males have one tooth evident per side, one-third of the distance from the snout tip to the corner of the mouth (Jefferson et al., 1993).

Sowerby's beaked whale males and females attain lengths of at least 5.5 and 5.1 m (18.0 and 16.7 ft), respectively (Jefferson et al., 1993). The beak is long and distinct. The melon also has a hump on the top. Two small teeth are evident along the middle of the lower jaw in adult males. Coloration has generally been described as charcoal gray dorsally and lighter below (Jefferson et al., 1993). Gray spotting has been noted on adults, although younger animals may also display a lesser degree of spotting (Jefferson et al., 1993).

True's beaked whales reach lengths of slightly over 5 m (17 ft) and weigh up to 1,400 kg (3,086 lb) (Jefferson et al., 1993). Coloration is generally similar to other mesoplodonts. Newborns are likely between 2.0 and 2.5 m (6.6 and 8.2 ft) long. A pair of teeth is located at the tip of the lower jaw.

Status **–** The best estimate of mesoplodont and Cuvier's beaked whale abundance combined in the western North Atlantic is 3,513 individuals (Waring et al., 2007). 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, it was not possible for this study to discern finer-scale population differences within the North Atlantic (Dalebout et al., 2005). Using mark-recapture techniques, 133 northern bottlenose whales have been estimated to utilize the Gully (Nova Scotia) (Gowans et al., 2000). It is not possible to obtain any additional species-specific estimates due to the difficulty of individual identification at sea.

The best estimate of abundance for the Cuvier's beaked whale in the northern GOMEX is 95 individuals (Mullin and Fulling, 2004; Waring et al., 2006). The best estimate of abundance for *Mesoplodon* spp. in the northern GOMEX is 106 individuals (Mullin and Fulling, 2004; Waring et al., 2006). It is not possible to obtain species-specific estimates due to the difficulty of identifying specimens at sea. The GOMEX Cuvier's beaked whale and *Mesoplodon* spp. populations are provisionally being considered as separate stocks for management purposes although there is currently no information to differentiate these stocks from the Atlantic Ocean stock(s) (Waring et al., 2006).

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 =11.7 min), shallow dives and long-duration (mean=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 minutes to depths greater than 800 m (2,625 ft), with one long dive occurring on average every two hours; 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 sec (Manghi et al., 1999)), while pulsed sounds had a narrow peak frequency of 13 to 17 kHz, lasting 15 to 44 sec 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, 1971b).

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 was often multimodal, and peak frequencies ranged between 2 and 22 kHz (mean=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 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 DTAGs (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-ear adaptations). 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-ear adaptations). Ketten (2000-ear adaptations) 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).

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).

Northern bottlenose whales are restricted to northern latitudes of the North Atlantic. This species is routinely found in the Gully, a submarine canyon off the coast of Nova Scotia, near the southern and western limits of the species' range (Gowans et al., 2000).

The ranges of most mesoplodonts are poorly known. In the western North Atlantic and Gulf of Mexico, these animals are known mostly from strandings (Mead, 1989b; MacLeod, 2000a; 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 Gervais' beaked whale is the most frequently stranded beaked whale in the Gulf of Mexico (Würsig et al., 2000). 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). The stranding on the Gulf coast of Florida is considered to be extralimital (Jefferson and Schiro, 1997; 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). Macleod and Mitchell (2006) described the northern GOMEX continental shelf margin as "a key area" for beaked whales.

Atlantic Ocean, Offshore of the Southeastern United States

Five species of beaked whales may occur in the waters off the southeastern United States including Cuvier's beaked, Gervais' beaked, Blainville's beaked, and True's beaked. The Sowerby's beaked whale is endemic to the North Atlantic and is considered to be more of a temperate species (MacLeod et al., 2006). The single stranding record from the Gulf coast of Florida is considered to be extralimital (Jefferson and Schiro, 1997; MacLeod et al., 2006). In the VACAPES, CHPT, and JAX/CHASN OPAREAs, beaked whale occurrence is assumed to be the same for all seasons and to primarily occur from the shelf break to the deeper offshore waters.

Atlantic Ocean, Offshore of the Northeastern United States

To determine beaked whale occurrence for the NE OPAREAs, information regarding unidentified beaked whales, Blainville's beaked whale, Cuvier's beaked whale, Sowerby's beaked whale, and northern bottlenose whale was pooled. Insufficient data are available for Gervais' beaked whale and True's beaked whale. In general, beaked whales occur in deeper waters off the continental slope. Overall, summer has the highest occurrences of beaked whales. During the wintertime, beaked whales may sporadically occur, extending from the continental slope to those deeper waters over the continental rise, from the southern flank of Georges Bank south to the VACAPES OPAREA. Stranding data suggest that beaked whales may occur as far north as southern Maine.

In the springtime, beaked whales may occur over the continental slope, in waters from the Scotian Shelf, through the southern regions of Narragansett Bay and Atlantic City OPAREAS.

In the summer, the general occurrence of beaked whales extends from waters over the continental slope to those deeper waters over the continental rise, from Browns Bank south to the VACAPES OPAREA. During this season beaked whales may occur in greater concentrations outside the Northeast Channel, along the southern flank of Georges Bank, southeastern region of Narragansett Bay OPAREA, and in the southwestern region of the NE OPAREAs.

Lastly, in the fall, beaked whales may sporadically occur, extending from the continental slope to those deeper waters over the continental rise, from outside the Northeast Channel to the southern map extent, and the western region of the Narragansett Bay OPAREA, just north of the Hudson Canyon.

Gulf of Mexico

Beaked whales are considered to be a deep water species. There are a handful of beaked whale sightings on the continental shelf off Mississippi and Alabama made during the Esher et al. (1992) surveys. Many surveys have taken place on the continental shelf in this region, yet this is the only survey program that recorded beaked whales. Two of the beaked whale sightings reported during the fall in the near vicinity of the shelf break are suspect with group sizes of 6 and 10 individuals, respectively. These are much larger group sizes than are typically reported. There is also one beaked whale sighting off Mobile Bay, Alabama, in waters with a bottom depth of approximately 30 m (98 ft). This could be a sighting of an individual which may have later stranded.

In the winter, sightings are in waters seaward of the shelf break, particularly over the continental slope. This is a time of year with both decreased survey effort and high sea states that can make sighting cetaceans (especially beaked whales) difficult. Occurrence should be expected in deep waters throughout the entire northern GOMEX.

The spring is the season with the most survey effort; sightings are throughout the deep waters of the northern GOMEX. Beaked whales are anticipated to occur throughout deep waters of the Gulf. The area of greatest concentration may occur over the abyssal plain at the southern edge of the GOMEX. Other patches of high concentrations may occur in waters over the Florida Escarpment and in the region influenced by the Tortugas Gyre.

In the summer, sightings are throughout most of the deep waters of the northern GOMEX. There may be patchy occurrence primarily in the central and eastern GOMEX, particularly in the Mississippi Canyon region and around parts of the Florida Escarpment. The areas of greatest concentration are in waters over the continental slope and abyssal plain south of Louisiana.

Fall is a season with a lesser amount of recorded sightings, likely due to decreased survey effort and high Beaufort sea states that can make sighting cetaceans difficult during this time of year. Occurrence should be expected in deep waters throughout the entire northern GOMEX.

4.2.5 Rough-Toothed Dolphin (*Steno bredanensis*)

***Description* –** This is a relatively robust dolphin with a cone-shaped head; it is the only one with no demarcation between the melon and beak (Jefferson et al., 1993). The “forehead” slopes smoothly from the blowhole onto the long, narrow beak (Reeves et al., 2002). The rough-toothed dolphin has large flippers that are set far back on the sides and a prominent falcate dorsal fin (Jefferson et al., 1993). The body is dark gray with a prominent narrow dorsal cape that dips slightly down onto the side below the dorsal fin. The lips and much of the lower jaw are white, and many individuals have white scratches and spots on the body from cookie-cutter sharks and other rough-toothed dolphins. The rough-toothed dolphin reaches 2.8 m (9.2 ft) in length (Jefferson et al., 1993).

***Status* –** No abundance estimate is available for rough-toothed dolphins in the western North Atlantic. The best estimate of abundance for rough-toothed dolphins in the northern GOMEX is 2,223 individuals (Fulling et al., 2003; Mullin and Fulling, 2004; Waring et al., 2006).

***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 microseconds [µsec]) 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 sec) 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).

Auditory evoked potential (AEP) measurements were performed on six individuals involved in a mass stranding event on Hutchinson Island, Florida in August 2004 (Cook et al., 2005). The rough-toothed dolphin can detect sounds between 5 and 80 kHz and is most likely capable of detecting frequencies much higher than 80 kHz (Cook et al., 2005).

***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). Rough-toothed dolphins occur in low densities throughout the eastern tropical Pacific where surface water temperatures are generally above 25° C (Perrin and Walker, 1975). This species is not a commonly encountered species in the areas where it is known to occur (Jefferson, 2002c). 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; Würsig et al., 2000). Two separate mass strandings of rough-toothed dolphins occurred in the Florida Panhandle during December 1997 and 1998 (Rhinehart et al., 1999). Additionally, a mass stranding of a minimum of 70 individuals occurred off the Florida Keys on 2 March 2005 (Banick and Borger, 2005).

Atlantic Ocean, Offshore of the Southeastern United States

Rough-toothed dolphins may occur in waters off the shelf break in the VACAPES, CHPT, and JAX/CHASN OPAREA based on their preference for deep-waters. A few strandings and two sightings of rough-toothed dolphins have been recorded in or near the VACAPES OPAREA. It is assumed that rough-toothed dolphin could occur year round. During the winter, the rough-toothed dolphin's is generally expected in warmer waters, so their occurrence may follow the western edge of the standard deviation of the Gulf Stream.

Atlantic Ocean, Offshore of the Northeastern United States

The rough-toothed dolphin is extralimital at all times of the year in the NE OPAREAs based on the warm-water preference of this species. There are only two confirmed sighting of this species, which occurred in June and September 1979.

Gulf of Mexico

Rough-toothed dolphins occur in both oceanic and continental shelf waters in the northern Gulf of Mexico (Fulling et al., 2003; Mullin and Fulling, 2004). Rough-toothed dolphins were seen in all seasons during GulfCet aerial surveys of the northern Gulf of Mexico between 1992 and 1998 (Hansen et al., 1996; Mullin and Hoggard, 2000).

In the winter, there is only one sighting record available for this species during this season. Two stranded and rehabilitated individuals were released with tags in late March 1998 off Sarasota, Florida, and remained in the northeastern GOMEX (Wells et al., 1999). This is a time of year that is typically data deficient for deep water cetaceans in the Gulf because there is little survey effort. It is also the time when Beaufort sea states are highest which makes detection of species much more difficult (Mullin et al., 2004).

In the spring, rough-toothed dolphins occur in the deeper waters seaward of the shelf break, including over the abyssal plain. Sighting concentrations are predicted to be inshore of the Florida Escarpment and over the continental slope south of Louisiana.

In the summer, the greatest concentration of this species is suggested to be over the abyssal plain near the central edge of the study area. Other concentrations are predicted on the west Florida Shelf and in the Mississippi Canyon region. This is the only time of the year that occurrence is also anticipated in continental shelf waters off southern Texas. The occurrence patterns for this season likely reflect the most realistic picture for the species since both oceanic and shelf occurrences are predicted.

In the fall, two sighting records are available for rough-toothed dolphins during this season. The predicted occurrence is in the Mississippi Canyon region. It should be noted that this is a time of year when Beaufort sea states are high which makes detection of species much more difficult (Mullin et al., 2004).

4.2.6 Bottlenose Dolphin (*Tursiops truncatus*)

Description – Bottlenose dolphins are large and robust, varying in color from light gray to charcoal. The genus *Tursiops* is named for its short, stocky snout that is distinct from the melon (Jefferson et al., 1993). The dorsal fin is tall and falcate. There are striking regional variations in body size, with adult lengths from 1.9 to 3.8 m (6.2 to 12.5 ft) (Jefferson et al., 1993).

The taxonomy of the genus *Tursiops* has been debated for decades and continues to be contested. Two *Tursiops* species are currently recognized: the bottlenose dolphin (*Tursiops truncatus*) and Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) (Rice, 1998; IWC, 2005). It is likely that additional species-level taxonomy will be recognized based on future genetic and morphometric analyses (Natoli et al., 2004). Indo-Pacific bottlenose dolphins are found in coastal Indo-Pacific tropics (Curry and Smith, 1997), while all other forms are considered to be bottlenose dolphins.

Scientists currently recognize several nearshore (coastal) and an offshore morphotype or form of bottlenose dolphins, which are distinguished by external and cranial morphology, hematology, diet, and parasite load (Duffield et al., 1983; Hersh and Duffield, 1990; Mead and Potter, 1995; Curry and Smith, 1997). There is also a clear genetic distinction between nearshore and offshore bottlenose dolphins worldwide (Curry and Smith, 1997; Hoelzel et al., 1998). It has been suggested that the two forms should be considered different species (Curry and Smith, 1997; Kingston and Rosel, 2004), but no official taxonomic revisions have yet been made.

Status – Two forms of bottlenose dolphins are recognized in the western North Atlantic Ocean: nearshore (coastal) and offshore morphotypes. Each morphotype is referred to as a stock by NMFS. There is a complex mosaic that comprises the coastal stock (NMFS-SEFSC, 2001; Waring et al., 2007). NMFS recognizes the mosaic to be seven discrete management units (MU) that have distinct spatial and temporal components: Northern Migratory MU, Northern North

Carolina MU, Southern North Carolina MU, South Carolina MU, Georgia, Northern Florida MU, and Central Florida MU (Waring et al., 2007). Three MUs occur during the summer (May through October) in the CHPT OPAREA: Northern Migratory, Northern North Carolina, and Southern North Carolina. During the winter (November through April), the Northern Migratory, Northern North Carolina, and Southern North Carolina MUs overlap along the coast of North Carolina and are referred to as the Winter Mixed MU (Waring et al., 2007).

NMFS provides abundance estimates for each MU by season. During the summer, the best estimates of abundance for the Northern Migratory, Northern North Carolina, and Southern North Carolina MUs are 17,466; 7,079; and 3,786 individuals, respectively (Waring et al., 2007). During the winter, an estimated 16,913 individuals make up the Winter Mixed MU (Waring et al., 2007). The MUs making up the coastal stock are considered depleted under the MMPA (Waring et al., 2007).

From 1987 to 1988, the annual number of bottlenose dolphins stranded along the eastern United States increased tenfold relative to previous years (MMC, 2002). This die-off started in the mid-Atlantic region, moved northward and then southward to encompass nearly the entire eastern seaboard from New Jersey to central Florida (MMC, 2002). The pattern of strandings was considered evidence for a single coastal migratory stock along the eastern United States Analysis of the event suggested that more than half of this stock may have died during the event (MMC, 2002). In April 2006, NMFS published a draft Bottlenose Dolphin Take Reduction Plan, to reduce the incidental mortality and serious injury to the Atlantic coastal stocks of bottlenose dolphins in commercial fisheries to below PBR (NMFS, 2006e).

Currently, a single western North Atlantic offshore stock is recognized seaward of 34 km (18 NM) from the U.S. coastline (Waring et al., 2007). The minimum population estimate for this stock is 70,775 individuals (Waring et al., 2007).

There is a need for information to accurately identify stocks of bottlenose dolphins in the GOMEX (Hubard and Swartz, 2002; MMC, 2002; Sellas et al., 2005). As noted earlier, offshore and coastal forms are recognized. In the northern GOMEX, there are coastal stocks; a continental shelf stock; an oceanic stock; and bay, sound, and estuarine stocks (Waring et al., 2006). Sellas et al. (2005) reported the first evidence that the coastal stock off west central Florida is genetically separated from the adjacent inshore areas, while Fazioli et al. (2006) recently demonstrated that dolphins found inshore within bays, sounds, and estuaries on the west central Florida coast move into the nearby Gulf waters used by the coastal stocks. Genetic, photo-identification, and tagging data support the concept of relatively discrete bay, sound, and estuarine stocks; these 33 stocks recognized by the NOAA Stock Assessment Report are all thought to occur inshore of the GOMEX study area and are not discussed further here.

There are three coastal stocks in the northern GOMEX that occupy waters from the shore to the 20-m (66-foot) isobath: Eastern Coastal, Northern Coastal, and Western Coastal (Waring et al., 2006). The Western Coastal stock inhabits the nearshore waters from the Texas/Mexico border to the Mississippi River mouth; the best estimate for this stock is 3,449 individuals (Waring et al., 2006). The Northern Coastal stock is defined from the Mississippi River mouth to approximately 84°W; the best estimate is 4,191 dolphins (Waring et al., 2006). The Eastern Coastal stock is defined from 84°W to Key West, Florida; the best estimate is 9,912 individuals (Waring et al., 2006).

The Continental Shelf stock is defined as dolphins inhabiting the waters from the Texas/Mexico border to Key West, Florida, between the 20- and 200-m (66- and 656-ft) isobaths (Waring et al., 2006). The best estimate of abundance for this stock is 25,320 bottlenose dolphins (Fulling et al., 2003; Waring et al., 2006). The continental shelf stock probably consists of a mixture of both the coastal and offshore ecotypes.

The Oceanic stock is provisionally defined as bottlenose dolphins inhabiting waters from the 200-m (656-ft) isobath to the seaward extent of the EEZ (Waring et al., 2006). The best estimate of abundance for the bottlenose dolphin in oceanic waters of the northern GOMEX is 2,239 individuals (Mullin and Fulling, 2004; Waring et al., 2006). This stock is believed to consist of the offshore form of bottlenose dolphins described by Hersh and Duffield (1990). Both inshore/coastal stocks and the oceanic stock are separate from the continental shelf stock; however, the continental shelf stock may overlap with coastal stocks and the oceanic stock in some areas and may be genetically indistinguishable from those other stocks (Waring et al., 2006).

In the last few decades, there have been five unusual mortality events involving bottlenose dolphins in the GOMEX (NOAA and FFWCC, 2004). The most recent occurred between 10 March and 13 April 2004, in which 107 bottlenose dolphins dead stranded along the Florida Panhandle (NOAA and FFWCC, 2004). Analyses indicated that breve toxins and low levels of domoic acid were present in the stranded animals, possibly leading to the stranding event (NOAA and FFWCC, 2004; Flewelling et al., 2005). NOAA contracted Mote Marine Laboratory to assess the health of bottlenose dolphins (including live captures and tracking) in St. Joseph Bay in the Florida Panhandle during April thru July 2005 (Balmer and Wells, 2006).

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 sec 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 percent 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, one-second pulse with sound exposure level (SEL) of 195 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 minutes 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.

Distribution – The overall range of the bottlenose dolphin is worldwide in tropical and temperate waters. This species occurs in all three major oceans and many seas. Dolphins of the genus *Tursiops* generally do not range poleward of 45º, except around the United Kingdom and northern Europe (Jefferson et al., 1993). Climate changes can contribute to range extensions as witnessed in association with the 1982/1983 El Niño event when the range of some bottlenose dolphins known to the San Diego, California area was extended 600 km (324 NM) northward to Monterey Bay (Wells et al., 1990). Bottlenose dolphins continue to occur in Monterey Bay to this day.

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).

Genetic analyses and spatial patterns observed from aerial surveys indicate regional and seasonal distribution differences between the coastal and offshore stocks. North of Cape Hatteras, the coastal stock is thought to be restricted to waters less than 25 m (82 ft) in depth, while offshore dolphins generally range beyond the 50-m (164-ft) isobath (CETAP, 1982; Kenney, 1990; Waring et al., 2007). Mitochondrial DNA and spatial analyses from dolphins south of Cape Hatteras suggest individuals sighted within 7.5 km (4 NM) of shore are of the coastal form and those beyond 34 km (18 NM) from shore and in waters with a bottom depth greater than 34 m (112 ft) are of the offshore form (Torres et al., 2003). However, Torres et al. (2003) also found an extensive region of overlap between the coastal and offshore stocks between 7.5 (4.0 NM) and 34 km (18 NM) from shore.

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 (less than 20 m [66 ft] deep) while the offshore form is in deeper waters (greater than 40 m [131 ft] deep) (Waring et al., 2007). 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 (102 ft) and 75 km (40 NM) from shore while offshore dolphins may occur in waters as shallow as 13 m (43 ft) (Garrison et al., 2003b). Additional aerial surveys and genetic sampling are required to better understand the distribution of the two stocks throughout the year.

Discrete MUs exhibit seasonal migrations regulated by temperature and prey availability (Torres et al., 2005; Waring et al., 2007), traveling as far north as New Jersey in summer and as far south as central Florida in winter (Waring et al., 2007). During the summer, the Northern Migratory MU occurs from the New York/New Jersey border to the Virginia/North Carolina border. The Northern North Carolina MU ranges from the Virginia/North Carolina border to Cape Lookout, North Carolina during the summer months, and the Southern North Carolina MU ranges from Cape Lookout, North Carolina to Murrell's Inlet, South Carolina at this time of year. In the winter months, these three MUs overlap along the coast of North Carolina and southern Virginia. Coastal bottlenose dolphins along the western Atlantic coast may exhibit either resident or migratory patterns (Waring et al., 2007). Photo-identification studies support evidence of year-round resident bottlenose dolphin populations in Beaufort and Wilmington, North Carolina (Koster et al., 2000; Waring et al., 2007); these are the northernmost documented sites of year-round residency for bottlenose dolphins in the western North Atlantic (Koster et al., 2000). A high rate of exchange occurs between the Beaufort and Wilmington sites as well (Waring et al., 2007). Individuals from the Northern Migratory MU 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).

The offshore stock is expected to remain in the Gulf Stream during the winter months (Mead and Potter, 1990); this theory is supported by recent stable isotope analysis in teeth collected from coastal and offshore individuals, indicating significant differences in distributions between the two stocks. Despite small sample sizes, such evidence suggests offshore dolphins may not undergo seasonal migrations (Cortese, 2000).

The bottlenose dolphin is by far the most widespread and common cetacean in coastal waters of the GOMEX (Würsig et al., 2000). Bottlenose dolphins are frequently sighted near the Mississippi River Delta (Baumgartner et al., 2001) and have even been known to travel several kilometers up the Mississippi River.

Atlantic Ocean, Offshore of the Southeastern United States

In the U.S. Atlantic, the bottlenose dolphin is distributed along the coast from Long Island, New York, to the Florida Keys and up through the Gulf of Mexico. Aerial surveys conducted between 1978 and 1982 (CETAP, 1982) north of Cape Hatteras, North Carolina, identified two concentrations of bottlenose dolphins, one inshore of the 25-m (82-ft) isobath and the other offshore of the 50-m (164-ft) isobath. The lowest density of bottlenose dolphins was observed over the continental shelf, with higher densities along the coast and near the continental shelf edge. It was suggested therefore, that the coastal morphotype is restricted to waters less than 25 m (82 ft) deep north of Cape Hatteras (Kenney, 1990). Similar patterns were observed during summer months north of Cape Lookout, NC in more recent aerial surveys (Garrison and Yeung, 2001; Garrison et al., 2003). However, south of Cape Lookout during both winter and summer months, there was no clear longitudinal discontinuity in bottlenose dolphin sightings (Garrison and Yeung, 2001; Garrison et al., 2003).

Bottlenose dolphins occur in the VACAPES, CHPT and JAX/CHASN OPAREAs year-round. The bottlenose dolphin is among the most numerous marine mammal species in the coastal waters.

Atlantic Ocean, Offshore of the Northeastern United States

Bottlenose dolphins occur year-round in waters over the continental shelf extending to deeper waters over the abyssal plain, from the Scotian Shelf south to the VACAPES OPAREA. Most of the sightings seem to occur in the vicinity of the continental slope.

In the wintertime, bottlenose dolphins may occur over the continental shelf and slope waters, from Cape Cod Bay and the tip of Georges Bank to the southern map extent. During this season, the greatest number of bottlenose dolphins occurs outside the NE OPAREAs south towards the VACAPES OPAREA.

In the springtime, bottlenose dolphins occur primarily over the continental self and slope, in waters from Jeffreys Bank and south towards the VACAPES OPAREA. Few occurrences may be found in the deeper waters of the southern region of the NE OPAREAs. During the spring months, this species may occur in greater concentrations in the vicinity of the continental slope, near the tip of Georges Bank, in the center and southern regions of Narragansett Bay and

Atlantic City OPAREAs respectively, and just south of the NE OPAREAs. Bottlenose dolphin sightings in the northeast region increase during spring, as individuals move north into the NE OPAREAs as water temperatures increase (NMFS-SEFSC, 2001; Waring et al., 2004).

In the summer, the general occurrence of bottlenose dolphins extends from waters over the continental shelf to those deeper waters over the southern region of the NE OPAREAs. During this season, bottlenose dolphins may occur in greater concentrations in the vicinity of the continental slope, along the southern flank of Georges Bank (eastern region of Narragansett Bay OPAREA) and the southern region of the Atlantic City OPAREA, and in the waters over the New England Sea Mount Chain. In the fall, bottlenose dolphins may occur from Jeffreys Bank to the southern map extent, in waters over the continental shelf extending to those deeper waters over the continental rise. During this season, bottlenose dolphins may be found in greater concentrations in waters over Gilbert Canyon, just east of Narragansett Bay OPAREA.

Gulf of Mexico

Bottlenose dolphins are abundant in continental shelf waters throughout the northern GOMEX (Fulling et al., 2003; Waring et al., 2006). Mullin and Fulling (2004) noted that in oceanic waters, bottlenose dolphins are encountered primarily in upper continental slope waters (less than 1,000 m in bottom depth) and that highest densities are in the northeastern Gulf.

In the winter, bottlenose dolphins may occur on the outer continental shelf and upper slope of the western Gulf and nearshore waters in the north-central and north-eastern Gulf, as well as the DeSoto Canyon region and Florida Escarpment. The large number of sightings in shelf waters off Mississippi, Alabama, and the Florida Panhandle are a result of aerial surveys conducted here during this season. It is well-known that the bottlenose dolphin occurs in nearshore waters west of the Mississippi River or over most of the Florida Shelf throughout these areas year-round; the apparent absence of occurrence in these areas is biased by the lack of survey effort during this time of year.

In the spring, bottlenose dolphins occur on the outer continental shelf and upper slope of the western Gulf and nearshore waters in the north-central and north-eastern Gulf, as well as the DeSoto Canyon region and Florida Escarpment. The large number of sightings in shelf waters off Mississippi, Alabama, and the Florida Panhandle are a result of aerial surveys conducted here during this season.

In summer, occurrence is predicted throughout the vast majority of shelf waters, as well as over the continental slope. There may be increased occurrence in shelf waters off Matagorda, Corpus Christi, and Galveston bays in Texas; on the shelf just to the west of the Mississippi Canyon; on the shelf off the Mississippi River Delta; and in an area on the Florida Shelf. Significant occurrences are anticipated near all bays in the northern Gulf.

As with the summer, occurrence is predicted throughout the vast majority of shelf waters, as well as the continental slope waters. There may be pockets of increased occurrence in shelf waters off Matagorda and Corpus Christi bays in Texas and on the Florida Shelf off Sarasota and Tampa bays; these are all well-known areas of bottlenose dolphin occurrence. Other areas of increased occurrence are over the Florida Escarpment and in an area off the Mississippi River Delta.

4.2.7 Pantropical Spotted Dolphins (*Stenella attenuata*)

Description – The pantropical spotted dolphin is a rather slender dolphin. This species has a dark dorsal cape, while the lower sides and belly of adults are gray. The beak is long and thin; the lips and beak tip tend to be bright white. A dark gray band encircles each eye and continues forward to the apex of the melon; there is also a dark gape-to-flipper stripe (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). Some populations may be virtually unspotted (Jefferson, 2006). Adults may reach 2.6 m (8.5 ft) in length (Jefferson et al., 1993).

Status – The best estimate of abundance of the western North Atlantic stock of pantropical spotted dolphins is 4,439 individuals (Waring et al., 2007). There is no information on stock differentiation for pantropical spotted dolphins in the U.S. Atlantic (Waring et al., 2007). The best estimate of abundance for the pantropical spotted dolphin in the northern GOMEX is 91,321 individuals (Mullin and Fulling, 2004; Waring et al., 2006). The pantropical spotted dolphin is the most abundant and commonly seen cetacean in deep waters of the northern GOMEX (Davis and Fargion, 1996; Jefferson, 1996a; Mullin and Hansen, 1999; Davis et al., 2000; Würsig et al., 2000; Mullin et al., 2004).

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 and 1997).

Distribution – Pantropical spotted dolphins occur in subtropical and tropical waters worldwide (Perrin and Hohn, 1994). Although there are coastal populations in shallow nearshore waters of Central America, most pantropical spotted dolphins occur in deep oceanic waters of the upper continental slope and deeper. 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., 2007). In the Atlantic, this species is considered broadly sympatric with Atlantic spotted dolphins (Perrin and Hohn, 1994). Most sightings of this species in the GOMEX occur over the lower continental slope (Davis et al., 1998), although they are widely distributed in waters beyond the shelf edge.

Atlantic Ocean, Offshore of the Southeastern United States

The pantropical spotted dolphin is a deepwater species (Jefferson et al., 1993). 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., 2007). 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. Therefore, the low number of sightings of pantropical spotted dolphins in offshore waters may be more of a reflection of survey observers not distinguishing between the two species.

The only records documented in the VACAPES OPAREA include one sighting near the shelf break in summer and one bycatch record in winter in the southern portion of the VACAPES OPAREA. In addition, there are a few sightings recorded along the continental shelf break south of Chesapeake Bay in the VACAPES OPAREA during spring. There is only one sighting (off-effort) in the CHPT OPAREA during winter, even though this is a time of year with increased survey effort. In JAX/CHASN, most sightings during winter are recorded in shelf waters on the Northern Right Whale calving grounds due to increased survey effort in this area. Note that survey effort does not cover all the deep waters of the Southeast OPAREAs. Based on sighting data and known habitat preferences, occurrence is most likely in waters seaward of the shelf break throughout the Southeast OPAREAs.

Atlantic Ocean, Offshore of the Northeastern United States

Spotted dolphins are found primarily south of Georges Basin, most of which are found in the summer, while scattered occurrences are found in the spring and fall. No occurrences of spotted dolphins are expected in the NE OPAREAs during the winter.

Spotted dolphins are not expected to occur in the NE OPAREAs during winter.

In the springtime, spotted dolphins primarily occur in the southwest region of the NE OPAREAs, in waters over the continental slope and rise, with two occurrence records indicating that they may occur further north near the southern region of the Gulf of Maine.

In the summer, spotted dolphins occur primarily in those deeper waters over the southern region of the NE OPAREAs, including over the New England Sea Mount Chain, with few occurrences found on the continental self, from the northern flank of Georges Bank to the southern map extent. During this season, spotted dolphins may occur in greater concentrations in the waters over the northern flank of Georges Bank, outside any of the NE OPAREAs.

Lastly, in the fall, spotted dolphins primarily occur in deeper waters over the southern region of the study area, with the southern flank of Georges Bank representing the northern-most limit of the distribution.

Gulf of Mexico

Pantropical spotted dolphins are widely distributed in oceanic waters of the Gulf (Mullin and Fulling, 2004). Based on sighting survey data, this is the most commonly seen cetacean in deep waters of GOMEX.

In the winter, the pantropical spotted dolphin occurs in waters beyond the shelf break. Areas of increased occurrence are over a few areas of the Florida Escarpment, including the area the Tortugas Gyre influences, and over the slope off the Texas-Louisiana border.

Spring is the season with the most survey effort and a large number of sightings throughout the entire area of survey coverage. The pantropical spotted dolphin is predicted to occur in oceanic waters throughout the vast majority of the northern Gulf. There is an area of increased occurrence in waters over the abyssal plain south of the Mississippi Canyon region. There may be areas of greater occurrence also in the DeSoto Canyon region and over the Florida Escarpment.

In summer, occurrence is predicted in oceanic waters throughout the vast majority of the northern Gulf. There may be areas of increased occurrence west of the Mississippi Canyon region and in two areas over the Florida Escarpment.

Fall is the season with the least amount of recorded sightings, likely due to decreased survey effort during this season and inclement weather conditions that can make sighting cetaceans difficult during this time of year. Patchy occurrence is predicted seaward of the shelf break in waters over the continental slope. No seasonal shifts in occurrence for this species are known for this area.

4.2.8 Atlantic Spotted Dolphins (*Stenella frontalis*)

Description – The Atlantic spotted dolphin tends to resemble bottlenose dolphins more than it does the pantropical spotted dolphin (Jefferson et al., 1993). In body shape, it is somewhat intermediate between the two, with a moderately long but rather thick beak. The dorsal fin is tall and falcate and there is generally a prominent spinal blaze. Adults are up to 2.3 m (7.5 ft) long and can weigh as much as 143 kg (315 lb) (Jefferson et al., 1993). Atlantic spotted dolphins are born spotless and develop spots as they age (Perrin et al., 1994c; Dudzinski, 1996; Herzing, 1997). Some Atlantic spotted dolphin individuals become so heavily spotted that the dark cape and spinal blaze are difficult to see (Perrin et al., 1994c; Dudzinski, 1996; 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 (135 to 189 NM) of the coast and a smaller, less-spotted form that inhabits offshore waters (Perrin et al., 1994c). The largest body size occurs in waters over the continental shelf of North America (East Coast and Gulf of Mexico) and Central America (Perrin, 2002a). The smallest Atlantic spotted dolphins are those around oceanic islands, such as the Azores and on the high seas in the western North Atlantic (Perrin, 2002a).

***Status* –** The best estimate of Atlantic spotted dolphin abundance in the western North Atlantic is 50,978 individuals (Waring et al., 2007). 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 best estimate of abundance for the Atlantic spotted dolphin in the northern GOMEX is 30,947 individuals (Fulling et al., 2003; Mullin and Fulling, 2004; Waring et al., 2006). The northern GOMEX population was recently confirmed to be genetically differentiated from the western North Atlantic populations (Adams and Rosel, 2006).

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 percent 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).

***Distribution* –** Atlantic spotted dolphins are distributed in warm-temperate and tropical Atlantic waters from approximately 45º N to 35º 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). Atlantic spotted dolphins may occur in both continental shelf and offshore waters (Perrin et al., 1994c). Known densities of Atlantic spotted dolphins are highest in the eastern GOMEX, east of Mobile Bay (Fulling et al., 2003). Atlantic spotted dolphins in the northern GOMEX are abundant in continental shelf waters (Fulling et al., 2003; Waring et al., 2006). In oceanic waters, this species usually occurs near the shelf break and upper continental slope waters (Davis et al., 1998; Mullin and Hansen, 1999).

Atlantic Ocean, Offshore of the Southeastern United States

The Atlantic spotted dolphin is found in tropical and warm-temperate waters of the Atlantic Ocean and the northern limit of its range is Cape Cod. The pantropical spotted dolphin is broadly sympatric (occupying the same geographical location without interbreeding) with the Atlantic spotted dolphin in the Atlantic Ocean. There are confirmed sightings of both Atlantic and pantropical spotted dolphins in the VACAPES OPAREA during winter, spring, and summer. They generally occur in waters with a bottom depth ranging from 10 to 20 m (33 to 66 ft), with an eastward extension to the 3,000-m (9,840-ft) isobath. Spotted dolphins are expected to occur in the vicinity of VACAPES OPAREA.

There are confirmed sightings and strandings of Atlantic spotted dolphins during all seasons in and near the CHPT OPAREA. There is only one confirmed record for a pantropical spotted dolphin during any of the seasons, but it is reasonable to assume that this species would occur in the CHPT OPAREA, given the large number of spotted dolphin sightings where species identity was not provided. Spotted dolphins are likely to occur in waters from the coastline to seaward of the eastern boundary of the CHPT OPAREA throughout the year.

Spotted dolphins are likely to occur from the coastline to seaward of the eastern boundary of the JAX/CHASN OPAREA throughout the year. The pantropical spotted dolphin is a deep-water species, and the Atlantic spotted dolphin may occur in both shelf and offshore waters. Sightings of spotted dolphins in coastal waters are most likely of the Atlantic spotted dolphin.

Atlantic Ocean, Offshore of the Northeastern United States

Spotted dolphins are found primarily south of Georges Basin, most of which are found in the summer, while scattered occurrences are found in the spring and fall. No occurrences of spotted dolphins are expected in the NE OPAREAs during the winter.

Spotted dolphins are not expected to occur in the NE OPAREAs during winter.

In the springtime, spotted dolphins primarily occur in the southwest region of the NE OPAREAs, in waters over the continental slope and rise, with two occurrence records indicating that they may occur further north near the southern region of the Gulf of Maine.

In the summer, spotted dolphins occur primarily in those deeper waters over the southern region of the NE OPAREAs, including over the New England Sea Mount Chain, with few occurrences found on the continental self, from the northern flank of Georges Bank to the southern map extent. During this season, spotted dolphins may occur in greater concentrations in the waters over the northern flank of Georges Bank, outside any of the NE OPAREAs.

Lastly, in the fall, spotted dolphins primarily occur in deeper waters over the southern region of the study area, with the southern flank of Georges Bank representing the northern most limit of the distribution.

Gulf of Mexico

Atlantic spotted dolphins in the northern GOMEX are abundant in continental shelf waters (Fulling et al., 2003; Waring et al., 2006). In oceanic waters, this species usually occurs near the shelf break and upper continental slope waters (Davis et al., 1998; Mullin and Hansen, 1999). Atlantic spotted dolphins are most abundant in the eastern GOMEX (Fulling et al., 2003). On the West Florida shelf, spotted dolphins are more common in deeper waters than bottlenose dolphins (Griffin and Griffin, 2003); Griffin and Griffin (2004) reported higher densities of spotted dolphins in this area during November through May.

In winter, there may be occurrence in waters over the continental shelf and along the shelf break throughout the entire northern GOMEX. Stranding data suggest that this species may be more common than the survey data demonstrate.

Occurrence during spring is primarily in the vicinity of the shelf break from central Texas to southwestern Florida. Sighting data reflect high usage of the Florida Shelf by this species.

In summer, occurrence is primarily in waters over the continental shelf, along the shelf break throughout the entire northern GOMEX, and over the Florida Escarpment. Sighting data shows increased usage of the Florida Shelf, as well as the Florida Panhandle and inshore of DeSoto Canyon. An additional area of increased occurrence is predicted in shelf waters off western Louisiana.

In fall, the sighting data demonstrate occurrence in waters over the continental shelf and along the shelf break throughout the entire northern GOMEX. There are numerous sightings in the Mississippi River delta region and Florida Panhandle. This is the season with the least amount of systematic survey effort, and inclement weather conditions can make sighting cetaceans difficult during this time of year.

4.2.9 Spinner Dolphin (*Stenella longirostris*)

***Description* –** The spinner dolphin has a very long, slender beak (Jefferson et al., 1993). The dorsal fin ranges from slightly falcate to triangular or even canted forward in some geographic forms. 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 (7.9 ft) in length (Jefferson et al., 1993). There are four known subspecies of spinner dolphins and probably other undescribed ones (Perrin, 1998; Perrin et al., 1999).

***Status* –** No estimate of abundances are currently available for the western North Atlantic stock of spinner dolphins (Waring et al., 2007). Stock structure in the western North Atlantic is unknown (Waring et al., 2007). The best estimate of abundance for spinner dolphins in the northern GOMEX is 11,971 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

Diving Behavior – Spinner dolphins feed primarily on small mesopelagic fishes, squids, and sergestid shrimps, 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).

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 poorly known (Waring et al., 2007). Spinner dolphins occur year-round in the deep waters of the GOMEX.

Atlantic Ocean, Offshore of the Southeastern United States

The primary distribution of spinner dolphins is offshore, and spinner dolphin sightings off the northeastern U.S. coast have occurred exclusively in deeper waters. In the VACAPES OPAREA, this species is thought to occur from the continental shelf edge and to extend eastward of the VACAPES OPAREA boundary, with the Gulf Stream’s warm water creating a northern boundary. Winter is the only season with sighting data for this species in the VACAPES OPAREA.

In the CHPT OPAREA, stranding records exist for North Carolina and represent the northernmost distribution records for this species in the western North Atlantic. There are numerous records for the spinner dolphin in deep waters off of North Carolina. Spinner dolphins are oceanic and are expected to occupy waters from the continental shelf edge (the 200-m [656-ft] isobath) to deep offshore waters. This species may occur in any season.

There are a few confirmed records for this species in the JAX/CHASN OPAREA and this species may occur in the waters seaward of the shelf break in any season.

Atlantic Ocean, Offshore of the Northeastern United States

Spinner dolphins may occur primarily in those deep waters over the southern region of the NE OPAREAs, with northern limits extending to 40ºN. There is one record of a spinner dolphin inside the Narragansett Bay OPAREA, which was during the summer.

Gulf of Mexico

Spinner dolphins occur year-round in the deep waters of the GOMEX. Mullin and Fulling (2004) noted that the vast majority of spinner dolphin sightings made by NMFS-SEFSC were over the continental slope in the northeastern GOMEX. During the Fritts aerial surveys of the 1980s sightings were recorded in waters off southern Florida with a bottom depth of less than 200 m (656 ft) (Fritts et al., 1983). Based on the known habitat preferences of the spinner dolphin in the Gulf of Mexico, it is now thought that these animals were misidentified (Jefferson and Schiro, 1997; Würsig et al., 2000). It is probable that these dolphins were actually Atlantic spotted dolphins, based on known habitat preferences and distribution of this species.

In winter, spinner dolphins occur seaward of the shelf break including waters over the continental slope, primarily east of the Mississippi River, although also in the Mississippi Canyon region. The area of greatest occurrence is suggested to be southeast of DeSoto Canyon. It should be noted that this is a time of year when Beaufort sea states are highest, making detection much more difficult (Mullin et al., 2004).

During the spring, as in winter, spinner dolphins occur seaward of the shelf break including waters over the continental slope, primarily east of the Mississippi River, although also in the Mississippi Canyon region. The areas of greatest occurrence are likely to be in the DeSoto Canyon region, in waters over the Florida Escarpment, and in the area influenced by the Tortugas Gyre. It would be realistic to expect that this species is not relegated to central and eastern GOMEX and likely occurs throughout deep waters of the GOMEX, with the greatest likelihood of encountering this species being east of the Mississippi River.

In the summer, spinner dolphins may occur in the deeper waters of the north-central Gulf from the Mississippi Canyon to the Florida Panhandle. Increased occurrences of spinner dolphins may be found in the deeper waters just south of the Alabama slope.

In the fall, the presence of spinner dolphins in the GOMEX is recognized only based on sparse sighting and stranding data. The available sighting data places the species in the region of the Mississippi Canyon and DeSoto Canyon. Spring is the season that is most likely representative of what to expect for this species' occurrence, particularly since no seasonality for the species is known.

4.2.10 Clymene Dolphin (*Stenella clymene*)

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 dorsal fin is tall and only slightly falcate. A three-part color pattern consisting of a dark gray cape, light gray sides, and white belly is characteristic of this species (Jefferson and Curry, 2003). The cape dips in two places, first above the eye and then below the dorsal fin. The lips and beak tip are black. There is also a dark stripe on the top of the beak, as well as a dark variably shaped "moustache" on the middle of the top of the beak. The Clymene dolphin can reach at least 2 m (7 ft) in length and weights of at least 85 kg (187 lb) (Jefferson et al., 1993).

***Status* –** Clymene dolphins have only been recognized as a valid species since 1981 (Perrin et al., 1981). 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., 2007). The best estimate of abundance for the western North Atlantic stock of Clymene dolphins is 6,086 individuals (Waring et al., 2007). The best estimate of abundance for Clymene dolphins in the northern GOMEX is 17,355 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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).

***Distribution* –** Clymene dolphins are known only from the subtropical and tropical Atlantic Ocean (Perrin and Mead, 1994; Fertl et al., 2003). In the western Atlantic Ocean, Clymene dolphins are known from New Jersey to Brazil, including the Gulf of Mexico and Caribbean Sea (Fertl et al., 2003; Moreno et al., 2005). Although it is not clear if the actual density is higher, there are more Clymene dolphin records from the GOMEX than from the rest of this species' range combined (Jefferson et al., 1995; Fertl et al., 2003).

Atlantic Ocean, Offshore of the Southeastern United States

Sightings of Clymene dolphins have been recorded along the eastern United States as far north as New Jersey. In the VACAPES OPAREA, this dolphin most likely occurs during fall, winter, and spring from the continental shelf edge to the 4,000-m (13,120-ft) isobath, with the Gulf Stream's warm water creating a northern boundary. During the summer, this area extends further south, to beyond the eastern boundary of the OPAREA to encompass those warm waters. Summer is the only season with sighting data for the VACAPES OPAREA.

Summer is the only season with confirmed sightings of Clymene dolphins in the CHPT OPAREA, all of which were made during NMFS surveys. Based on these sightings, and on the preference of this species for warm waters, the Clymene dolphin is most likely to occur from the 100-m (328-ft) isobath to seaward of the eastern boundary of the CHPT OPAREA during the summer.

As a tropical species, the Clymene dolphin is likely to occur in the JAX/CHASN OPAREA primarily during the summer. Clymene dolphins have been found stranded along the coast of Florida adjacent to the JAX/CHASN OPAREA and further south throughout the year.

Atlantic Ocean, Offshore of the Northeastern United States

There is only one sighting and one stranding of the Clymene dolphin as far north as New Jersey. Based on the preference of this species for warmer waters, this species is expected to have an extralimital occurrence in the NE OPAREAs during all times of the year.

Gulf of Mexico

The Clymene dolphin is a deep water species. Mullin and Hansen (1999) noted that the majority of sightings for this species in the Gulf are west of the Mississippi River. Two mass strandings of Clymene dolphins were reported in the Florida Keys: one in July 1983 and the other in December 1992 (Jefferson et al., 1995). Both mass strandings took place over the course of a few days; therefore, they appear as multiple stranding records for the two events since carcasses were collected over the course of a few days.

There are few records during the winter; this is likely more an artifact of sparse survey effort and typically poor sighting conditions (e.g., rough seas) during this time of the year, since there are no known seasonal shifts in occurrence for this species in the Gulf.

Spring is the time of the year with the most survey effort and occurrence is expected seaward of the shelf break in most of the area of the western and central Gulf, with extension into the Mississippi River Delta region and the DeSoto Canyon.
During summer, Clymene dolphins may occur in deeper waters south of the continental slope, extending from the western Louisiana to the Florida Panhandle. Fewer occurrence records are available for the summer than spring.

In the fall, there is one sighting in very deep waters and a handful of strandings that are primarily in the Florida Keys which reflect the species' occurrence in the Gulf during this time of the year. No seasonality in occurrence is known for this species; anticipated occurrence is waters seaward of the shelf break.

4.2.11 Striped Dolphin (*Stenella coeruleoalba*)

Description – The striped dolphin is uniquely marked with black lateral stripes from eye to flipper and eye to anus. There is also a white V-shaped "spinal blaze" originating above and behind the eye and narrowing to a point below and behind the dorsal fin (Leatherwood and Reeves, 1983). There is a dark cape and white belly. This is a relatively robust dolphin with a long, slender beak and prominent dorsal fin. This species reaches 2.6 m (8.5 ft) in length.

Status – The best estimate of striped dolphin abundance in the western North Atlantic is 94,462 individuals (Waring et al., 2007). The best estimate of abundance for striped dolphins in the northern GOMEX is 6,505 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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 possess 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).

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 (Würsig et al., 2000). 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). Along the Southeastern United States, striped dolphins are generally distributed north of Cape Hatteras (CETAP, 1982). As noted by Mullin and Hansen (1999), this species is generally distributed in deep waters throughout the entire northern GOMEX.

Atlantic Ocean, Offshore of the Southeastern United States

Striped dolphins are usually found outside the continental shelf, typically over the continental slope out to oceanic waters and often in waters associated with convergence zones and waters influenced by upwelling. In the VACAPES OPAREA, they are likely to occur at the shelf break and over the continental slope. Sightings predominantly occur along the north wall of the Gulf Stream, but not within this current where it travels through the southern portion of the VACAPES OPAREA.

Aside from strandings, there is only one record of the striped dolphin near the CHPT OPAREA—a sighting that is near the northern perimeter of the OPAREA. In contrast to the other dolphins in the stenellid dolphin group, the striped dolphin prefers more temperate waters. Striped dolphin may occur throughout the year from the 100-m (328-ft) isobath to seaward of the eastern boundary of the CHPT OPAREA. The striped dolphin is not likely occur in the deeper waters of this OPAREA.

The striped dolphin may occur but are not likely in the JAX/CHASN OPAREA throughout the year from the vicinity of the continental shelf break to seaward of the eastern boundary of the JAX/CHASN OPAREA. Based on their preference, in contrast to other dolphins, for more temperate waters, striped dolphins are more likely to occur well north of the JAX/CHASN OPAREA.

Atlantic Ocean, Offshore of the Northeastern United States

Striped dolphins may occur in the waters over the continental slope and deeper waters of the abyssal plain, from the Scotian Shelf to the southern map extent. The distribution of occurrences is consistent with known occurrences (CETAP, 1982). In general, striped dolphins occur south of Georges Bank during winter, spring, and fall, with summer having the greatest number of occurrence records.

During the wintertime, striped dolphins occur primarily over the continental slope, extending out to the southern boundary of the Study Area, in waters from the southern flank of Georges Bank south towards the VACAPES OPAREA. Stranding records suggest that striped dolphins may occur as far north as the central coast of Maine.

In the springtime, striped dolphins generally occur in the waters over the continental slope and those deeper waters over the southern region of the NE OPAREAs, extending from the southern flank of Georges Bank and south towards the VACAPES OPAREA. Based on the relative frequency of sightings of unidentified Stenellids and the known distribution of the Stenellid species, it is likely that many of the animals that could not be identified in the available data are actually striped dolphins.

In the summertime, the general occurrence of striped dolphins extends from waters over the continental slope to those deeper waters over the southern region of the NE OPAREAs, from the Scotian Shelf to off the coast of Virginia. During this season, greater occurrences of striped dolphins may be found southeast of Browns Bank, over the New England Sea Mount Chain, the eastern and southern edged of Narragansett Bay OPAREA, and south of the Atlantic City OPAREA.

In the fall, striped dolphins may occur over the continental slope and rise waters, from the southern flank of Georges Bank to the northern coast of Virginia.

Gulf of Mexico

The striped dolphin is an oceanic species likely to occur seaward of the shelf break. As noted by Mullin and Hansen (1999), this species is generally distributed in deep waters throughout the entire northern GOMEX. During the Fritts aerial surveys of the early 1980s, striped dolphins were often recorded in shallow waters around southern Florida (Fritts et al., 1983). As noted earlier, striped dolphins have an apparent preference for deep waters. It is likely these sightings in waters over the continental shelf were misidentifications of Atlantic spotted dolphins (younger animals are not spotted and have a prominent spinal blaze like striped dolphins) (Jefferson and Schiro, 1997; Würsig et al., 2000).

In winter, striped dolphins are predicted to occur in waters over the continental slope, primarily in the central and eastern Gulf. Areas of greatest concentration are predicted for the Mississippi Canyon and DeSoto Canyon regions. This is a time of year with reduced survey effort, and it is more likely that occurrence is throughout the northern GOMEX seaward of the shelf break.

During spring, occurrence for the striped dolphins is predicted throughout the northern Gulf in waters over the continental slope and abyssal plain. The greatest concentration is in the DeSoto Canyon region, with an additional area over the abyssal plain. This is the season with the most survey effort and the largest (and most widespread) number of striped dolphin sightings.

In summer, occurrence is likely throughout the northern GOMEX near the shelf break and over the continental slope.

Fall is the season with the least amount of recorded sightings, likely due to decreased survey effort during this season and inclement weather conditions that can make sighting cetaceans difficult during this time of year. It is likely that the occurrence for the striped dolphin matches that in spring, and is predicted throughout the northern Gulf in waters over the continental slope and abyssal plain

4.2.12 Common Dolphin (*Delphinus* spp.)

Description – Two species of *Delphinus spp.* are present in the North Atlantic: the long-beaked common dolphin (*Delphinus capensis*) and the short-beaked common dolphin (*Delphinus delphis*) (Heyning and Perrin, 1994; Rosel et al., 1994). Only the short-beaked common dolphin is expected to occur in the U.S. western North Atlantic.

Short-beaked common dolphins are moderately robust dolphins, with a moderate-length beak, and a tall, slightly falcate dorsal fin. The beak is shorter than in long-beaked common dolphins, and the melon rises from the beak at a steeper angle (Heyning and Perrin, 1994). Short-beaked common dolphins are distinctively marked with a V-shaped saddle caused by a dip in the cape below the dorsal fin, yielding an hourglass pattern on the side of the body (Jefferson et al., 1993). The back is dark brownish-gray, the belly is white, and the anterior flank patch is tan to cream in color. The lips are dark, and there is a dark stripe from the eye to the apex of the melon and another one from the chin to the flipper (the latter is diagnostic to the genus). There are often variable light patches on the flippers and dorsal fin. Length ranges up to about 2.3 m (7.5 ft) (females) and 2.6 m (8.5 ft) (males); however, there is substantial geographic variation (Jefferson et al., 1993).

Status – The best estimate of abundance for the Western North Atlantic *Delphinus* spp. stock is 120,743 individuals (Waring et al., 2007). There is no information available for western North Atlantic common dolphin stock structure (Waring et al., 2007).

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 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).

Distribution – *Delphinus* is widely distributed globally in temperate, subtropical, and tropical seas. 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).

Atlantic Ocean, Offshore of the Southeastern United States

The common dolphin occurs year-round in the VACAPES OPAREA. Winter and spring are the seasons with the most sightings and strandings. Common dolphins may occur during summer through winter from shoreward of the 50-m (164-ft) isobath to outside of the 3,000-m (9,840-ft) isobath. During summer, common dolphins are found in an area of the northeastern section of the VACAPES OPAREA. The common dolphin is likely to occur in the vicinity of the VACAPES OPAREA.

The common dolphin is uncommon off North Carolina, highly pelagic, and seldom encountered in shelf waters. It is widespread north of Cape Hatteras, but less common to the south, although it has been recorded as far south as Florida. The occurrence of common dolphins south of Cape Hatteras is questionable. Old confirmed records (pre-1970s) exist for common dolphins in this area, but no confirmed newer ones. Common dolphins are only likely to occur in the northernmost portion of the CHPT OPAREA to just south of Cape Hatteras, bounded on the east by the warmer waters of the Gulf Stream. Sixty-eight percent of common dolphins captured in foreign fishing activities were caught along the shelf edge north of the CHPT OPAREA.

In the past, the common dolphin was frequently found off the northeast coast of Florida but has been conspicuously absent since about 1960. The reasons for the apparent shift of range are not known. Based on the water temperature preferences of this species, they are not likely to occur during the winter, spring, and fall, and they are not expected to occur in the JAX/CHASN OPAREA during the summer.

Atlantic Ocean, Offshore of the Northeastern United States

Common dolphins occur year round throughout the NE OPAREAs in continental shelf and slope waters. Along the U.S. northeastern coast, common dolphins are concentrated between the 100- and 200-m (328- and 656-ft) isobaths. The overall distribution of occurrences found is consistent with reported sightings (Selzer and Payne, 1988; Evans, 1994). The general distribution of common dolphins shifts to the warmer waters in southern region of the NE OPAREAs during winter.

In the wintertime, common dolphins occur primarily over the continental shelf and slope, in waters from off Cape Cod and Georges Bank south towards the VACAPES OPAREA. Common dolphins may also occur in the deeper waters just south of the NE OPAREAs. During this season, common dolphins may occur near the shelf break in the Atlantic City OPAREA, with the greatest occurrences found outside of the NE OPAREAs off Virginia.

In the springtime, the general occurrence of common dolphins extends from waters over the continental shelf to those deeper waters over the continental rise, from Crowell Basin to the southern map extent. A few additional records (sightings) show common dolphins may also occur in the northern part of the Gulf of Maine. During this season, greater concentrations of common dolphins may occur in the vicinity of the shelf break along the southern flank of Georges Bank and in the Atlantic City OPAREA with the highest concentrations of common dolphins occurring just out of the NE OPAREAs in deeper water off the Virginia shelf break. Based upon their habitat preferences, it is not surprising that these animals are commonly found along the region’s major escarpments and seamounts (Evans, 1994).

In the summertime, common dolphins generally occur in continental shelf and slope waters from the Bay of Fundy and Scotian Shelf (through much of the Boston OPAREA) to northern Virginia as well as an area directly south of the Great South Channel in deeper water. The highest concentrations of common dolphins are found from the southern flank of Georges Bank into the deeper waters over the continental rise.

In the fall, common dolphins are generally found in the waters of the continental shelf seaward from the northern coast of Maine to the southern coast of Virginia, when this species is particularly abundant along the northern edge of Georges Bank. During this season, common dolphins may be found in greater concentrations in the vicinity of the continental shelf edge extending from Georges Bank to the center of the Narragansett OPAREA.

Gulf of Mexico

The common dolphin is not expected to occur within the Gulf of Mexico. All reports of *Delphinus* spp. from the Gulf of Mexico were actually misidentified Clymene and spinner dolphins.

4.2.13 Fraser’s Dolphin (*Lagenodelphis hosei*)

Description – The Fraser's dolphin reaches a maximum length of 2.7 m (8.5 ft) and is generally more robust than other small delphinids (Jefferson et al., 1993). This species has a short stubby beak, small flippers and flukes, and a small subtriangular dorsal fin. The most conspicuous feature of the Fraser's dolphin coloration is the dark band running from the face to the anus (Jefferson et al., 1997), although it is not present in younger animals and appears to be geographically variable (Jefferson, 2002a). The stripe is set off from the surrounding areas by thin, pale, cream-colored borders. There is also a dark chin-to-flipper stripe.

***Status* –** No abundance estimate of Fraser's dolphins in the western North Atlantic is available (Waring et al., 2007). The best estimate of abundance for Fraser's dolphins in the northern GOMEX is 726 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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 sec) (Leatherwood et al., 1993). There are no empirical hearing data hearing data available for this species.

***Distribution* –** Fraser's dolphins are found in subtropical and tropical waters around the world, typically between 30º N and 30º S (Jefferson et al., 1993). Strandings in temperate areas are considered extralimital and usually are associated with anomalously warm water temperatures (Perrin et al., 1994b). Few records are available from the Atlantic Ocean (Leatherwood et al., 1993; Watkins et al., 1994; Bolaños and Villarroel-Marin, 2003). The first record for the GOMEX was a mass stranding in the Florida Keys in 1981 (Hersh and Odell, 1986). Since then, there have been documented strandings on the west coast of Florida and in southern Texas (Clark et al., 2002).

Atlantic Ocean, Offshore of the Southeastern United States

Fraser's dolphin is considered a deep-water species. There is one record for Fraser's dolphin in the VACAPES OPAREA—a sighting made during a summer shipboard survey, a group of Fraser's dolphins and melon-headed whales was sighted in waters east of Cape Hatteras, North Carolina, with a bottom depth of 3,000 m (9,843 ft). Due to the low number of sightings and the warm-water preference of this species, Fraser's dolphins are not likely in the VACAPES OPAREA. Based on this one sighting north of the CHPT OPAREA (in the VACAPES OPAREA) in waters seaward of the 2,000-m (6,560-ft) isobath and on the warm-water preference of this species, Fraser's dolphins are also not likely to occur in the CHPT OPAREA. There have been no confirmed sightings of Fraser's dolphin in the JAX/CHASN OPAREA. Fraser's dolphins may occur but are not likely to occur from the vicinity of the continental shelf break to waters seaward of the eastern boundary of the JAX/CHASN OPAREA throughout the year.

Atlantic Ocean, Offshore of the Northeastern United States

Fraser's dolphin is a deep-water species that prefers warm waters. The Fraser's dolphin is not expected to occur within the western North Atlantic Ocean offshore of the northeastern United States.

Gulf of Mexico

As noted by Mullin and Fulling (2004), this is a rare species that is thought to be present in the northern GOMEX, even during years with survey effort when they are not sighted. The Fraser's dolphin is an oceanic species; it is expected to occur off the shelf break. This determination was based on the distribution of sightings in the GOMEX and the known habitat preferences of this species. Fraser's dolphins are sighted over the abyssal plain in the southern GOMEX (Leatherwood et al., 1993).

4.2.14 Risso's Dolphin (*Grampus griseus*)

***Description* –** Risso's dolphins are moderately large, robust animals reaching at least 3.8 m (12.5 ft) in length (Jefferson et al., 1993). The head is blunt and squarish without a distinct beak, and there is a vertical crease on the front of the melon. The dorsal fin is very tall and falcate. Young Risso's dolphins range from light gray to dark brownish gray and are relatively unmarked (Jefferson et al., 1993). Adults range from dark gray to nearly white and are heavily covered with white scratches and splotches.

***Status* –** The best estimate of Risso's dolphin abundance in the western North Atlantic is 20,479 individuals (Waring et al., 2007). The best estimate of abundance for Risso's dolphins in the northern GOMEX is 2,169 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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 seconds) 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., 2004b).

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.

***Distribution* –** Risso's dolphins are distributed worldwide in cool-temperate to tropical waters from roughly 60º N to 60º S, where SSTs are generally greater than 10º C (Kruse et al., 1999). In the western North Atlantic, this species is found from Newfoundland southward to the Gulf of Mexico, throughout the Caribbean, and around the equator (Würsig et al., 2000). In general, U.S. Atlantic Risso's dolphins occupy the mid-Atlantic continental shelf year-round, although they are rarely observed in the Gulf of Maine (Payne et al., 1984). In the GOMEX, Risso's dolphins occur year-round in the waters from the outer continental shelf seaward

Atlantic Ocean, Offshore of the Southeastern United States

During the fall and winter, the Risso's dolphin is likely to occur from the 100-m (328-ft) isobath eastward of the boundary of the VACAPES OPAREA. In the spring and summer Risso's dolphins may occur from the 50-m (164-ft) isobath eastward of the boundary of the OPAREA. During all four seasons, there have been Risso's dolphin sightings and by-catch records that are associated with the Gulf Stream. .

The Risso's dolphin is likely to occur from the 50-m (164-ft) isobath to eastward of the boundary of the CHPT OPAREA throughout the year, and year-round from the 50-m (164-ft) isobath to seaward of the eastern boundary of the JAX/CHASN OPAREA. On the basis of the sporadic sightings in shallower waters well north of the JAX/CHASN OPAREA, Risso's dolphins are less likely to occur between the 30- and 50-m (98- and 164-ft) isobath throughout the year.

Atlantic Ocean, Offshore of the Northeastern United States

Risso's dolphins occur year-round in waters extending from the continental shelf to the continental rise, from the Scotian Shelf to the southern map extent. The overall distribution of Risso's dolphins in the NE OPAREAs seems to shift south during winter. The distribution of occurrences is consistent with known occurrences and seasonal distributions (CETAP, 1982; Payne et al., 1984).

In the wintertime, Risso's dolphins may occur over the continental shelf and slope, in waters extending from Jeffreys Bank south towards the VACAPES OPAREA.

In the springtime, the general occurrence of Risso's dolphins may be found over the continental shelf and slope waters, extending from the southern coast of Maine.

In the summertime, Risso's dolphins primarily occur in the vicinity of the continental slope and rise, in waters extending from Roseway Basin south towards the VACAPES OPAREA.

In the fall, Risso's dolphins generally occur over the continental shelf and slope waters, extending from Jeffreys Bank to the southern map extent. Greater occurrences of Risso's dolphins may be found near the northeast edge of the Atlantic City OPAREA and in the vicinity of the continental slope, off the coast of Virginia.

Gulf of Mexico

In general, Risso's dolphins occur year-round in the waters from the outer continental shelf seaward throughout the study area.

In the winter, Risso's dolphins are predicted to occur along the shelf break and over the continental slope. Interestingly, Mullin and Fulling (2004) found evidence of a three-fold increase in abundance in winter in the northeastern GOMEX compared to summer.

Spring is the season with the most survey effort and the largest (and most widespread) number of Risso's dolphin sightings. Risso's dolphins are predicted not only along the shelf break and continental slope but also over deeper waters of the abyssal plain. Three areas of concentration are off the DeSoto Canyon Region, off the Florida Escarpment, and in the region influenced by the Tortugas Gyre. These are all in areas of increased primary productivity, which would attract cephalopods, thereby attracting Risso's dolphins.

In the summer, Risso's dolphins may occur along the shelf break, over the continental slope, and over the abyssal plain. There may be a concentrated occurrence for Risso's dolphins in the region influenced by the Tortugas Gyre, which would be an area of increased biological productivity.

Fall is the season with the least amount of recorded sightings, likely due to decreased survey effort and inclement weather conditions that can make sighting cetaceans difficult during this time of year.

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

Description – The Atlantic white-sided dolphin has a stocky body with a short thick beak and tall falcate dorsal fin. Individuals have a complex color pattern (Jefferson et al., 1993). They are black on the back, top of the beak, flippers, and flukes. The sides are gray. There is a white band below the dorsal that connects with a yellow band on the tail stock. Adults are 2.5 to 2.8 m (8.2 to 9.2 ft) in length.

Status – Three stock units have been suggested for the Atlantic white-sided dolphin in the western North Atlantic: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea (Palka et al., 1997; Waring et al., 2004). However, recent mitochondrial DNA analysis indicates that no definite stock structure exists (Amaral et al., 2001). The total number of white-sided dolphins along the United States and Canadian Atlantic coast is unknown. The Gulf of Maine stock occurs in the study area. The best estimate of abundance for the Gulf of Maine stock of white-sided dolphins is 51,640 individuals (Waring et al., 2004).

Diving Behavior – There is no diving information available for this species. However, it is known that Atlantic white-sided dolphins feed on pelagic and benthopelagic fishes, such as capelin, herring, hake, sand lance, smelt, and cod and cephalopods, such as squids (Katona et al., 1978; Sergeant et al., 1980; Kenney et al., 1985; Selzer and Payne, 1988; Waring et al., 1990; Overholtz and Waring, 1991; Weinrich et al., 2001).

Acoustics and Hearing – The only information available on Atlantic white-sided vocalizations is that the dominant frequency is 6 to 15 kHz (Thomson and Richardson, 1995). There are no hearing data available for this species.

Distribution – Atlantic white-sided dolphins are found in cold temperate to subpolar waters of the North Atlantic, from New England in the west and France in the east, north to southern Greenland, Iceland, and southern Norway (Jefferson et al., 1993). This species is most common over the continental shelf from Hudson Canyon north to the Gulf of Maine (Palka et al., 1997). Virginia and North Carolina appear to represent the southern edge of the range (Testaverde and Mead, 1980). Sighting data indicate seasonal shifts in distribution, perhaps a reflection of an inshore/offshore movement (CETAP, 1982; Payne et al., 1990b; Northridge et al., 1997). The spatial distribution of Atlantic white-sided dolphin sightings closely parallels sand lance distribution and abundance patterns (Selzer and Payne, 1988; Kenney et al., 1996).

During January to April, low numbers of white-sided dolphins may be found from Georges Bank to Jeffreys Ledge. Even lower numbers are found south of Georges Bank (also when a few strandings have been collected on Virginia and North Carolina beaches) (Payne et al., 1990b; Palka et al., 1997; Waring et al., 2004). From June through September, large numbers of white-sided dolphins are found from Georges Bank to the lower Bay of Fundy (Payne et al., 1990b; Waring et al., 2004). During this time, strandings occur from New Brunswick, Canada to New York (Palka et al., 1997). From October to December, white-sided dolphins occur at intermediate densities from southern Georges Bank to the southern Gulf of Maine. Sightings occur year-round south of Georges Bank, particularly around Hudson Canyon, but in low densities (CETAP, 1982; Payne et al., 1990b; Palka et al., 1997; Waring et al., 2004).

Atlantic white-sided dolphins have the ability to move through a wide-ranging area; a rehabilitated individual was tracked over 300 km (162 NM) in 64.3 hrs (Mate et al., 1994). Photo-identification work also indicates widespread movements (Weinrich et al., 2001).

Atlantic Ocean, Offshore of the Southeastern United States

This dolphin is known to occur only in the northern portion of the VACAPES OPAREA in all seasons, based on its preference for colder waters. Sightings are recorded mostly in the northern VACAPES OPAREA and vicinity. Strandings and bycatch records are also documented near the VACAPES OPAREA. Due to this species' preference for colder waters, the Gulf Stream may be a southern boundary for Atlantic white-sided dolphin distribution. This species is likely to occur primarily in waters over the continental shelf throughout the VACAPES OPAREA year-round. However, distribution may also range further offshore which is evidenced by the sighting records offshore in waters over the continental slope in and near the VACAPES OPAREA. Atlantic white-sided dolphins are not expected to occur in the CHPT or JAX/CHASN OPAREAs.

Atlantic Ocean, Offshore of the Northeastern United States

Atlantic white-sided dolphins occur year-round throughout most of the northern region of the NE OPAREAs in continental shelf and slope waters. Overall, spring, summer, and fall have higher occurrences of Atlantic white-sided dolphins than winter.

In the wintertime, Atlantic white-sided dolphins occur primarily in the continental shelf and slope waters, in the western and southern regions of the Gulf of Maine, with scattered occurrences extending to the southern region of the NE OPAREAs. These areas include Jeffreys Ledge and a small section of Georges Bank, both of which have been documented as areas of low dolphin abundance during winter months (Payne et al., 1990b; Palka et al., 1997; Waring et al., 2004).

In the springtime, Atlantic white-sided dolphins occur primarily over the continental shelf and slope, in waters extending from Jeffreys Bank and Roseway Basin to the southern region of the

NE OPAREAs. Atlantic white-sided dolphins may occur in greater concentrations in waters over the northern flank of Georges Bank, east of Cape Cod, and over Nantucket Shoals in the northern region of the Narragansett Bay OPAREA. During spring, the occurrence of Atlantic white-sided dolphins in the NE OPAREAs coincides with the distribution and period of peak abundance of sand lance.

In the summer, the general occurrence of Atlantic white-sided dolphins extends from waters over the continental shelf to those deeper waters over the continental rise, from the Bay of Fundy and the Scotian Shelf to the southern region of the NE OPAREAs. During this season, greater concentrations of Atlantic white-sided dolphins may be found in the waters over Jordan Basin, east of Cape Cod, and east of the Northeast Channel.

In the fall, Atlantic white-sided dolphins are general found in waters over the continental shelf and slope, from the Bay of Fundy and the Scotian Shelf to just east of New Jersey. During this season, Atlantic white-sided dolphins may occur in greater concentrations in waters over Jeffreys Bank and just east of Cape Cod. The distribution of white-sided dolphins is more dispersed throughout the Gulf of Maine in fall than in spring due to the reduced availability of sand lance in the area (Selzer and Payne, 1988).

Gulf of Mexico

The white-sided dolphin is not expected to occur within the Gulf of Mexico.

4.2.16 White-Beaked Dolphin (*Lagenorhynchus albirostris*)

Description – The white-beaked dolphin is an extremely robust dolphin, which reaches lengths of 3.2 m and a maximum weight of 354 kg (780 lb) (Jefferson et al., 1993; Reeves et al., 1999b). The beak is short and thick. The back and sides of this species are basically black or dark gray. The beak and most of the belly are white to light gray, and the beak is often mottled (Jefferson et al., 1993). There may be dark or light flecks in the area between the eye and the flipper.

Status –At least two white-beaked dolphin stocks are present in the North Atlantic: one in the eastern and one in the western (Waring et al., 2007). An abundance of 573 white-beaked dolphins was estimated during a 1980 aerial survey between Cape Hatteras, North Carolina and Nova Scotia (CETAP, 1982). However, this out-dated count was not corrected for dive time or g(0) and is, therefore, not thought to accurately represent current population size. There are no current estimates of abundance for the western North Atlantic stock (Waring et al., 2007).

Diving Behavior – There is no information available on depths to which the white-beaked dolphin may dive.

Acoustics and Hearing – White-beaked dolphins produce sounds such as clicks and squeals. The clicks are presumably used for echolocation (Rasmussen et al., 2002). Maximum source levels of clicks are 219 dB re 1 µPa-m peak-to-peak (Rasmussen et al., 2002). Squeals range from 6.5 to 15 kHz (noted in Lien et al., 2001). There is no information available on the hearing capability of this species.

Distribution – The white-beaked dolphin is found only in cold-temperate and subarctic North Atlantic waters and appears to be more common in eastern rather than western waters (Lien et al., 2001). The range of the white-beaked dolphin overlaps that of the Atlantic white-sided dolphin, but the white-beaked dolphin is regarded as the more northerly of the two species (Leatherwood and Reeves, 1983). In addition, studies in the eastern North Atlantic suggest that the white-beaked dolphin has a more coastal feeding habit in contrast to the Atlantic white-sided dolphin which mainly feeds offshore (Das et al., 2003).

In the western North Atlantic, white-beaked dolphins occur from eastern Greenland through the Davis Strait and south to Massachusetts (Lien et al., 2001). White-beaked dolphins are found near the northern limits of their range between spring and late fall; they appear to winter further south and some may remain there until late spring or early summer (Leatherwood and Reeves, 1983). The northward shift that occurs during the summer appears to follow the progression of spawning capelin (Lien et al., 2001).

Off the northeastern United States, white-beaked dolphins sightings are concentrated in the western Gulf of Maine and around Cape Cod (CETAP, 1982). Prior to the 1970s, these dolphins were found primarily over the continental shelf in the Gulf of Maine and over Georges Bank. However, since then, they have occurred primarily in waters over the continental slope and have been replaced by Atlantic white-sided dolphins (Sergeant et al., 1980; Katona et al., 1993). This shift may result from a sand lance increase and herring decline in continental shelf waters (Payne et al., 1986; Payne et al., 1990b; Kenney et al., 1996).

Atlantic Ocean, Offshore of the Southeastern United States

The white-beaked dolphin is found in the north Atlantic Ocean in cold-temperate and subarctic waters. The lone sighting record for the white-beaked dolphin in the VACAPES OPAREA occurred on the continental shelf edge during spring. Any occurrences of the white-beaked dolphin in the VACAPES OPAREA are considered to be extralimital. It is unlikely that this species would occur in the VACAPES OPAREA during any season.

Atlantic Ocean, Offshore of the Northeastern United States

In general, white-beaked dolphins occur primarily in waters over the continental shelf from the Bay of Fundy to the Hudson Canyon. Overall, winter, spring, and summer have more occurrences of white-beaked dolphins in the NE OPAREAs than the fall.

In the wintertime, white-beaked dolphins occur primarily over the continental shelf waters, from just west of Georges Basin to Hudson Canyon. During this season, the greatest concentration of white-beaked dolphins may occur just west of Georges Basin. In the springtime, white-beaked dolphins occur over the continental shelf waters, in the western and southern region of the Gulf of Maine, and Nantucket Shoals. During this season, a greater concentration of white-beaked dolphins may occur over Nantucket Shoals, in the northern region of Narragansett Bay OPAREA. In the summertime, the general occurrence of white-beaked dolphins extends from the Bay of Fundy and Browns Bank to northern New Jersey, with a few occurrence records found in the northern region of Narragansett Bay OPAREA, primarily in waters over the continental shelf. A northward shift in white-beaked dolphin occurrence was noted, making it likely that this species may occur further north of the NE OPAREAs during this time of year (Lien et al., 2001). In the fall, white-beaked dolphins may be found in Cape Cod Bay and in waters over the eastern tip of Georges Bank.

Gulf of Mexico

The white-beaked dolphin is not expected to occur within the Gulf of Mexico.

4.2.17 Melon-Headed Whale (*Peponocephala electra*)

Description **–** Melon-headed whales at sea closely resemble pygmy killer whales; both species have a blunt head 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). The body is charcoal gray to black, with unpigmented lips (which often appear light gray, pink, or white) and a white urogenital patch (Perryman et al., 1994). This species also has a triangular face "mask" and indistinct cape (which dips much lower below the dorsal fin than that of pygmy killer whales). Melon-headed whales reach a maximum length of 2.75 m (9.02 ft) (Jefferson et al., 1993).

Status **–** There are no abundance estimates for melon-headed whales in the western North Atlantic (Waring et al., 2007). The best estimate of abundance for melon-headed whales in the northern GOMEX is 3,451 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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 (4,921 ft) 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.

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). The first two occurrence records for this species in the GOMEX were strandings in Texas and Louisiana during 1990 and 1991, respectively (Barron and Jefferson, 1993).

Atlantic Ocean, Offshore of the Southeastern United States

Melon-headed and pygmy killer whales can be difficult to distinguish from one another, and on many occasions only a determination of “pygmy killer whale/melon-headed whale” can be made. Two sightings of melon-headed whales are recorded in deep (greater than 2,500 m [8,202 ft]) offshore waters along the path of the Gulf Stream in the southern VACAPES OPAREA. Based on warm water preferences, melon-headed whale occurrence in the VACAPES OPAREA during winter is likely influenced by the Gulf Stream. One sighting of melon-headed whales is recorded in offshore waters north of the CHPT OPAREA. One stranding of a melon-headed whale is recorded just inshore of the JAX/CHASN OPAREA along the coast of Florida. In March 2006, five adult melon-headed whales mass stranded along the central Atlantic coast of Florida just south of the OPAREA (Bossart et al., 2007). This is the first reported mass stranding of this species in the southeastern United States. The melon-headed whale is an oceanic species; it is likely to occur seaward of the shelf break year-round throughout the Southeast OPAREAs.

Atlantic Ocean, Offshore of the Northeastern United States

The melon-headed whale is not expected to occur within the western North Atlantic Ocean offshore of the Northeastern United States.

Gulf of Mexico

The melon-headed whale is an oceanic species; this is confirmed by the distribution of sighting records, which show the species to occur in waters seaward of the shelf break. Mullin and Hansen (1999) noted that melon-headed whales appear to be more frequently sighted west of the Mississippi River. This is supported by the distribution of sighting records in the GOMEX. No seasonality to their occurrence is expected. The large number of sightings during the spring is due to high survey coverage during this time of year.

4.2.18 Pygmy Killer Whale (*Feresa attenuata*)

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). The body of the pygmy killer whale is somewhat slender (especially posterior to the dorsal fin) with a rounded head that has little or no beak (Jefferson et al., 1993). The color of this species is dark gray to black with a prominent narrow cape that dips only slightly below the dorsal fin and a white to light gray ventral band that widens around the genitals. The lips and snout tip are sometimes white. Pygmy killer whales reach lengths of up to 2.6 m (8.5 ft) (Jefferson et al., 1993).

Status There are no estimates of abundances for pygmy killer whales in the western North Atlantic (Waring et al., 2007). The best estimate of abundance for pygmy killer whales in the northern GOMEX is 408 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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., 2004a). 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., 2004a). These clicks possess characteristics of echolocation clicks (Madsen et al., 2004a). There are no empirical hearing data available for this species.

Distribution – Pygmy killer whales have a worldwide distribution in tropical and subtropical waters, generally not ranging north of 40º N or south of 35º S (Jefferson et al., 1993). Most records from outside the tropics are associated with unseasonable intrusions of warm water into higher latitudes (Ross and Leatherwood, 1994). There are relatively few records of this species in the western North Atlantic; this species does not appear to be common in the GOMEX (Davis and Fargion, 1996; Jefferson and Schiro, 1997; Davis et al., 2000; Würsig et al., 2000). Würsig et al. (2000) suggested that the sparse number of sightings might be at least in part due to the somewhat cryptic behavior of the pygmy killer whale.

Atlantic Ocean, Offshore of the Southeastern United States

Only one confirmed record, a fall stranding north of Cape Hatteras, is documented for pygmy killer whales in the VACAPES OPAREA and vicinity. Based on warm water preferences, pygmy killer whale occurrence in the VACAPES OPAREA during winter is likely influenced by the Gulf Stream. Few strandings and an offshore sighting are recorded near the CHPT OPAREA. Records of pygmy killer whales in this region include several strandings inshore of the JAX/CHASN OPAREA and two sightings in offshore waters of the JAX/CHASN OPAREA. The pygmy killer whale is an oceanic species; occurrence is likely seaward of the shelf break year-round throughout the Southeast OPAREAs.

Atlantic Ocean, Offshore of the Northeastern United States

The pygmy killer whale should be considered rare in the Northeastern United States during all times of the year; as it primarily occurs in tropical waters. Although no sightings have occurred within the NE OPAREAs, there are four occurrence records for this species in the Northeastern United States: one sighting during August 1981 (CETAP, 1982) and three during the course of two days of a NMFS shipboard survey in July 1995. The closest sighting was made during July 1995, 31.5 km (69.4 NM) south of the southwestern most corner of the Narragansett OPAREA.

Gulf of Mexico

As stated previously, pygmy killer whales and melon-headed whales can be difficult to distinguish from one another, and on many occasions, only a determination of “pygmy killer whale/melon-headed whale” can be made. The occurrence of both species is considered similar and therefore appears combined. In the northern GOMEX, the pygmy killer whale is found primarily in deeper waters beyond the continental shelf (Davis and Fargion, 1996; Davis et al., 2000; Würsig et al., 2000) extending out to waters over the abyssal plain. Pygmy killer whales are thought to occur year-round in the Gulf in small numbers (Würsig et al., 2000). No seasonality to their occurrence is expected. The large number of sightings during the spring is due to high survey coverage during this time of year.

4.2.19 False Killer Whale (*Pseudorca crassidens*)

Description – The false killer whale is a large, dark gray to black dolphin with a faint gray patch on the chest and sometimes light gray areas on the head (Jefferson et al., 1993). The false killer whale has a long slender body, a rounded overhanging forehead, and little or no beak (Jefferson et al., 1993). The dorsal fin is falcate and slender. 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). Individuals reach maximum lengths of 6.1 m (20.0 ft) (Jefferson et al., 1993).

Status – There are no abundance estimates available for this species in the western North Atlantic (Waring et al., 2007). The best estimate of abundance for false killer whales in the northern GOMEX is 1,038 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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., 2004b).

False killer whales can hear frequencies ranging from approximately 2 to 115 kHz with best hearing sensitivity ranging from 16 to 64 kHz (Thomas et al., 1988). Additional behavioral audiograms of false killer whales support a range of best hearing sensitivity between 16 and 24 kHz, with peak sensitivity at 20 kHz (Yuen et al., 2005). The same study also measured audiograms using the ABR technique, which came to similar results, with a range of best hearing sensitivity between 16 and 22.5 kHz, peaking at 22.5 kHz (Yuen et al., 2005). Behavioral audiograms in this study consistently resulted in lower thresholds than those obtained by ABR.

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). False killer whales are primarily offshore animals, although they do come close to shore, particularly around oceanic islands (Baird, 2002). Most sightings in the Gulf of Mexico have been made in oceanic waters greater than 200 m (656 ft) deep, although there are some sightings in waters over the continental shelf (Davis and Fargion, 1996). Inshore movements are occasionally associated with movements of prey and shoreward flooding of warm ocean currents (Stacey et al., 1994).

Atlantic Ocean, Offshore of the Southeastern United States

The false killer whale is found primarily in deep-water and offshore areas in tropical and warm-temperate waters. The warm waters of the Gulf Stream likely influence occurrence in the southern VACAPES OPAREA. A small number of sightings and strandings are recorded near the VACAPES OPAREA; the sightings reflect the preference of this species for offshore waters. A small number of sightings are recorded in the CHPT OPAREA. A small number of sightings are recorded in offshore waters of the JAX/CHASN OPAREA. Strandings are also recorded in this region. Occurrence is likely seaward of the shelf break throughout the Southeast OPAREAs year-round.

Atlantic Ocean, Offshore of the Northeastern United States

The false killer whale is distributed worldwide throughout warm temperate and tropical oceans. False killer whales may occur in waters over Jeffreys Bank, south of the southern flank of Georges Bank and Narragansett Bay OPAREA, and in the vicinity of Cape Cod during summer, fall, and winter. No species sightings have occurred during the spring.

Gulf of Mexico

Most sightings in the Gulf of Mexico have been made seaward of the shelf break, although there are also sightings from over the continental shelf (Davis and Fargion, 1996; Jefferson and Schiro, 1997; Mullin and Fulling, 2004). Mullin and Hansen (1999) and Mullin and Fulling (2004) reported that most NMFS-SEFSC sightings were east of the Mississippi River. There is the possibility of encountering false killer whales between the 50-m (164-ft) isobath and the shelf break based on the fact that false killer whales sometimes make their way into shallower waters, as well as the many sightings reported by sport fishermen in the mid-1960s of “blackfish” (most likely false killer whales based on the descriptions) in waters offshore of Pensacola and Panama City, Florida (Brown et al., 1966). There were also occasional reports of fish stealing by these animals (the false killer whale frequently has been implicated in such fishery interactions). No seasonal differences in the occurrence patterns of this species are expected in the GOMEX.

4.2.20 Killer Whale (*Orcinus orca*)

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 [3.3 to 5.9 ft] in height). The white oval eye patch and variably shaped saddle patch, in conjunction with the shape and notches in the dorsal fin, help in identifying individuals. The killer whale has a blunt head with a stubby, poorly defined beak and large, oval flippers. Females may reach 7.7 (25.3 ft) m in length and males 9.0 m (29.5 ft) (Dahlheim and Heyning, 1999). This is the largest member of the dolphin family.

Status **–** There are no estimates of abundance for killer whales in the western North Atlantic (Waring et al., 2007). 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 best estimate of abundance for killer whales in the northern GOMEX is 133 individuals (Mullin and Fulling, 2004; Waring et al., 2006). The GOMEX population is considered a separate stock for management purposes, although there is currently no information to differentiate this stock from the Atlantic Ocean stock(s) (Waring et al., 2006).

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, 2002b). 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 and 2002b). Dialects have been documented in northern Norway (Ford, 2002a) 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).

Distribution – Killer whales are found throughout all oceans and contiguous seas, from equatorial regions to polar pack ice zones of both hemispheres. Although found in tropical waters and the open ocean, killer whales are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning, 1999). Ford (2002b) noted that this species has a sporadic occurrence in most regions. In the western North Atlantic, killer whales are known from the polar pack ice southward to Florida, the Lesser Antilles, and the Gulf of Mexico (Würsig et al., 2000), where they have been sighted year-round (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997; Würsig et al., 2000). Killer whales are sighted year-round in the northern GOMEX (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997; Würsig et al., 2000).It is not known whether killer whales in the Gulf of Mexico range more widely into the Caribbean Sea and the adjacent North Atlantic (Würsig et al., 2000). Year-round killer whale occurrence in the western North Atlantic is considered to be south of 35° N (Katona et al., 1988).

Atlantic Ocean, Offshore of the Southeastern United States

Several killer whale sightings are recorded in both shallow and deep waters of the VACAPES OPAREA and vicinity. A small number of killer whale sightings are recorded in both shallow and deep waters of the CHPT and JAX/CHASN OPAREAs and vicinity. Strandings are also reported along the coasts of North Carolina and Florida. Occurrence would be likely seaward of the shoreline year-round based on sighting data and the diverse habitat preferences of this species.

Atlantic Ocean, Offshore of the Northeastern United States

Killer whales may occur year-round in the NE OPAREAs, primarily in waters over the continental shelf and rise, from the Bay of Fundy to New Jersey. They are characterized as uncommon in waters of the U.S. Atlantic EEZ.

Gulf of Mexico

Killer whales in the GOMEX are sighted most often in waters with a bottom depth greater than 200 m (656 ft) (averaging 1,242 m [4,075 ft]; range of 256 to 2,652 m [840 to 8,701 ft]), although there have also been occasional sightings over the continental shelf (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997). Killer whale sightings in the northern GOMEX are generally clumped in a broad region south of the Mississippi River Delta (O'Sullivan and Mullin, 1997). It should be noted, however, that southern Texas (specifically, the Port Aransas area) seems to be an area where there are a number of anecdotal reports of killer whale sightings.

Killer whales are not expected to occur during the winter; however, there are two historical stranding records in the Florida Keys (O'Sullivan and Mullin, 1997). There was a sighting of 14 individuals reported 90 NM (167 km) off Port Aransas, TX on 18 January 2004 (Mauch, 2004; McCune, 2004).

During the spring, O’Sullivan and Mullin’s (1997) assessment showed that killer whales are generally clumped south of the Mississippi River Delta. There is an area of concentration in deep waters of the Gulf that is likely a reflection of a sighting(s) of a large group(s) of individuals and probably does not reflect a true area of concentration for the species.

During summer, there are certainly less reported sightings during this time of year, with the Mississippi River Delta region and southern Texas having the most sightings.

During the fall, killer whales are not expected to occur, however, this is the season with the least amount of survey effort, and inclement weather conditions can make sighting cetaceans difficult during this time of year. Additionally, as noted earlier, killer whales are only sporadically sighted in the Gulf. O'Sullivan and Mullin (1997) erroneously report a November 1951 sighting off southern Texas, attributing this record to Gunter (1954); it should be noted that Gunter reports that sighting as occurring during summer 1951; this was verified by Jefferson and Schiro (1997). The one stranding lists a date of 26 November 1921. This is actually a 26 December 1921 stranding that is reported by Moore (1953) and verified by both Jefferson and Schiro (1997) and O'Sullivan and Mullin (1997) as occurring during December.

4.2.21 Long-Finned and Short-Finned Pilot Whales (*Globicephala* spp.)

Description – Pilot whales are among the largest dolphins, with long-finned pilot whales potentially reaching 5.7 m (18.7 ft) (females) and 6.7 m (22.0 ft) (males) in length. Short-finned pilot whales may reach 5.5 m (18.0 ft) (females) and 6.1 m (20.0 ft) (males) in length (Jefferson et al., 1993). Pilot whales have bulbous heads, with a forehead that sometimes overhangs the rostrum, and little or no beak. The falcate dorsal fin is distinctive; being generally longer than it is high, with a rounded tip and set well forward of the body's mid-length. 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 percent of the total body length. Short-finned pilot whale flippers are sickle shaped. Pilot whales are black, with a light-gray saddle patch behind the dorsal fin in some individuals. There is also a white to light-gray anchor-shaped patch on the chest. Short-finned pilot whales have flippers that are somewhat shorter than long-finned pilot whale at 16 to 22 percent of the total body length (Jefferson et al., 1993).

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., 2007). Neither the long-finned or short-finned pilot whale is currently a strategic stock (Waring et al., 2007). Fullard et al. (2000) proposed a stock structure for long-finned pilot whales in the North Atlantic that was correlated with sea-surface temperature. This involved a cold-water population west of the Labrador and North Atlantic current and a warm-water population that extended across the North Atlantic in the warmer water of the Gulf Stream. The best estimate of abundance for the short-finned pilot whale in the northern GOMEX is 2,388 individuals (Mullin and Fulling, 2004; Waring et al., 2006).

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 sec., 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).

***Distribution* –** Long-finned pilot whales are distributed in subpolar to temperate North Atlantic waters offshore and in some coastal waters. Short-finned pilot whales are found worldwide in warm-temperate and tropical offshore waters. Short-finned pilot whales are considered to be a tropical species that usually does not range north of 50º N or south of 40º S (Jefferson et al., 1993). However, strandings have been reported as far north as New Jersey (Payne and Heinemann, 1993). The apparent ranges of the two pilot whale species overlap in shelf/shelf-edge and slope waters of the northeastern United States between 35°N and 38° to 39°N (New Jersey to Cape Hatteras, North Carolina) (Payne and Heinemann, 1993). The short-finned pilot whale usually does not range north of 50°N or south of 40°S, 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., 2007). 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).

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). From June through September, pilot whales are broadly distributed over the continental shelf (Payne et al., 1990a), with the greater percentage of pilot whale sightings along the continental shelf breaks in the northeastern portion of Georges Bank and onto the Scotian Shelf. From May through October, pilot whales predominantly occur on the northern edge of central Georges Bank (Payne et al., 1990a). Movements from June through September continue northward into the Gulf of Maine and into Canadian waters. From September through December, the largest concentrations of pilot whales occur along the southwestern edge of Georges Bank. By December, many pilot whales have already moved offshore and southward (Payne and Heinemann, 1993).

Short-finned pilot whales seem to move from offshore to continental shelf break waters and then northward to approximately 39º 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). Only the short-finned pilot whale is known in the GOMEX.

Atlantic Ocean, Offshore of the Southeastern United States

Pilot whales are considered a shelf-edge species. The short-finned pilot whale is considered to be a more tropical species, common south of Cape Hatteras, North Carolina; however, strandings have been reported as far north as New Jersey. Pilot whales are likely to occur in the VACAPES OPAREA in spring, summer, and fall. Both species of pilot whales are likely to occur year-round in waters on the continental shelf, over the shelf break, and into deeper waters past the eastern boundary of the VACAPES OPAREA.

Identifying the species of pilot whale is difficult at sea, and the CHPT OPAREA is located in the overlap area for the ranges of both pilot whale species. North of Cape Hatteras, pilot whales are likely to occur in waters year-round on the continental shelf, over the shelf-edge, and into deep water past the CHPT OPAREA. Pilot whales may occur from the shore to across the continental shelf.

Pilot whales are likely to occur in the JAX/CHASN OPAREA from the vicinity of the continental shelf break into waters seaward of the OPAREA boundary. Pilot whales may occur between the shore and the vicinity of the continental shelf break for all seasons. This is based upon sightings of pilot whales on the continental shelf (including waters quite close to shore) to the north of the JAX/CHASN OPAREA.

Atlantic Ocean, Offshore of the Northeastern United States

Pilot whales may occur year-round, in waters extending from the continental shelf to the continental rise, from the Bay of Fundy south towards the VACAPES OPAREA. In general, spring and summer have the greatest occurrences of pilot whales in the Northeast.

In the wintertime, pilot whales may occur over the continental shelf and slope waters from Jeffreys Bank and south towards the VACAPES OPAREA. Pilot whales seem to primarily occur in the vicinity of the continental slope waters along the southern flank of Georges Bank south towards the VACAPES OPAREA and within Cape Cod Bay. The short-finned pilot whale is considered to be rare in the NE OPAREAs; the species boundary is considered to be in the New Jersey to Cape Hatteras area (Payne and Heinemann, 1993).

In the springtime, pilot whales occur primarily over the continental shelf and slope, in waters extending from Jordan Basin and the Scotian Shelf south towards the VACAPES OPAREA. Sightings are common in Georges Bank during this time of year (Payne and Heinemann, 1993).

During this season, greater concentrations of pilot whales may be found just south of the New England Sea Mount Chain and south towards the VACAPES OPAREA, in the vicinity of the continental slope.

In the summertime, pilot whales are generally found in the waters of the continental shelf seaward from the Bay of Fundy and the Scotian Shelf and south towards the VACAPES OPAREA. Pilot whales seem to primarily occur in the vicinity of the continental shelf break in waters from the Scotian Shelf south towards the VACAPES OPAREA, and along the northern flank of Georges Bank. During this season, a greater concentration of pilot whales may occur at mouth of the Northeast Channel.

In the fall, pilot whales may occur in waters over the continental shelf and slope, from the Bay of Fundy and the Scotian Shelf and south towards the VACAPES OPAREA. During this season, pilot whales may be found in greater concentrations near the western tip of Georges Basin, with the greatest concentrations found south near the VACAPES OPAREA, in the vicinity of the continental slope.

Gulf of Mexico

As noted by Jefferson and Schiro (1997), the identifications of many pilot whale specimen records in the GOMEX, and most or all sightings, have not been unequivocally shown to be of the short-finned pilot whale. There are no confirmed records of long-finned pilot whales in the GOMEX (Würsig et al., 2000). Based on known distribution and habitat preferences of pilot whales, it is assumed that all of the pilot whale records in the northern GOMEX are of the short-finned pilot whale (Jefferson and Schiro, 1997; Würsig et al., 2000).

There is a preponderance of pilot whales in the historical records for the northern Gulf. Pilot whales, however, are less often reported during recent surveys, such as GulfCet (Jefferson and Schiro, 1997; Würsig et al., 2000). The reason for this apparent decline is not known, but Jefferson and Schiro (1997) suggested that abundance or distribution patterns might have changed over the past few decades, perhaps due to changes in available prey species which was noted off Catalina Island, California (Shane, 1994).

Mullin and Hansen (1999) noted that pilot whales are sighted almost exclusively west of the Mississippi River. There are a large number of historical strandings on the western coast of Florida and in the Florida Keys.

During the winter, there are no known seasonal changes in occurrence patterns for this species in the Gulf.

Spring is the season with the most survey effort. This species occurs in areas of steep bottom topography in most of the western Gulf, as well as in the region of the Mississippi River Delta and southwest of the Florida Keys.

In the summer, this species occurs in areas of steep bottom topography in most of the western Gulf, in the region of the Mississippi River Delta, and southwest of the Florida Keys. The pattern is similar in many respects to that predicted for spring, with some shifts in areas of concentration that might be indicative of temporal (yearly) differences in survey effort and sighting conditions.

In the fall, occurrence may be concentrated in locations around the shelf break, in particular, south of the Mississippi River Delta, over the continental slope. This is a time of a year with less survey effort than some other seasons (specifically spring and summer); therefore, it is possible that occurrence would be shown over a larger area if there was more survey effort during this time of year.

4.2.22 Harbor Porpoise (*Phocoena phocoena*)

Description **–** Harbor porpoises are the smallest cetaceans in the North Atlantic with a maximum length of 2.0 m (6.6 ft) (Jefferson et al., 1993). The body is stocky, dark gray to black dorsally and white ventrally. There may be a dark stripe from the mouth to the flipper. The head is blunt, with no distinct beak. The flippers are small and pointed and the dorsal fin is short and triangular, located slightly behind the middle of the back.

Status **–** There are four proposed harbor porpoise populations in the western North Atlantic: Gulf of Maine and Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland stocks (Gaskin, 1992). The best estimate of abundance for the Gulf of Maine and Bay of Fundy stock is 89,700 individuals (Waring et al., 2007).

Diving Behavior – Harbor porpoises make brief dives, generally lasting less than 5 min (Westgate et al., 1995). Tagged harbor porpoise individuals spend 3 to 7 percent of their time at the surface and 33 to 60 percent in the upper 2 m (7 ft) (Westgate et al., 1995; Read and Westgate, 1997). Average dive depths range from 14 to 41 m (46 to 135 ft) with a maximum known dive of 226 m (741 ft) and average dive durations ranging from 44 to 103 sec (Westgate et al., 1995). Westgate and Read (1998) noted that dive records of tagged porpoises did not reflect the vertical migration of their prey; porpoises made deep dives during both day and night.

Acoustics and Hearing – Harbor porpoise vocalizations include clicks and pulses (Ketten, 1998), as well as whistle-like signals (Verboom and Kastelein, 1995). The dominant frequency range is 110 to 150 kHz, with source levels between 135 and 205 dB re 1 µPa-m (Ketten, 1998) (Villadsgaard, 2007). Echolocation signals include one or two low-frequency components in the 1.4 to 2.5 kHz range (Verboom and Kastelein, 1995).

A behavioral audiogram of a harbor porpoise indicated the range of best sensitivity is 8 to 32 kHz at levels between 45 and 50 dB re 1 µPa-m (Andersen, 1970); however, auditory-evoked potential studies showed a much higher frequency of approximately 125 to 130 kHz (Bibikov, 1992). The auditory-evoked potential method suggests that the harbor porpoise actually has two frequency ranges of best sensitivity. More recent psycho-acoustic studies found the range of best hearing to be 16 to 140 kHz, with a reduced sensitivity around 64 kHz (Kastelein et al., 2002). Maximum sensitivity occurs between 100 and 140 kHz (Kastelein et al., 2002).

Distribution – Harbor porpoises occur in subpolar to cool-temperate waters in the North Atlantic and Pacific (Read, 1999). Off the northeastern United States, harbor porpoise distribution is strongly concentrated in the Gulf of Maine/Georges Bank region, with more scattered occurrences to the mid-Atlantic (CETAP, 1982; Northridge, 1996). Stranding data indicate that the southern limit is northern Florida (Polacheck, 1995; Read, 1999). Genetic evidence suggests limited trans-Atlantic movement (Rosel et al., 1999a).

From July through September, harbor porpoises are concentrated in the northern Gulf of Maine and southern Bay of Fundy, generally in waters less than 150 m (492 ft) deep (Palka, 1995), with a few sightings in the upper Bay of Fundy and on the northern edge of Georges Bank (Palka, 2000). From October through December, harbor porpoise densities are widely dispersed from New Jersey to Maine, with lower densities to the north and south of this region (NMFS, 2001). Most harbor porpoises are found on the continental shelf, with some sightings in continental slope and offshore waters (Westgate et al., 1998; Waring et al., 2007). During this time, sightings are concentrated in the southwestern and northern Gulf of Maine, as well as in the Bay of Fundy (CETAP, 1982). From January through March, intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada (NMFS, 2001). The New Jersey shore and approaches to New York harbor may represent an important January to March habitat (Westgate et al., 1998). A satellite tagged harbor porpoise, "Gus", was rehabilitated and released off the coast of Maine and followed the continental slope south to near Cape Hatteras between January and March of 2004 (WhaleNet, 2004). During this time of year, significant numbers of porpoises occur along the mid-Atlantic shore from New Jersey to North Carolina, where they are subject to incidental mortality in a variety of coastal gillnet fisheries (Cox et al., 1998; Waring et al., 2007). Mid-Atlantic porpoise bycatches occur from December through May (Waring et al., 2007). Data indicate that only juvenile harbor porpoises are present in nearshore waters of the mid-Atlantic during this time (Cox et al., 1998). Harbor porpoises are not tied to shallow, nearshore waters during winter, as evidenced by a harbor porpoise caught in a pelagic drift net off North Carolina (Read et al., 1996). A largely offshore harbor porpoise distribution during winter explains the paucity of sightings in the Bay of Fundy and Gulf of Maine (CETAP, 1982). However, stocks rather than simply migrants from the Gulf of Maine and Bay of Fundy stock (Rosel et al., 1999b).

A noteworthy unusual mortality event took place between 1 January and 28 March 2005 during which 38 harbor porpoises stranded along the coast of North Carolina (Hohn et al., 2006; MMC, 2006). Most of the stranded individuals were calves and many were emaciated, indicating that the harbor porpoises had difficulty finding food (MMC, 2006).

Atlantic Ocean, Offshore of the Southeastern United States

The southern limit for this species in the western North Atlantic is northern Florida, based on stranding information. During the winter and spring, there is a concentration of recorded by-catch and strandings in the vicinity of Cape Hatteras, most probably due to catches in gillnets and driftnets. The harbor porpoise is restricted to cool waters, where aggregations of prey are concentrated. They are seldom found in waters warmer than 17°C (64°F). In the VACAPES OPAREA, this species primarily occurs on the continental shelf, but there are also recorded sightings in offshore waters. The harbor porpoise may occur in the fall, winter, and spring from the 2,000-m (6,561.7-ft) isobath to eastward of the boundary of the VACAPES OPAREA. During winter, high concentrations of harbor porpoises are likely in the area from the coastline to the 200-m (656.2-ft) isobath, based on the increase in sighting records of harbor porpoise in this area during winter.

Harbor porpoises are likely to occur only in the northwestern tip of the CHPT OPAREA (with the southern boundary of its occurrence being the Gulf Stream) in the fall and winter. Taken into consideration was the possibility that some individual harbor porpoises might make their way into the northern portion of this OPAREA at that time of the year. There are only some stranding records for south of the Virginia/Maryland border during the spring and fall, and no sightings or by-catch records. During summer, harbor porpoises are concentrated in the northern Gulf of Maine and lower Bay of Fundy region and are not likely to occur as far south as the CHPT OPAREA.

Atlantic Ocean, Offshore of the Northeastern United States

Harbor porpoises occur year-round throughout the northern region of the NE OPAREAs, primarily in continental shelf waters. The overall distribution seems to be concentrated in the Gulf of Maine, which is consistent with reported findings (CETAP, 1982; Northridge, 1996). The general distribution seems to shift further north in summer and fall.

In the wintertime, harbor porpoises occur in the continental shelf waters, extending from the northern coast of Maine and south towards the VACAPES OPAREA. Most of the occurrence records are in the Gulf of Maine. During winter (January through March), intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada (NMFS, 2001).

In the springtime, harbor porpoises generally occur over the continental shelf, in waters extending from the Bay of Fundy to off the coast of Maryland. The distribution of the occurrence records seem to be concentrated in the Gulf of Maine and over Georges Bank.

In the summertime, harbor porpoises primarily occur in waters over the continental shelf, extending from the Bay of Fundy and the Scotian Shelf to off the northern coast of New Jersey. The overall distribution of occurrences seems to shift to the northern regions, with a few scattered occurrences found near Georges Bank. During this season, the harbor porpoise may occur in greater concentrations near the coasts of southern New Brunswick and northern Maine.

In the fall, harbor porpoises may occur in waters over the continental shelf, extending from the Bay of Fundy. The general distribution occurs primarily in the Gulf of Maine. During this season, harbor porpoises may occur in greater concentrations near the southern coast of New Brunswick.

Gulf of Mexico

The harbor porpoise is not expected to occur within the Gulf of Mexico.

4.3 PINNIPEDS

The composition and distribution of the seal population in the northeastern United States has become increasingly complex. The northern part of the U.S. eastern seaboard has experienced a significant increase in stranded ice seals since the late 1980s (Kraus and Early, 1995; McAlpine and Walker, 1999; Sadove et al., 1999; Slocum et al., 1999 and 2003; Mignucci-Giannoni and Odell, 2001). In the winter, there are harp and hooded seals in the Gulf of Maine in numbers never before observed. McAlpine and Walker (1999) speculated that the cause for this increase may be due to the collapsed fish stocks that can no longer support the currently large seal populations, forcing seals to move to less optimal feeding grounds further south. Alteration in the extent and productivity of ice-edge systems may affect the density of important ice-associated prey of pinnipeds, such as Arctic cod (Tynan and DeMaster, 1997).

Pinnipeds occur primarily close to shore in the northern part of the western North Atlantic, although they have been observed some distance from shore during spring in the vicinity of the Great South Channel. The seals commonly occurring in the waters of the Northeast use the numerous islands and ledges to haul out of the water where they rest, pup, and molt. Although there are a few sporadic sighting and bycatch records from MAB waters, pinnipeds do occur in the southern portion of the U.S. Northeast as indicated by the number of stranding records from New York and New Jersey. While more pinniped strandings occur in the winter and spring months, the number of seals sighted at sea and in coastal waters of Maine and Massachusetts is highest in spring and summer. The lower number of pinniped sightings in the fall and winter may be due to the decreased survey effort during those time periods.

4.3.1 Hooded Seals (*Cystophora cristata*)

Description – Hooded seals are large; adult males are approximately 2.5 m (8.2 ft) in length and weigh on average 300 kg (661 lb), with some individuals reaching over 400 kg (882 lb) (Kovacs, 2002). Females are smaller, measuring approximately 2.2 m (7.2 ft) and weighing an average of 200 kg (441 lb) (Kovacs, 2002). Hooded seal pups are blue-black on their backs and silver-gray on their bellies; hence, the common name “blue-back” for the pups. Adults are gray to blue-black in color with an overlay pattern of black mottling (Reeves and Ling, 1981). The face is black to behind the eyes; the flippers are also dark (Reeves and Ling, 1981). The most unique feature of this species is the prominent two-part nasal ornament of sexually mature males that gives the species its common name; it is used to display to females and to other males during the breeding season. When relaxed, this nasal appendage hangs as a loose, wrinkled sac over the front of males’ noses. However, when they clamp their nostrils shut and inflate the sac, it becomes a large, tight, bilobed “hood” that covers the front of the face and top of the head. Adult males also have a very elastic nasal septum that they can extrude through one of their nostrils as a membranous pink balloon.

Status – The world’s hooded seal population consists of three separate stocks which are identified with a specific breeding site: Western North Atlantic (Newfoundland/Labrador and Gulf of St. Lawrence), eastern Greenland (“West Ice”), and Davis Strait (Waring et al., 2006). The Western North Atlantic stock is divided into two breeding herds: the Front herd breeds off the coast of Newfoundland and Labrador while the Gulf herd breeds in the Gulf of St. Lawrence

(Waring et al., 2006). The other two stocks represent separate breeding herds. Recent genetic studies indicate that the world's hooded seals comprise a single panmictic genetic population; therefore, the four breeding herds are not genetically isolated (Coltman et al., 2007).

The best estimate of abundance for western North Atlantic hooded seals is 592,100 (Waring et al., 2007). There are no recent pup counts to assess the current population size in either U.S. waters (Waring et al., 2007). Dramatic increases in hooded seal numbers on Sable Island have occurred concurrently with the recent increases of extralimital occurrences along the northeastern United States (Lucas and Daoust, 2002).

***Diving Behavior* –** Hooded seals feed primarily on deepwater fishes and squids (Reeves and Ling, 1981; Campbell, 1987; Kovacs, 2002). Adult hooded seals can dive to depths of over 1,000 m (3,281 ft) and remain underwater for nearly an hour (Folkow and Blix, 1999).

***Acoustics and Hearing* –** Hooded seals emit five different vocalizations, although it is suspected that their vocal repertoire is more diverse (Ballard and Kovacs, 1995). Males and females, as well as different age classes, have been recorded producing sounds (Ballard and Kovacs, 1995). Hooded seal calls are primarily aerial but can be produced underwater. Underwater sounds have most of their energy below 4 kHz and include "grungs", whoops, moans, trills, knocks, snorts, and buzzes (Terhune and Ronald, 1973; Ballard and Kovacs, 1995). Males produce low-frequency sounds in air that coincide with dominance displays utilizing the nasal appendage. Vester et al. (2003) recorded ultrasonic clicks produced by hooded seals, with a frequency range of 66 to 120 kHz and average source levels of 143 dB re 1 μPa-m in conjunction with hunting fish.

There are no direct measurements of the hearing abilities of the hooded seal (Kastelein, 2007; Southall, 2007). Composite Arctic seal hearing data is considered here in the absence of such information as recommended by NMFS (Southall, 2007). The range of underwater hearing for the ringed seal (*Pusa hispida*) ranges from 2.8 to 45 kHz, while in-air, they hear best in the range of 3 to 10 kHz (Terhune and Ronald, 1975). The harp seal's (*Pagophilus groenlandicus*) underwater hearing range is from 1 to 40 kHz, with increased sensitivity at 2 and 22.9 kHz (measured from 0.76 to 100 kHz) (Terhune and Ronald, 1972). In-air, they hear from 1 to 32 kHz with greatest sensitivity at 29 dB at 4 kHz (Terhune and Ronald, 1971).

***Distribution* –** Hooded seals inhabit the pack ice zone of the North Atlantic from the Gulf of St. Lawrence, Newfoundland, and Labrador in the west to the Barents Sea (Campbell, 1987). Hooded seals are not common south of the Gulf of St. Lawrence (Lucas and Daoust, 2002). There was one sighting of a female hooded seal in the Pacific Ocean in 1990; however, this is not typical as she was more than 12,800 km (6,907 NM) outside her normal range (Dudley, 1992). Hooded seals are concentrated in three discrete areas during the breeding season: in the "Front" off the coast of Newfoundland-Labrador and in the Gulf of St. Lawrence; in the Davis Strait; and on the "West Ice" around Jan Mayen Island off eastern Greenland (Campbell, 1987). After the breeding season, hooded seal adults feed along the continental slope off southern Newfoundland and the southern Grand Banks for roughly 20 days before moving northward across the Labrador Basin to west Greenland in June (Bowen and Siniff, 1999). Thereafter, individuals move into traditional molting areas on the southeast Greenland coast, near the

Denmark Strait, or in a smaller patch along the northeast Greenland coast (Kovacs, 2002). After the molt in late June and August, hooded seals disperse. Some individuals move south and west around the southern tip of Greenland and then north along western Greenland. Others move to the east and north between Greenland and Svalbard during late summer and early fall (Waring et al., 2006). Not much is known about the activities of hooded seals during the remainder of the year from molting until they reassemble in February for breeding (Campbell, 1987).

The range of hooded seals may be considerably influenced by changes in ice cover and climate (Campbell, 1987; Johnston et al., 2005b). Hooded seals can make extensive movements and show a tendency toward wandering, with extralimital sightings documented as far south as Puerto Rico and the Virgin Islands (Mignucci-Giannoni and Odell, 2001; Mignucci-Giannoni and Haddow, 2002). Most extralimital sightings occur between late January and mid-May off the northeastern United States and during summer and fall off the southeastern United States and in the Caribbean Sea (McAlpine et al., 1999a; McAlpine et al., 1999b; Harris et al., 2001; Mignucci-Giannoni and Odell, 2001). These extralimital animals have primarily been immature individuals, although adults are occasionally reported, including an incidence of pupping in Maine (Richardson, 1975; Jakush, 2004). Between January and September 2006, a total of 55 hooded seals stranded along the East Coast of the U.S. and as far south as the U.S. Virgin Islands; the majority of these strandings occurred during July, August, and September (NOAA, 2006c).

Atlantic Ocean, Offshore of the Southeastern United States

Hooded seals are one of the two species of ice seals that are recognized as great wanderers but rarely venture into the VACAPES or CHPT regions. There are three records for hooded seals for North Carolina. Although they appear in places far from their normal breeding and foraging range, hooded seals are not expected to occur within these OPAREAs. There are five records for hooded seals for Georgia and Florida; the majority of these records are for July and August. Hooded seals are not expected to occur in JAX/CHASN OPAREA.

Atlantic Ocean, Offshore of the Northeastern United States

Hooded seals may occur throughout the NE OPAREAs, from the northern coast of Maine to the southern coast of Delaware. In general, the occurrence of hooded seals is greatest during winter.

Gulf of Mexico

The hooded seal is not expected to occur within the Gulf of Mexico.

4.3.2 Harp Seals (*Pagophilus groenlandicus*)

Description – These medium-sized phocid seals reach a size of 1.7 m (5.6 ft) and 130 kg (287 lb); females are slightly smaller (Lavigne, 2002). Adults typically have a light gray pelage, a black face, and a black saddle behind the shoulders. This black saddle extends in a lateral band on both sides toward the pelvis, forming a pattern that resembles a harp. Some adults are sparsely spotted, with the harp pattern not completely developed (Reeves et al., 2002). Newborn pups, called "whitecoats" have a long, white coat that is replaced soon after weaning (at about 3 to 4 weeks) by a short, silver pelage with scattered, small dark spots.

Status – The harp seal is the most abundant pinniped in the western North Atlantic Ocean (Hammill and Stenson, 2005). The 2004 Canadian population is estimated at around 5.9 million seals and has changed little since 1996 (DFO, 2005). Data are insufficient to calculate a population estimate for U.S. waters (Waring et al., 2007). The total population of harp seals is divided among three separate breeding stocks in the White Sea, the Greenland Sea between Jan Mayen and Svalbard, and the western North Atlantic (Reeves et al., 2002). The western North Atlantic stock is the largest; it is divided into two breeding herds: The "Front" herd breeds off the coast of Newfoundland and Labrador, while the "Gulf" herd breeds near the Magdalen Islands (Reeves et al., 2002; Waring et al., 2007).

In addition to subsistence hunts in the Canadian Arctic and Greenland, harp seals are harvested commercially in the Gulf of St. Lawrence and off the coast of northeast Newfoundland and Labrador (DFO, 2003a).

Diving Behavior – Most foraging occurs at depths of less than 90 m (295 ft), although dives as deep as 568 m (1,864 ft) have been recorded (Lydersen and Kovacs, 1993; Folkow et al., 2004).

Acoustics and Hearing – The harp seal's vocal repertoire consists of at least 27 underwater and two aerial call types (Serrano, 2001). Harp seals are most vocal during the breeding season (Ronald and Healey, 1981). Serrano (2001) found that calls of low frequency and with few pulse repetitions were predominantly used outside the breeding season, while calls of high frequency and with a high number of pulse repetitions predominated in the breeding season. Terhune and Ronald (1986) measured source levels of underwater vocalizations of 140 dB re 1 μPa-m. Vester et al. (2001) recorded ultrasonic clicks with a frequency range of 66 to 120 kHz, with the main energy at 93±22 kHz and average source levels of 143+ dB re 1 μPa-m in conjunction with live fish hunting.

Behavioral audiograms have been obtained for harp seals (Terhune and Ronald, 1972). The harp seal's ear is adapted for better hearing underwater. Underwater, hearing measures between 0.76 to 100 kHz, with areas of increased sensitivity at 2 and 22.9 kHz (Terhune and Ronald, 1972). In air, hearing is irregular and slightly insensitive with the audiogram being generally flat (Terhune and Ronald, 1971).

Distribution – Harp seals are distributed in the pack ice of the North Atlantic and Arctic oceans, from Newfoundland and the Gulf of St. Lawrence to northern Russia (Reeves et al., 2002). Most of the western North Atlantic harp seals congregate off the east coast of Newfoundland-Labrador (the Front) to pup and breed. The remainder (the Gulf herd) gather to pup near the Magdalen Islands in the Gulf of St. Lawrence (Ronald and Dougan, 1982). Females reach the breeding grounds at the Gulf of St. Lawrence by mid-February and at the Front by early March (Ronald and Dougan, 1982). During the early period of pupping, males are found in separate concentrations. Once mating has ended, harp seals move to more northerly ice in preparation for the annual molt, leaving the newly weaned pups at the breeding grounds. In April, juveniles of both sexes and adult males form dense molting concentrations on the pack ice at the Front. Adult females join these concentrations in late April. By mid-May, most of the population follows the retreating ice edge north. After molting in April, harp seals leave the drifting ice and move north along the east coast of Canada toward their Arctic summering grounds, spending this time in the open water among the ice floes of the Eastern Canadian Arctic or along the west coast of Greenland. Harp seals arrive in June when capelin (an important prey item) concentrate to spawn (Bowen and Siniff, 1999). With the formation of new ice in September, harp seals begin their southward movements along the Labrador coast, usually reaching the entrance to the Gulf of St. Lawrence by early winter (Waring et al., 2004). There, the population then splits into the two breeding groups, one moving into the Gulf of St. Lawrence and the other remaining off the coast of Newfoundland. During January and February, adult harp seals disperse widely throughout the Gulf of St. Lawrence and over the continental shelf off Newfoundland to fatten in preparation for reproduction. Not all juvenile harp seals make the southward mass movement; some remain in the Arctic along the southwestern coast of Greenland (Bowen and Siniff, 1999). The large-scale movements of harp seals represent an annual round trip of more than 4,000 km (2,158 NM) (Bowen and Siniff, 1999).

The number of sightings and strandings of harp seals off the northeastern U.S. has been increasing (McAlpine and Walker, 1990; Rubinstein, 1994; Stevick and Fernald, 1998; McAlpine et al., 1999a; McAlpine et al., 1999b; Harris et al., 2002). These occurrences are usually during January through May (Harris et al., 2002), when the western North Atlantic stock of harp seals is at its most southern point in distribution (Waring et al., 2004). Harp seals occasionally enter the Bay of Fundy; however, McAlpine and Walker (1999) suggested that winter ocean surface currents might limit the probability of extralimital occurrences into this bay.

Atlantic Ocean, Offshore of the Southeastern United States

On occasion, a harp seal wanders south of the normal feeding and breeding areas off Newfoundland during the wintertime. There is a record of an adult harp seal that was found in March, 1945 at Cape Henry, Virginia. A few of these wandering seals stay into the summer months in southern waters. Strandings outside of the normal species range occur between early February and late May and involve animals of both sexes and various ages. Harp seals are not expected to occur within the VACAPES, CHPT, or JAX/CHASN OPAREAs.

Atlantic Ocean, Offshore of the Northeastern United States

Harp seals may occur in the NE OPAREAs from the northern coast of Maine to the southern coast of Delaware during winter and spring and from southern coast of Maine to Long Island during fall. Occurrence information is derived almost solely from the stranding record. There is only one occurrence record of harp seals near the southern coast of Maine during summer.

Gulf of Mexico

The harp seal is not expected to occur within the Gulf of Mexico.

4.3.3 Gray Seals (*Halichoerus grypus*)

Description – Gray seals are large and robust; adult males can reach 2.3 m (7.5 ft) in length and weigh 310 kg (683 lb) (Jefferson et al., 1993). The sexes are sexually dimorphic; males are up to three times larger than females (Bonner, 1981). The species name *grypus* means “hook-nosed”, referring to the Roman nose profile of the adult male (Hall, 2002). In Canada, the gray seal is often referred to as the ‘horse-headed” seal due to the elongated snout of the males (Lesage and Hammill, 2001). The head has a wide muzzle, and the nostrils form a distinctive, almost “W” shape (Jefferson et al., 1993). Pelage color and pattern are individually variable, with most gray seals seen in shades of gray, slightly darker above than below (Jefferson et al., 1993). There are usually numerous irregular blotches and spots on the back. Males are generally more uniformly dark when mature whereas females exhibit the more distinct markings on the fur (Hall, 2002).

Status – Next to harbor seals, gray seals are the most commonly sighted seal in the northeastern United States. There are at least three populations of gray seal in the North Atlantic Ocean: eastern North Atlantic, western North Atlantic, and Baltic (Boskovic et al., 1996). The western North Atlantic stock is equivalent to the eastern Canada breeding population (Waring et al., 2007). There are two breeding concentrations in eastern Canada: one at Sable Island and the other on the pack ice in the Gulf of St. Lawrence. These two breeding groups are treated as separate populations for management purposes (Mohn and Bowen, 1996). There is an estimated 195,000 gray seals in Canada (DFO, 2003a). The herd on Sable Island is thought be growing and may have more than doubled in number, but the Gulf of St. Lawrence population is declining (Bowen et al., 2003). This decline has been attributed to sharp decline in the quantity of suitable ice breeding habitat in the southern Gulf of St. Lawrence possibly due to climate change (Hammill et al., 2003).

Present data are insufficient to calculate the minimum population estimate for gray seals in U.S. waters (Baraff and Loughlin, 2000; Waring et al., 2007). Gray seal abundance appears to be increasing in the U.S. Atlantic EEZ (Waring et al., 2007).

Diving Behavior – While at sea, and even when traveling, gray seals do not swim at the water’s surface (Thompson and Fedak, 1993). Gray seals are able to dive to depths up to 400 m (1,312 ft); however, the majority of dives are only 40 to 100 m (131 to 328 ft) (Goulet et al., 2001; Lesage and Hammill, 2001). The maximum dive duration is just over 9 min (Lydersen et al., 1994). In areas with deeper waters, gray seals are reported to dive for as long as 32 min (Thompson and Fedak, 1993; Goulet et al., 2001). Surface intervals between dives are most often 1.2 min (Boyd and Croxall, 1996).

Acoustics and Hearing – Ketten (1998) determined that most pinnipeds species have peak sensitivities between 1 to 20 kHz. Asselin et al. (1993) classified all gray seal vocalizations into seven call types. The majority of calls consisted of guttural "rups" and "rupes", ranging from 0.1 to 3 kHz, or low-frequency growls ranging from 0.1 to 0.4 kHz (Asselin et al., 1993). The hearing ability of the gray seal has been studied using auditory evoked potential methods. In water, gray seals are most sensitive at frequencies of 20 or 25 kHz. Gray seals have in-air hearing sensitivities at 4 kHz (Ridgway and Joyce, 1975).

Distribution **–** The gray seal is found throughout temperate and subarctic waters on both sides of the North Atlantic Ocean (Davies, 1957). In the western North Atlantic Ocean, the gray seal population is centered in the Canadian Maritimes, including the Gulf of St. Lawrence and the Atlantic Coasts of Nova Scotia, Newfoundland, and Labrador. The largest concentrations are found in the southern half of the Gulf of St. Lawrence (where most seals breed on ice) and around Sable Island (where most seals breed on land) (Davies, 1957; Hammill and Gosselin, 1995; Hammill et al., 1998).

Gray seals were historically distributed along the northeastern United States from Maine to Connecticut (Waters, 1967; Rough, 1995; Wood et al., 2003). It is thought they were extirpated during the 17th century, possibly due to Native American exploitation, European colonization/exploitation, and/or climate change (Waters, 1967; Wood et al., 2003). Gray seals currently range into the northeastern United States, with strandings as far south as North Carolina (Hammill et al., 1998; Waring et al., 2007). Small numbers of gray seals and pupping have been observed on several isolated islands along the central coast of Maine and in Nantucket Sound (the southernmost breeding site is Muskeget Island) (Andrews and Mott, 1967; Rough, 1995; Waring et al., 2007). Resident colonies and pupping has been observed in Maine since 1994, on a few islands (Seal and Green) in Penobscot Bay (Waring et al., 2007). Spring and summer sightings off Maine are primarily on offshore ledges of the central coast of Maine (Richardson, 1976). In the late 1990s, a breeding population of at least 400 animals was documented year-round on outer Cape Cod and Muskeget Island (Barlas, 1999; Waring et al., 2004). Hoover et al. (1999) reported sighting as many as 30 adult gray seals at one haulout site in New York. There are also gray seal sightings and strandings on Long Island Sound.

From December to February, gray seals in the western North Atlantic Ocean aggregate into two main breeding colonies located on Sable Island and in the southern Gulf of St. Lawrence. Post-breeding, gray seals disperse widely; they remain offshore until the spring molt (May to June) (Rough, 1995; Lesage and Hammill, 2001). After the molt is completed, there is a second dispersal; the destination of these dispersals off eastern Canada is varied and depends on the originating population (Sable Island versus non-Sable Island). In November to December, gray seals return to the southern Gulf of St. Lawrence or to Sable Island for the breeding season. Some gray seals found breeding in the northeastern United States bear brands and tags indicating that they had been born on Sable Island (Wood et al., 2003).

Atlantic Ocean, Offshore of the Southeastern United States

Gray seals occur from southern New England to Labrador, but the highest concentration of this species is centered in the Sable Island region off Nova Scotia. Vagrants have been reported as far south as Virginia. A female pupped at Assateague Island, Virginia, in 1986; another birth was reported at the same place in 1989. Gray seals are not expected to occur in the VACAPES, CHPT, or JAX/CHASN OPAREAs.

Atlantic Ocean, Offshore of the Northeastern United States

Gray seals may occur year round throughout the continental shelf region of the NE OPAREAs. The distribution of gray seals is focused primarily in the Bay of Fundy during spring through fall, extending further south during winter and spring. Gray seals range south into the northeastern United States, with strandings reported as far south as North Carolina (Hammill et al., 1998; Waring et al., 2004).

In the wintertime, the general occurrence of gray seals extends from the Bay of Fundy to Delaware, in waters on the continental shelf and near the coast.

In the springtime, gray seals may occur in waters on the continental shelf and near the coast, extending from the Bay of Fundy to Delaware. During this season, gray seals may occur in greater concentrations in the Bay of Fundy.

In the summertime, gray seals generally occur in waters on the continental shelf and near the coast, extending from the Bay of Fundy and the Scotian Shelf to Long Island.

In the fall, gray seals may occur in waters on the continental shelf and near the coast, extending from the Bay of Fundy and the Scotian Shelf to Nantucket, with one record of occurrence near the Delaware coast. During this season, gray seals may occur in greater concentrations in the Bay of Fundy.

Gulf of Mexico

The gray seal is not expected to occur within the Gulf of Mexico.

4.3.4 Harbor Seals (*Phoca vitulina concolor*)

Description – The harbor seal (or common seal) is a small-to medium-sized seal. Adult males attain a maximum length of 1.9 m (6.2 ft) and weigh 70 to 150 kg (154 to 331 lb); females reach 1.7 m (5.6 ft) in length and weigh between 60 and 110 kg (132 to 243 lb) (Jefferson et al., 1993). The harbor seal has a dog-like head with nostrils that form a broad V-shape; this is one of the characteristics that distinguish them from immature gray seals (Baird, 2001). Adult harbor seals exhibit considerable variability in the color and pattern of their pelage; the background color is tannish-gray overlaid by small darker spots, ring-like markings, or blotches (Bigg, 1981).

Status – Five subspecies of *Phoca vitulin*a are recognized; *Phoca vitulina concolor* is the form found in the western North Atlantic (Rice, 1998). Harbor seals are the most common and frequently reported seals in the northeastern United States (Katona et al., 1993). Currently, harbor seals along the coast of the eastern United States and Canadian coasts are considered a single population (Waring et al., 2007).

Pressure from hunting bounties in the late 1800s through 1962 resulted in a reduction or complete elimination of harbor seals in heavily exploited areas (Barlas, 1999). A limit to the southward dispersion of harbor seals from Maine rookeries indirectly lead to their present seasonal occurrence. During the winter of 1980, a large-scale influenza epidemic in Gulf of Maine harbor seals resulted in a mass mortality event (Geraci et al., 1982). The population has since rebounded.

The best estimate of abundance of harbor seals in the western North Atlantic stock is 99,340 individuals (Waring et al., 2007). An estimated 5,575 harbor seals over-wintered in southern New England in 1999, increasing from an estimated 2,834 individuals in 1981 (Barlas, 1999). Kraus and Early (1995) suggested that the northeastern U.S. population increase could represent increasing southward shifts in wintering distribution.

Diving Behavior **–** Harbor seals are generally shallow divers. About 50 percent of dives are shallower than 40 m (131 ft) and 95 percent are shallower than 250 m (820 ft) (Gjertz et al., 2001; Krafft et al., 2002; Eguchi and Harvey, 2005). Dive durations are shorter than 10 min, with about 90 percent lasting less than 7 min (Gjertz et al., 2001). However, a tagged harbor seal in Monterey Bay dove as deep as 481 m (1,578 ft) and dive durations for older individuals may be as long as 32 min (Eguchi and Harvey, 2005). Harbor seal pups swim and dive with their mothers, although for shorter periods when mothers are performing bouts of relatively deep dives (Bowen et al., 1999; Jørgensen et al., 2001; Bekkby and Bjørge, 2003).

Acoustics and Hearing **–** Harbor seal males and females produce a variety of low-frequency in-air vocalizations including snorts, grunts, and growls, while pups make individually unique calls for mother recognition (main energy at 0.35 kHz) (Thomson and Richardson, 1995). Adult males also produce several underwater sounds such as roars, bubbly growls, grunts, groans, and creaks during the breeding season. These sounds typically range from 0.025 to 4 kHz (duration range: 0.1 sec to 11 seconds) (Hanggi and Schusterman, 1994). Hanggi and Schusteman (1994) found that there is individual variation in the dominant frequency range of sounds between different males, and Van Parijs et al. (2003) reported oceanic, regional, population, and site-specific levels of variation (i.e., could represent vocal dialects) between males.

Harbor seals hear nearly as well in air as underwater (Kastak and Schusterman, 1998). Harbor seals are capable of hearing frequencies from 1 to 180 kHz (most sensitive at frequencies between 1 kHz and 60 kHz using behavioral response testing) in water and from 0.25 to 30 kHz in air (most sensitive from 6 to 16 kHz using behavior and auditory brainstem response testing) (Richardson, 1995; Terhune and Turnbull, 1995; Wolski et al., 2003). Despite the absence of an external ear, harbor seals are capable of directional hearing in-air, giving them the ability to mask out background noise (Holt and Schusterman, 2007). Underwater sound localization was demonstrated by Bodson et al. (2006). TTS for the harbor seal was assessed at 2.5 kHz and 3.53 kHz (exposure level was 80 and 95 dB above threshold), by Kastak et al. (2005). Data indicated that the range of TTS onset would be between 183-206 dB re: 1µPa^2-s (Kastak et al., 2005).

Distribution **–** Harbor seals are one of the most widespread pinniped species and are found in subarctic to temperate nearshore waters. Their distribution ranges from the east Baltic west across the Atlantic and Pacific Oceans to southern Japan (Stanley et al., 1996). Harbor seals are year-round residents of eastern Canada (Boulva, 1973) and coastal Maine (Katona et al., 1993; Gilbert and Guldager, 1998). The greatest concentrations of harbor seals in northeastern U.S. waters are found along the coast of Maine, specifically in Machias and Penobscot bays and off Mt. Desert and Swans Islands (Katona et al., 1993). Harbor seals are a coastal species, rarely found more than 20 km (11 NM) from shore, and frequently occupy bays, estuaries, and inlets (Baird, 2001).

Harbor seals occur south of Maine from late September through late May (Rosenfeld et al., 1988; Whitman and Payne, 1990; Barlas, 1999; Schroeder, 2000). During winter, the population divides and disperses offshore into the Gulf of Maine south into southern New England, and a portion remains in coastal waters of Maine and Canada. Harbor seals have recently been observed over-wintering as far south as New Jersey (Slocum et al., 1999). Payne and Selzer (1989) noted that 75 percent of harbor seals south of Maine are located at haulout sites on Cape Cod and Nantucket Island, with the largest aggregation occurring at Monomoy Island and adjacent shoals. Although harbor seals of all ages and both sexes frequent winter haulout sites south of Maine, many of the over-wintering individuals are immature, suggesting that there might be seasonal segregation resulting from age-related competition for haulout sites near preferred pupping ledges and age-related differences in food requirements (Whitman and Payne, 1990; Slocum and Schoelkopf, 2001). Extralimital occurrences have been observed as far south as Florida (Caldwell and Caldwell, 1969; Waring et al., 2007).

From at least October through December, harbor seal numbers decrease in Canadian waters (Terhune, 1985) but increase three to five fold south of Maine (Rosenfeld et al., 1988). A general southward movement along the Canadian coast and northeastern United States is thought to occur during this period (Rosenfeld et al., 1988). Tagging efforts by Gilbert and Wynne (1985) support this hypothesis. Tagged harbor seals in Nova Scotia and Maine were later resighted in Massachusetts. Prior to pupping, this generalized movement pattern reverses as animals move northward to the coasts of Maine and eastern Canada.

Atlantic Ocean, Offshore of the Southeastern United States

Vagrant harbor seals are occasionally found as far south as the Carolinas and Daytona Beach, Florida. Harbor seals are not expected to occur in the VACAPES, CHPT, or JAX/CHASN OPAREAs. Harbor seals that occur in these areas are apparently young individuals that disperse from the north during the winter.

Atlantic Ocean, Offshore of the Northeastern United States

Harbor seals may occur year round in waters over the continental shelf, extending from the Bay of Fundy to Delaware. Harbor seals occur south of Maine seasonally from late September through late May (Schneider and Payne, 1983; Payne and Schneider, 1984; Rosenfeld et al., 1988; Whitman and Payne, 1990; Barlas, 1999; Hoover et al., 1999; Schroeder and Kenney, 2001).The overall distribution of harbor seals shifts towards the southern region of the NE OPAREAs during winter and towards the northern region during summer. Few sighting records exist for harbor seals and all other seal species found in the NE OPAREAs due to low sightability of seals during aerial and shipboard surveys.

In the wintertime, harbor seals may be found in waters on the continental shelf and near the coast, extending from the southern coast of New Brunswick to the coast of Delaware.

In the springtime, harbor seals occur primarily in waters on the continental shelf and near the coast, extending from the Bay of Fundy to the southern tip of New Jersey. During this season, harbor seals may occur in greater concentrations off the western coast of Nova Scotia and northern coast of Maine.

In the summertime, harbor seals occur in waters on the continental shelf and near the coast, extending from the Bay of Fundy and Roseway Basin to Delaware. During this season, harbor seals may occur in greater concentrations in Roseway Basin, with the greatest occurrences found in Penobscot bays, near the coast of Maine just north of Jeffreys Bank. The greatest concentrations of seals in northeastern U.S. waters are found along the coast of Maine, specifically in Machias and Penobscot bays and off Mt. Desert and Swans islands (Katona et al., 1993).

In the fall, the general occurrence of harbor seals is found in waters on the continental shelf and near the coast, extending from the Bay of Fundy to Delaware.

Gulf of Mexico

The harbor seal is not expected to occur within the Gulf of Mexico.

4.3.5 Ringed Seals (*Pusa hispida*)

***Description* –** The ringed seal is one of the smallest pinnipeds. Adults are up to 1.65 m (5.4 ft) in length and weigh 50 to 110 kg (110 to 245 lb). Ringed seals resemble harbor seals, but are decidedly plumper. The ringed seal's coloration is its most distinctive feature. Ringed seal fur is light gray with black spots circled with rings of lighter color (Jefferson et al., 1993).

***Status* –** The ringed seal is the most numerous seal in the Northern Hemisphere (Frost and Lowry, 1981). There are five subspecies of the ringed seal; three occur in marine waters, while two are found in freshwater lakes (Amano et al., 2002). This species is primarily hunted throughout the Arctic for subsistence purposes (DFO, 2003a).

Diving Behavior – Median dive duration is less than 10 min for ringed seals (Lydersen, 1991; Teilmann et al., 1999; Gjertz et al., 2000). Ringed seals occasionally dive up to 50 min or longer (Gjertz et al., 2000). Ringed seals occasionally dive to depths of more than 250 m (820 ft) (Teilmann et al., 1999), though most dives are shallower than 100 m (328 ft) (Lydersen, 1991; Teilmann et al., 1999; Gjertz et al., 2000).

Acoustics and Hearing – Ringed seals produce clicks with a fundamental frequency of 4 kHz and varying harmonics up to 16 kHz (Schevill et al., 1963). Stirling (1973) described barks, high-pitched yelps, and low and high-pitched growls. Ringed seals appear to be most vocal during the breeding season (Stirling et al., 1983). Ringed seals are sensitivity to underwater sounds in the 8 to 60 kHz band (Terhune and Ronald, 1975 and 1976). The hearing ability of ringed seals has not been tested below 1 kHz (Terhune and Ronald, 1975).

***Distribution* –** The ringed seal has a circumpolar distribution throughout the Arctic Ocean, Hudson Bay, and Baltic and Bering seas (Reeves et al., 2002b). The ringed seal is expected only as far south as Newfoundland (Frost and Lowry, 1981). Ringed seals are able to cover long distances in relatively short times, with extralimital strays occasionally found as far south as Portugal in the Atlantic Ocean and California in the Pacific (Dudley, 1992; van Bree, 1996; Ridoux et al., 1998; Lucas and McAlpine, 2002). These extralimital strays are not necessarily lost to the population, since at least one individual is known to have returned to the vicinity of known normal ringed seal distribution (Ridoux et al., 1998).

Atlantic Ocean, Offshore of the Southeastern United States

The ringed seal is not expected to occur within the Atlantic Ocean, offshore of the Southeastern United States.

Atlantic Ocean, Offshore of the Northeastern United States

The ringed seal is extralimital at all times of the year offshore of the Northeastern United States. Although ringed seals sporadically strand in the Northeast United States (Katona et al., 1993; Slocum and Schoelkopf, 2001).

Gulf of Mexico

The ringed seal is not expected to occur within the Gulf of Mexico.

4.3.6 Walrus (*Odobenus rosmarus*)

Description **–** The walrus is a large pinniped. Adult males are substantially larger than females; males can attain lengths of 3.6 m (11.8 ft) and a weight up to 1,900 kg (4,189 lb), while females are up to 3 m (10 ft) in length and 1,200 kg (2,646 lb) in weight (Reeves et al., 2002b). The walrus has a large, robust torso, which is massive in adult males, that dwarfs its relatively small head (Fay, 1981). Perhaps the most distinguishing feature is the pair of long tusks, which are enlarged upper canine teeth that grow continually throughout the animal’s life (Reeves et al., 2002b). Walruses use their tusks mainly in social interactions, such as when males compete with one another for females during the breeding season, but also as an aid in hauling out and moving on ice floes (Reeves et al., 2002b). Walruses are sparsely covered with hair.

Status **–** Rice (1998) recognizes three subspecies of walrus, though Born et al. (2001) recognizes only the Atlantic and Pacific walruses. *Odobenus rosmarus rosmarus* occurs in the Atlantic-Arctic (Rice, 1998). There are eight stocks of Atlantic walrus (Born et al., 2001). Subsistence hunting for walrus occurs throughout this species’ normal range.

Diving Behavior **–** Walruses feed on benthic invertebrates at depths of less than 80 m (262 ft). The deepest recorded dive for this species was to 133 m (436 ft). Feeding walruses dive for approximately 5 min and then remain at the surface for 1 to 2 min.

Acoustics and Hearing**–** Walruses produce both aerial and underwater vocalizations; these are in the 0.5 to 8 kHz frequency range. The only source-level measurement of walrus vocalizations is of rutting whistles, which are 120 db re 1 μPa-m. During the breeding season, mature males produce underwater songs. There are four different types of these songs: coda song, diving vocalization song, intermediate song, and aberrant song. Walrus hearing is adapted to low frequency sound. The range of best hearing is from 1 to 12 kHz; maximum hearing sensitivity is at 12 kHz.

Distribution – The walrus has a disjunct circumpolar distribution in the Northern Hemisphere. The Atlantic walrus ranges from the eastern Canadian Arctic east to the Kara Sea in northern Russia (Reeves et al., 2002b). There are numerous extralimital records for walruses; in the western North Atlantic, walruses have been reported beyond their normal range in the Canadian Arctic, and as far south as Massachusetts in the northeastern United States (Allen, 1930; Manville and Favour, 1960; Harington, 1966; Wright, 1951; Mercer, 1967; Richer, 2003).

Because of their benthic mode of feeding, walrus are generally confined to the continental shelf where bottom depths are no greater than 80 to 100 m (262 to 328 ft) (NAMMC, 2004). The walrus primarily inhabits waters with moving pack ice. Walruses appear to prefer ice as a substrate on which to haulout, though they will also haulout on land (Fay, 1981).

Atlantic Ocean, Offshore of the Southeastern United States

The walrus is not expected to occur within the Atlantic Ocean, offshore of the Southeastern United States.

Atlantic Ocean, Offshore of the Northeastern United States

The walrus is extralimital at all times of the year to the NE OPAREAs.

Gulf of Mexico

The walrus is not expected to occur within the Gulf of Mexico.

4.4 SIRENIANS

4.4.1 West Indian Manatee (*Trichechus manatus*)

Description – The West Indian manatee is a rotund, slow-moving animal, which reaches a maximum length of 3.9 m (12.8 ft) (Jefferson et al., 1993). The manatee has a small head, a squarish snout containing two semi-circular nostrils at the front, and fleshy mobile lips. The tail is horizontal, rounded, and paddle-shaped. The body is gray or gray-brown and is covered with fine hairs that are sparsely distributed. The back of larger animals is often covered with distinctive scars from boat propeller cuts (Moore, 1956).

Status – West Indian manatees are classified as endangered under the ESA. 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 February 2006 produced a preliminary abundance estimate of 3,116 individuals (FMRI, 2006). Along Florida’s Gulf Coast, observers counted 1,474 West Indian manatees, while observers on the Atlantic coast counted

1,639. 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). West Indian manatees found along the Atlantic U.S. coast are of the Atlantic Region subpopulation (USFWS, 2001). Manatees from the western coast of Florida make up the other three subpopulations: Upper St. Johns River Region, Northwest Region, and the Southwest Region (USFWS, 2001).

In 1976, critical habitat was designated for the West Indian manatee in Florida (USFWS, 1976). The designated area included all of the West Indian manatee's known range at that time (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). There are two types of manatee protection areas in the state of Florida: manatee sanctuaries and manatee refuges (USFWS, 2001, 2002a and 2002b). 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, 2002a, and 2002b).

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 minutes. However, when bottom resting, manatees have been known to stay submerged for up to 24 minutes (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 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).

Distribution **–** West Indian manatees occur in warm, subtropical, and tropical waters of the western North Atlantic Ocean, from the southeastern United States 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, 1951a and 1951b; Beck, 2006a). 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. West Indian manatees are frequently reported in coastal rivers of Georgia and South Carolina during warmer months (Lefebvre et al., 2001).

Historically, West Indian manatees were likely restricted to southernmost Florida during winter and expanded their distribution northward during summer. However, industrial development has made warm-water refuges available (e.g., power plant effluent plumes), and the introduction of several exotic aquatic plant species has expanded the available food supply. These factors have enabled an expansion of West Indian manatee winter range (USFWS, 2001; Laist and Reynolds III, 2005).

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).

Although West Indian manatees are expected to inhabit nearshore areas, a few individuals have been sighted offshore. A West Indian manatee hit by a boat in Louisiana was determined to be an individual previously photographed in the Tampa Bay, Florida area (Fertl et al., 2005). A West Indian manatee photographed in January 2000 in the Bahamas was matched to a West Indian manatee sighted as a juvenile in 1994 on the west coast of Florida, indicating the potential for offshore movements (Reid, 2000). Reynolds and Ferguson (1984) reported sightings of two West Indian manatees 61 km (33 NM) northeast of the Dry Tortugas Islands, an area not considered to be part of this species' range. "Mo," a radio-tagged West Indian manatee that had been raised in captivity and released at Crystal River, Florida, wandered offshore and then apparently drifted south with offshore currents and was "rescued" in deepwater 37 km (20 NM) northwest of the Dry Tortugas (Lefebvre et al., 2001). Another West Indian manatee was also repeatedly sighted in the northern Gulf of Mexico, well over 100 km offshore in waters with a bottom depth of about 1,524 m (5,000 ft) (Fertl et al., 2005).

West Indian manatees off the east coast of Florida are also known to occasionally make their way further offshore. For example, "Xoshi" was radio-tagged and released in Biscayne Beach in March 1999. A few weeks later, she was "rescued" 60 km (32 NM) offshore of Port Canaveral, Florida, in the Gulf Stream (Reid et al., 1991). Perhaps the most famous long distance movements of any West Indian manatee were exhibited by the animal known as "Chessie," who gained fame in the summer of 1995 by swimming to Rhode Island, returning to Florida for the winter, and traveling north again to Virginia where he was last seen in 1996 (USGS, 2001). In early September 2001, "Chessie" was once again sighted in Virginia (USGS, 2001). More recently, in August 2006, a West Indian manatee was sighted in waters off Rhode Island, Massachusetts, and in the Hudson River in New York City (Anonymous, 2006; Beck, 2006b).

Atlantic Ocean, Offshore of the Southeastern United States

The endangered West Indian manatee occurs in nearshore waters, shoreward of the JAX/CHASN OPAREA with some individuals making their way further north along the East Coast towards the VACAPES OPAREA. However, there are no records for manatees in the VACAPES OPAREA. Manatees are not likely to occur in the vicinity of the VACAPES OPAREA.

There are no records for manatees within the CHPT OPAREA. Manatees have been sighted in estuarine and coastal waters of North Carolina in all seasons, with the greatest number of reports occurring during summer and fall. Manatees are not likely to occur in the CHPT OPAREA.

Although manatees potentially occur, it is unlikely that they would be seen in the Southeast OPAREAs. The manatee occurs primarily in freshwater systems, estuaries, and shallow nearshore coastal waters.

Atlantic Ocean, Offshore of the Northeastern United States

The West Indian manatee is extralimital to the NE MRA study area at all times of the year. Sightings on the Atlantic coast drop off markedly north of South Carolina (Lefebvre et al., 2001). In 1995, “Chessie” made a 4,828 km (2,605 NM), round-trip journey between Florida and Rhode Island, leaving Rhode Island in mid-August (USGS, 2001).

Gulf of Mexico

West Indian manatees occur year-round in coastal waters from Pensacola, Florida, south to the tip of Florida, although some sporadic occurrences have been documented as far west as Texas. This species is not likely to occur as far offshore as the OPAREA boundaries (3 NM [6 km]). There are sightings in waters within the OPAREA boundaries, although manatee experts note that these should be considered anomalies due to the known habitat preferences of this species (Beck, 2006a).

5. TYPE OF INCIDENTAL TAKE REQUESTED

The Navy requests a Letter of Authorization (LOA) pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act (MMPA) for the harassment of marine mammals incidental to Atlantic Fleet Active Sonar Training. It is understood that an LOA is applicable for up 5 years, and is appropriate where authorization for serious injury or mortality of marine mammals is requested. In addition, the Navy requests the take, by serious injury or mortality, of 10 beaked whales, although the Navy does not anticipate that marine mammal strandings or mortality will result from conducting AFAST activities within the study area. The request is for mid- frequency sonar, high-frequency sonar, and explosive source sonobuoy (AN/SSQ-110A) exercises and training events conducted within the Atlantic Fleet Active Sonar Training (AFAST) Study Area (Figure 1-1). The request is for a 5-year period commencing in December 2008.

The acoustic modeling approach taken in the AFAST Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) and this LOA request attempts to quantify potential exposures to marine mammals resulting from operation of mid- and high-frequency active 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.

Modeling results predict no marine mammal mortalities. Modeling results do predict that for this LOA request, 1 sperm whale, 46 bottlenose dolphins, 12 pantropical spotted dolphins, 24 Atlantic spotted dolphins, 2 spinner dolphin, 4 Clymene dolphins, 9 striped dolphins, 5 common dolphins, 7 Risso's dolphins, and 10 pilot whales, and 9 harbor seals could be exposed to sonar in excess of permanent threshold shift (PTS) threshold indicative of Level A injury. However, given standard mitigation measures presented in Chapter 11, and the increased likelihood that these species can be readily detected (e.g., sperm and humpback whales are large and the other small cetaceans are often seen in large groups), a single Level A exposure to these species is less likely to occur.

The history of Navy activities in the AFAST study area and analysis in this document indicate that military readiness activities are not expected to result in any sonar – induced mortalities to marine mammals.

There are natural and manmade sources of mortality other than sonar and underwater detonation that may contribute to stranding events as described in the Cetacean Stranding Section (Chapter 6). The actual cause of a particular stranding may not be immediately apparent when there is little evidence of physical trauma, especially in the case of disease or age-related mortalities. These events require careful scientific investigation by a collaborative team of subject matter experts to determine actual cause of death.

Given the frequency of naturally occurring marine mammal strandings (e.g., natural mortality), it is conceivable that a stranding could co-occur with a Navy exercise even though the stranding is actually unrelated to and not caused by Navy activities.

In a letter from NMFS to Navy dated October 2006, NMFS indicated that Section 101(a)(5)(A) authorization is appropriate for mid-frequency active sonar activities because it allows NMFS to consider the potential for incidental mortality. NMFS' letter indicated; "Because mid-frequency sonar has been implicated in several marine mammal stranding events including some involving serious injury and mortality, and because there is no scientific consensus regarding the causal link between sonar and stranding events, NMFS cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury of mortality." Accordingly, the Navy's LOA application will include requests for take, by mortality, of 10 beaked whales.

Evidence from five beaked whale strandings which have occurred over approximately a decade, suggests that the exposure of beaked whales to mid-frequency sonar in the presence of certain conditions (e.g., multiple units using tactical sonar, steep bathymetry, constricted channels, strong surface ducts, etc.) may result in strandings, potentially leading to mortality. Although these physical factors believed to contribute to the likelihood of beaked whale strandings are not present, in their aggregate, in the AFAST study area, scientific uncertainty exists regarding what other factors, or combination of factors, may contribute to beaked whale strandings.

Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality will result from the operation of mid-frequency sonar during Navy exercises within the AFAST study area. However, by authorizing a very small number of mortalities for beaked whales, if a single individual of this species is found dead coincident with Navy activities, a potentially lengthy investigation of the cause(s) of the death would not unnecessarily interfere with Navy training exercises. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the unlikely event that a causal relationship were to be found between Navy activities and a future stranding. The Navy's LOA application requests the take, by serious injury or mortality, of 10 beaked whales. These numbers may be modified through the MMPA process, based on available data.

6. NUMBERS AND SPECIES EXPOSED

The Marine Mammal Protection Act (MMPA) requires applicants to determine the number of marine mammals that are expected to be incidentally harassed by an action and the nature of the harassment (Level A or Level B). The Proposed Action is a military readiness activity as defined in the MMPA, and Section 6.2.2 below defines MMPA Level A and Level B as applicable to military readiness activities. Section 6.2.1 presents how the Level A and Level B harassment definitions were applied to develop the quantitative acoustic analysis methodologies used to assess the potential for the proposed action to affect marine mammals.

6.1 NON-ACOUSTIC EFFECTS

Non-acoustic effects analyzed in the Atlantic Fleet Active Sonar Training (AFAST) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) (DON, 2007) included vessel strikes, entanglement from training materials, and water quality effects associated with expended sonobuoy batteries, explosive residuals, and torpedo sodium fluorescein dye. Marine mammals are also subject to entanglement in expended materials, particularly anything incorporating loops or rings, hooks and lines, or sharp objects. Most documented cases of entanglements occur when whales encounter the vertical lines of fixed fishing gear. Possible expended materials from AFAST activities include sonobuoys, torpedoes, Acoustic Device Countermeasure (ADCs), and Expendable Mobile Acoustic Training Target (EMATTs).

6.1.1 Vessel Strikes

Ship strikes are known to affect large whales in the AFAST Study Area. The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., the sperm whale). In addition, some baleen whales, such as the North Atlantic right whale seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al., 2004). These species are primarily large, slow moving whales. Smaller marine mammals-for example, Atlantic bottlenose and Atlantic spotted dolphins-move 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 minutes; Jacquet et al. 1998) "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 (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 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 Officer of the Deck 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 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 and Executive Officers 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.

Additionally, the Navy implements additional mitigation measures to protect North Atlantic right whales. The east coast is a principal migratory corridor for North Atlantic right whales that travel between the calving/nursery areas in the Southeastern United States and feeding grounds in the northeast U.S. and Canada. Transit to the Study Area 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 percent) occurring within 18.5 km (10 NM), and 94.1 percent 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 vessel collisions to right whales suggests that the threat of ship strikes is proportionally greater to this species (Jensen and Silber, 2004). 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 collisions with North Atlantic right whales while transiting to and from mid-Atlantic ports during right whale migratory periods. 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 to 3 percent of 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 proactively adopt additional mitigation measures for transits in the vicinity of mid-Atlantic ports during right whale migration. 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.

Specifically, the Navy has unilaterally adopted the following measures:

- During months of expected Atlantic Ocean 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 56 kilometers (km) (30 Nautical Miles [NM]) of the coast in the mid-Atlantic will ensure at least two lookouts are posted, including at least one 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 meters (m) (1,500 feet [ft]) away from any observed whale, consistent with vessel safety.

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 United States. 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 Study Area the likelihood that a vessel collision would occur is very low.

6.1.2 Expended Materials

Possible expended materials from active sonar activities include sonobuoys, torpedoes, ADCs, and EMATTs. This section will discuss entanglement and direct strike potential related to expending these active sonar activity materials.

6.1.2.1 Entanglement

Marine mammals are subject to entanglement in expended materials, particularly anything incorporating loops or rings, hooks and lines, or sharp objects. Most documented cases of entanglements occur when whales encounter the vertical lines of fixed fishing gear. In general, expended materials from AFAST activities, including torpedo guidance wires and flex hoses, as well as sonobuoy and EMATT parachutes, generally sink to the ocean floor. All of the materials are negatively buoyant and will sink to the ocean floor. In addition, many of the expended materials are metallic and will sink rapidly. For example, the Improved Extended Echo Ranging (IEER) system parachutes are weighted with metal clips, which assist in their quick decent to the sea floor. Entanglement and the eventual drowning of a marine mammal from the expended materials will be unlikely, since the item will have to land directly on an animal, or an animal will have to swim into it before it sinks. The prey items for each of the species that feed on or near the seafloor such as humpback whales and North Atlantic Right Whales are much smaller in size than the materials that will be expended during exercises (DON, 1996), making the expended items difficult to ingest. Furthermore, sediments will cover the expended material and reduce the potential for entanglement. The probability of a marine mammal encountering a parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines is unlikely.

The size of an EMATT or sonobuoy parachute assembly is approximately 30 to 46 centimeters (cm) (12 to 18 inches [in]). These properties make it unlikely that entanglement could occur. For example, Hezen (as cited in DON, 1996) theorized that the entanglement of marine mammals with undersea cables was a direct result of the mammal coming into contact with loops in the cable (e.g., swimming through loops that then tightened around the mammal). Since the EMATTs and sonobuoys are so small, there is little potential that a marine mammal would be present at the immediate location of deployment and reconnaissance and very little potential for physical contact. Furthermore, the torpedo guidance wire and flex hoses would not form loops that could entangle marine animals.

6.1.2.2 Direct Strike

The size of EMATTs and sonobuoys (12 by 91 centimeters [cm] [5 by 36 inches (in)]), coupled with the low probability that an animal would occur at the immediate location of deployment and reconnaissance, provide little potential for a direct strike. Moreover, there is a negligible risk that a marine mammal could be struck by a torpedo or MK-30 training target during ASW training activities. The acoustic homing programs of torpedoes are designed to detect either the mechanical sound signature of the submarine or active sonar returns from its metal hull with large, internal air volume interface. Their homing logic does not detect or recognize the relatively small air volume associated with the lungs of marine mammals. Furthermore, the Navy has conducted exercise torpedo activities since 1968 and there have been no recorded or reported instances of a marine species strike by an exercise torpedo during the 14,322 exercise torpedo runs. Additionally, each torpedo obtains a thorough post-run inspection for damage. Therefore, it was determined there would be no potential to affect to marine mammals from direct strikes related to the use of EMATTs, sonobuoys, torpedoes, or MK-30 training targets.

6.2 ACOUSTIC EFFECTS

6.2.1 Ship Noise

Increased number of ships operating in the area will result in increased sound from vessel traffic. Marine mammals react to vessel-generated sounds in a variety of ways. Some respond negatively by retreating or engaging in antagonistic responses while other animals ignore the stimulus altogether (Watkins, 1986; Terhune and Verboom, 1999).

Most studies have ascertained the short-term response to vessel sound and vessel traffic (Watkins, et al.,1981; Baker, et al., 1983; Magalhães, et al., 2002); however, the long-term implications of ship sound on marine mammals is largely unknown (NMFS, 2007a).

Anthropogenic sound has increased in the marine environment over the past 50 years (NRC Richardson,et al., 1995; 2003). This sound increase can be attributed to increases in vessel traffic as well as sound from marine dredging and construction, oil and gas drilling, geophysical surveys, sonar, and underwater explosions (Richardson, et al., 1995).

Given the current ambient sound levels in the marine environment, the amount of sound contributed by the use of Navy vessels in the proposed exercises is very low. It is anticipated that any marine mammals exposed would exhibit only short-term reactions and would not suffer any long-term consequences from ship sound.

6.2.2 Acoustic Systems Analyzed

Table 6-1 presents all of the acoustic systems used during Atlantic Fleet active sonar activities. As stated previously, systems that are typically operated at frequencies greater than 200 kHz were not analyzed. Note that some systems were found to have similar acoustic output parameters (i.e., frequency, power, deflection angles). For these systems, the system with the larger acoustic footprint was modeled which is representative of all similar systems.

Table 6-1. Acoustic Systems Analyzed

Systems that were Analyzed			
System	***Frequency***	***Associated Platform***	***System Description***
AN/SQS-53	MF	DDG and CG hull-mounted sonar	Utilized 70% in search mode and 30% track mode
AN/AQS-13 or AN/AQS-22*	MF	Helicopter dipping sonar	AN/AQS-22: 10 pings/dip, 30 seconds between pings)- also used to represent AN/AQS-13
Explosive source sonobuoy (AN/SSQ-110A)	Impulsive	Helicopter and MPA deployed	Contains two 4.1 lb charges
AN/SQQ-32	HF	MCM over the side system	Used during MIW training events detect, classify, and localize bottom and moored mines
AN/BQS-15	HF	Submarine navigational sonar	Only used when entering and leaving port
AN/SQS-56	MF	FFG hull-mounted sonar	Utilized 70% in search mode and 30% track mode
MK-48 Torpedo	HF	Submarine fired exercise torpedo	Active for 15 min per torpedo run
MK-46 Torpedo	HF	Surface ship and aircraft fired exercise torpedo	(15 min per torpedo run), modeling also used to represent MK-54
AN/SLQ-25 (NIXIE)	MF	DDG, CG, and FFG towed array	20 mins per use
AN/SQS-53 and AN/SQS-56 (Kingfisher)	MF	DDG, CG, and FFG hull-mounted sonar (object detection)	only modeled 53 Kingfisher, used to represent 56
AN/BQQ-10	MF	Submarine hull-mounted sonar	2 pings per hour
Tonal sonobuoy (DICASS) (AN/SSQ-62)	MF	Helicopter and MPA deployed	12 pings, 30 secs between pings
ADC MK-3 and MK-2**	MF	Submarine fired countermeasure	20 mins
Submarine fired countermeasure	MF	Submarine fired countermeasure	20 mins per use

*AN/AQS-22 modeling is representative of all helicopter dipping sonar

**MK-3 modeling is representative of all ADCs

ADC – Acoustic Device Countermeasure; CG – Guided Missile Cruiser; DDG – Guided Missile Destroyer; DICASS – Directional Command-Activated Sonobuoy System; DIFAR – Directional Frequency Analysis and Recording; FFG – Fast Frigate; HF – High-Frequency; MF – Mid-Frequency; MPA – Maritime Patrol Aircraft

6.2.3 Analytical Framework for Assessing Marine Mammal Response to Active Sonar

Marine mammals respond to various types of man-made sounds introduced in the ocean environment. Responses are typically subtle and can include shorter surfacings, shorter dives, fewer blows per surfacing, longer intervals between blows (breaths), ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council of the National Academies [NRC], 2005). However, it is not known how these responses relate to significant effects (e.g., long-term effects or population consequences) (NRC, 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals.

In estimating the potential for marine mammals to be exposed to an acoustic source, the following actions were completed:

- Evaluated potential effects within the context of existing and current regulations, thresholds, and criteria.
- Identified all acoustic sources that will be used during active sonar activities.
- Identified the location, season, and time of the action to determine which marine mammal species are likely to be present.
- Determined the estimated number of marine mammals (i.e., density) of each species that will likely be present in the respective areas during active sonar activities.
- Applied the applicable acoustic threshold criteria to the predicted sound exposures from the proposed activity. The results of this effort are then evaluated to determine whether the predicted sound exposures from the acoustic model might be considered harassment.
- Considered potential harassment within the context of the affected marine mammal population, stock, or species to assess potential population viability. Particular focus on recruitment and survival are provided to analyze whether the effects of the action can be considered to have negligible effects to species or stocks.

The following flow-chart (Figure 6-1) is a representation of the general analytical frame work utilized in applying the specific thresholds. The framework presented in the flow chart, is organized from left to right, and is compartmentalized according to the phenomena that occur within each. These include the physics of sound propagation (Physics), the potential physiological processes associated with sound exposure (Physiology), the potential behavioral processes that might be affected as a function of sound exposure (Behavior), and the immediate impacts these changes may have on functions the animal is engaged in at the time of exposure (Life Function – Proximate). These compartmentalized effects 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).

Some boxes contained within the flow-chart are colored according to how they relate to the definitions of harassment in the Marine Mammal Protection Act (MMPA). Red boxes correspond to events that are injurious. By prior ruling and usage, these events would be considered as Level A harassment under the MMPA. Yellow boxes correspond to events that have the potential to qualify as Level B harassment under the MMPA. Based on prior ruling, the specific instance of temporary threshold shift (TTS) is considered as Level B harassment. Boxes that are shaded from red to yellow have the potential for injury and behavioral disturbance.

The analytical framework outlined within the flow-chart acknowledges that physiological responses must always precede behavioral responses (i.e., there can be no behavioral response without first some physiological effect of the sound) and an organization where each functional block only occurs once and all relevant inputs/outputs flow to/from a single instance.

6.2.3.1 Physics

Starting with a sound source, the attenuation of an emitted sound due to propagation loss is determined. Uniform animal distribution is overlaid onto the calculated sound fields to assess if animals are physically present at sufficient received sound levels to be considered “exposed” to the sound. If the animal is determined to be exposed, two possible scenarios must be considered with respect to the animal’s physiology– effects on the auditory system and effects on 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. Note that the model does not account for any animal response; rather the animals are considered stationary, accumulating energy until the threshold is tripped.

6.2.3.2 Physiology

Potential impacts to the auditory system are assessed by considering the characteristics of the received sound (e.g., amplitude, frequency, duration) and the sensitivity of the exposed animals. Some of these assessments can be numerically based (e.g., TTS, permanent threshold shift [PTS], perception). 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 the sound exposure are ranked in descending order with the most severe impact (auditory trauma) occurring at the top and the least severe impact occurring at the bottom (the sound is not perceived).

1. 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. Auditory trauma is always injurious, but could be temporary and not result in PTS. Auditory trauma is always assumed to result in a stress response.
2. Auditory fatigue refers to a loss of hearing sensitivity after sound stimulation. The loss of sensitivity persists after, sometimes long after, the cessation of the sound. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic exhaustion of the hair cells and cochlear tissues. The features of the exposure (e.g., amplitude, frequency, duration, temporal pattern) and the individual animal’s susceptibility would determine the severity of fatigue and whether the effects were temporary (TTS) or permanent (PTS). Auditory fatigue (PTS or TTS) is always assumed to result in a stress response.
3. Sounds with sufficient amplitude and duration to be detected amongst the background ambient noise are considered to be perceived. This category includes sounds from the threshold of audibility through the normal dynamic range of hearing (i.e., not capable of producing fatigue). To determine whether an animal perceives the sound, the

1

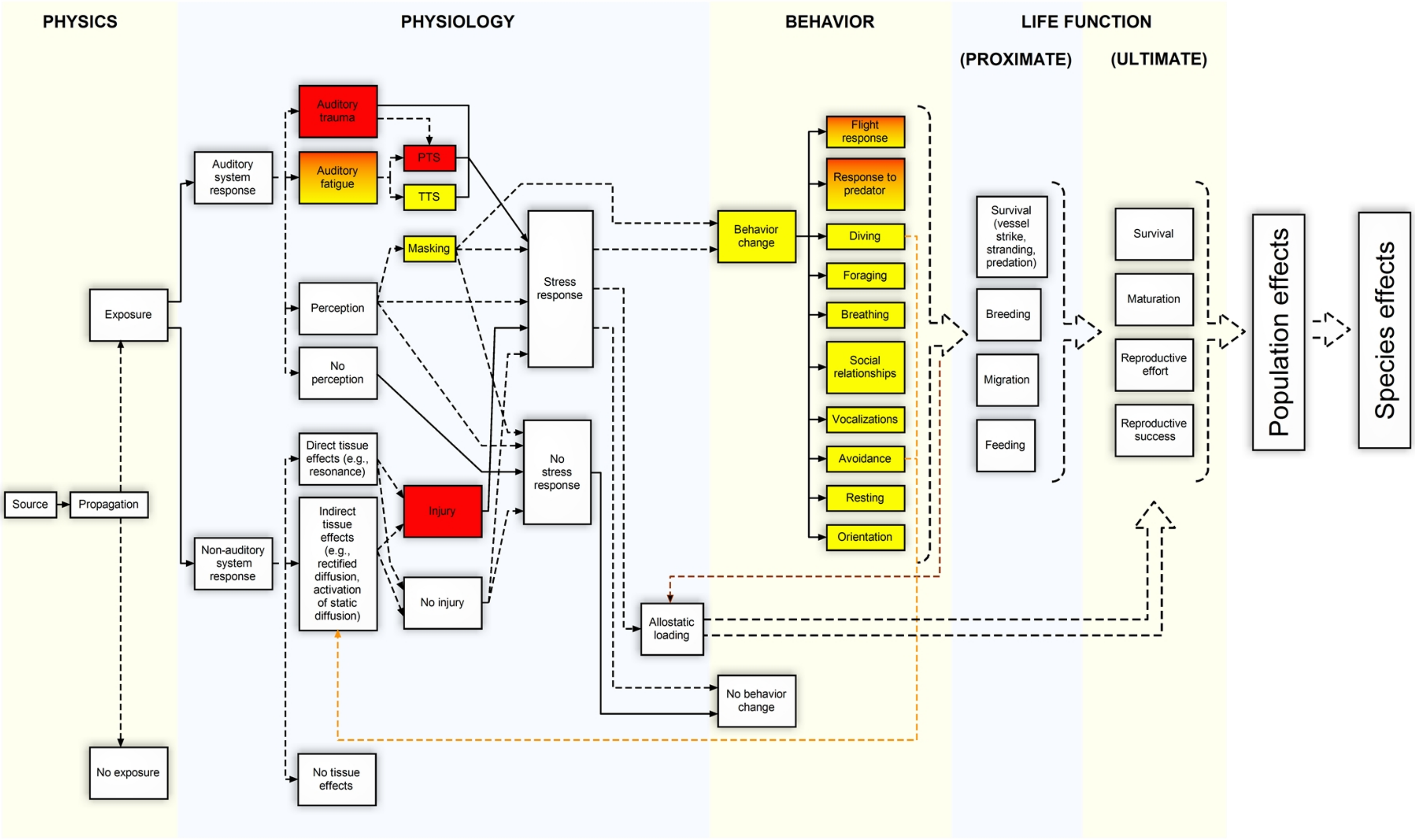

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Figure 6-1. Analytical Framework Flow-Chart

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from the threshold of audibility through the normal dynamic range of hearing (i.e., not capable of producing fatigue). 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.

Since audible sounds may interfere with an animal's ability to detect other sounds at the same time, perceived sounds have the potential to result in auditory masking. Unlike auditory fatigue, which always results in a stress response 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. 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 features of perceived sound (e.g., amplitude, duration, temporal pattern) are also used to judge whether the sound exposure is capable of producing a stress response. 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 of the exposure).

4. The received level is not of sufficient amplitude, frequency, and duration to be perceptible by the animal. By extension, this does not result in a stress 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. Each of the potential responses may or may not result in a stress response.

1. Direct tissue effects – Direct tissue responses to sound stimulation may range from tissue shearing (injury) to mechanical vibration with no resulting injury. Any tissue injury would produce a stress response whereas non-injurious stimulation may or may not.
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, the hypothesis that rectified diffusion occurs is based on the idea that bubbles that naturally exist in biological tissues can be stimulated to grow by an acoustic field. Under this hypothesis, one of three things could happen: (1) bubbles grow to the extent that tissue hemorrhage occurs (injury); (2) bubbles develop to the extent that a complement immune response is triggered or 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.

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

6.2.3.3 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 this flow chart and the upcoming discussions of allostasis and allostatic loading, 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) or the hypothalamic-pituitary-adrenal (HPA) axis (Reeder and Kramer, 2005). 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, predominantly cortisol in mammals. The amount of increase in circulating glucocorticoids above baseline may be in 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 nearly immediately and are used or cleared by the system quickly, whereas cortisol 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. 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.

The stress response may or may not result in a behavioral change**,** depending on the characteristics of the exposed animal. However, provided a stress response occurs we assume 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.

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, this flow chart assumes that the exposure does not contribute to the allostatic load. Additionally, without a stress response or auditory masking, it is assumed that there can be no behavioral change. Conversely, any immediate effect of exposure that produces an injury (i.e., red boxes on the flow chart) is assumed to also produce a stress response and contribute to the allostatic load.

6.2.3.4 Behavior

Acute stress responses may or may not cause a behavioral reaction. However, all changes in behavior are expected to result from an acute stress response. This expectation is based on the idea that some sort of physiological trigger must exist to change any 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.

Numerous behavioral changes can occur as a result of stress response 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 in the change and the severity of the response need to be estimated. Certain conditions, such as stampeding (i.e., flight response) or a response to a predator, might have a probability of resulting in injury. For example, a flight response, if significant enough, could produce a stranding event. Under the MMPA such an event would be considered a Level A harassment. 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. All behavioral disruptions have the potential to contribute to the allostatic load. This secondary potential is signified by the feedback from the collective behaviors to allostatic loading.

Special considerations are given to the potential for avoidance and disrupted diving patterns. 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. Although hypothetical in nature, the potential process is currently popular and hotly debated.

6.2.3.5 Life Function

6.2.3.5.1 Proximate Life Functions

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, is something that 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 is dependent upon 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.

6.2.3.5.2 Ultimate Life Functions

The ultimate life functions are those which enable an animal to contribute to the population (or stock, or species, etc.). 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. For example, unit level use of sonar by a vessel transiting through an area that is utilized for foraging, but not for breeding, may disrupt feeding by exposed animals for a brief period of time. Because of the brevity of the perturbation, the impact to ultimate life functions may be negligible. By contrast, weekly training over a period of years may have a more substantial impact because the stressor is chronic. Assessment of the magnitude of the stress response from the chronic perturbation would require an understanding of how and whether animals acclimate to a specific, repeated stressor and whether chronic elevations in the stress response (e.g., cortisol levels) produce 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.

6.2.4 Regulatory Framework

The MMPA prohibits the unauthorized harassment of marine mammals and provides the regulatory processes for authorization for any such harassment that might occur incidental to an otherwise lawful activity.

The regulatory framework for estimating potential acoustic effects from AFAST activities on marine mammal species makes use of the methodology that was developed in cooperation with NOAA for the Navy's Draft *Overseas Environmental Impact Statement/Environmental Impact Statement*, *Undersea Warfare Training Range (OEIS/EIS)* (DON, 2005b). Via response comment letter to Undersea Warfare Training Range (USWTR) received from NMFS 30 January 2006, NMFS concurred with the use of energy flux density level (EL) for the determination of physiological effects to marine mammals. Therefore, this methodology was used to estimate the annual exposure of marine mammals that may be considered Level A harassment (sound level threshold of 215 dB or above) or Level B harassment (sound levels below 215 decibel [dB] down to 195 dB) as a result of temporary, recoverable physiological effects.

In addition, the approach for estimating potential acoustic effects from AFAST activities on marine mammals makes use of the comments received on the Navy's Draft *Overseas Environmental Impact Statement/Environmental Impact Statement*, *Undersea Warfare Training Range (OEIS/EIS)* (DON, 2005b) and the *2006 Supplement to the 2002 Rim of the Pacific Programmatic Overseas Environmental Assessment* (DON, 2006g). NMFS and other commenters recommended the use of an alternate methodology to evaluate when sound exposures might result in behavioral effects without corresponding physiological effects (sound levels below the 195-dB threshold). As a result of these comments, this assessment used a dose-function approach to evaluate the potential for behavioral effects.

A number of Navy actions and NMFS rulings have helped to qualify possible activities deemed as "harassment" under the MMPA. As stated previously, "harassment" under the MMPA includes both potential injury (Level A) and disruptions of natural behavioral patterns to a point where they are abandoned or significantly altered (Level B). The acoustic effects analysis and exposure calculations are based on the following premises:

1. Harassment that may result from Navy operations is unintentional and incidental to those operations.
2. Use of an unambiguous definition of injury as defined in the Undersea Warfare Training Range Draft EIS/OEIS (DON, 2005b) and in previous rulings (NOAA, 2001 and 2002a): injury occurs when any biological tissue is damaged or lost as a result of the action.
3. Behavioral disruption might result in subsequent injury and injury may cause a subsequent behavioral disruption, so Level A and Level B harassment categories can overlap and are not necessarily mutually exclusive. However, based on prior ruling (NOAA, 2001 and 2006c), it is assumed that Level A and B do not overlap.

4. An individual animal predicted to experience simultaneous multiple injuries, multiple disruptions, or both are counted as a single take (see NOAA, 2001 and 2006c). An animal whose behavior is disrupted by an injury has already been counted as a Level A harassment and will not also be counted as a Level B harassment.

5. The acoustic effects analysis is based on primary exposures to the action. Secondary or indirect effects, such as such as susceptibility to predation following injury and injury resulting from disrupted behavior may not be readily determined unless directly observed, or the risk of occurrence concluded from previous well-documented examples. Consideration of secondary effects would result in some Level A harassment being considered Level B harassment, and vice versa, since much injury (Level A harassment) has the potential to disrupt behavior (Level B harassment), and much temporary physiological or behavioral disruption (Level B) could be conjectured to have the potential for injury (Level A). Consideration of secondary effects would lead to circular definitions of harassment.

6. Animals are uniformly distributed and remain stationary during the active sonar events; therefore, the model does not account for any animal response.

6.2.5 Integration of Regulatory and Biological Frameworks

This section presents a biological framework within which potential effects can be categorized and then related to the existing regulatory framework of injury (Level A) and behavioral disruption (Level B). The information presented in the subsections below was used to develop specific numerical exposure thresholds and dose-function estimations. Exposure thresholds were combined with sound propagation models and species distribution data to estimate the potential exposures.

6.2.5.1 Physiological and Behavioral Effects

Sound exposure may affect multiple biological traits of a marine animal; however, the MMPA as amended directs which traits should be used when determining effects. Effects that address injury are considered Level A harassment under MMPA. Effects that address behavioral disruption are considered Level B harassment under MMPA.

The biological framework discussed here is structured according to potential physiological and behavioral effects resulting from sound exposure. The range of effects may then be assessed to determine which qualify as injury or behavioral disturbance under MMPA regulations. Physiology and behavior are chosen over other biological traits because:

- They are consistent with regulatory statements defining harassment by injury and harassment by disturbance.
- They are components of other biological traits that may be relevant.
- They are a more sensitive and immediate indicator of effect.

For example, ecology is not used as the basis of the framework because the ecology of an animal is dependent on the interaction of an animal with the environment. The animal's interaction with the environment is driven both by its physiological function and its behavior, and an ecological effect may not be observable over short periods of observation. Ecological information is considered in the analysis of the effects to individual species.

A "physiological effect" is defined here as one in which the "normal" physiological function of the animal is altered in response to sound exposure. Physiological function is any of a collection of processes ranging from biochemical reactions to mechanical interaction and operation of organs and tissues within an animal. Physiological effects may range from the most significant of effects (i.e., mortality and serious injury) to lesser effects that define the lower end of the physiological effects range, such as the noninjurious distortion of auditory tissues. This latter physiological effect is important to the integration of the biological and regulatory frameworks and receives additional attention in later sections.

A "behavioral effect" is one in which the "normal" behavior or patterns of behavior of an animal are overtly disrupted in response to an acoustic exposure. Examples of behaviors of concern can be derived from the harassment definitions in the MMPA and the Endangered Species Act (ESA).

The term "normal" is used to qualify distinctions between physiological and behavioral effects. Its use follows the convention of normal daily variation in physiological and behavioral function without the influence of anthropogenic (e.g., man-made) acoustic sources. As a result, this document uses the following definitions:

- A physiological effect is a variation in an animal's physiology that results from an anthropogenic acoustic exposure and exceeds the normal daily variation in physiological function.
- A behavioral effect is a variation in an animal's behavior or behavior patterns that results from an anthropogenic acoustic exposure and exceeds the normal daily variation in behavior but arises through normal physiological process (it occurs without an accompanying physiological effect).

- The definitions of physiological effect and behavioral effect used here are specific to this document and should not be confused with more global definitions applied to the field of biology.

It is reasonable to expect some physiological effects to result in subsequent behavioral effects. For example, a marine mammal that suffers a severe injury may be expected to alter diving or foraging to the degree that its variation in these behaviors is outside that which is considered normal for the species. If a physiological effect is accompanied by a behavioral effect, the overall effect is characterized as a physiological effect; physiological effects take precedence over behavioral effects with regard to their ordering. This approach provides the most conservative ordering of effects with respect to severity, provides a rational approach to dealing with the overlap of the definitions, and avoids circular arguments.

The severity of physiological effects generally decreases with decreasing sound exposure and/or increasing distance from the sound source. The same generalization does not consistently hold for behavioral effects because they do not depend solely on the received sound level. Behavioral responses also depend on an animal's learned responses, innate response tendencies, motivational state, the pattern of the sound exposure, and the context in which the sound is presented. However, to provide a tractable approach to predicting acoustic effects that is relevant to the terms of behavioral disruption described in the MMPA, it is assumed here that the severities of behavioral effects also decrease with decreasing sound exposure and/or increasing distance from the sound source. Figure 6-2 shows the relationship between severity of effects, source distance, and exposure level.

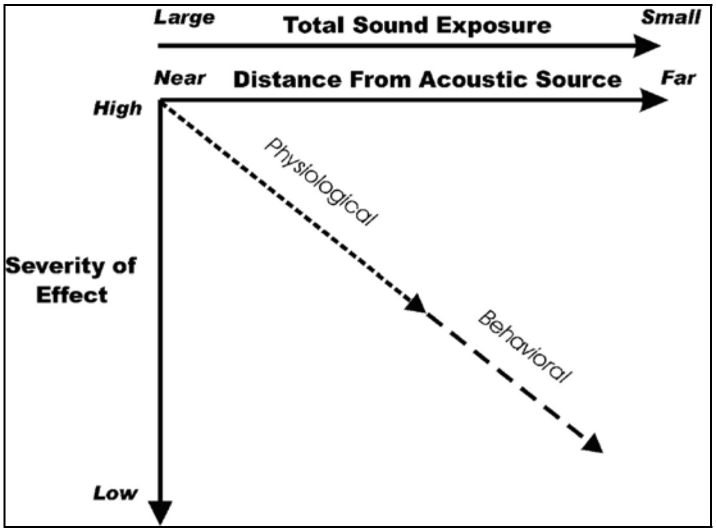

Figure 6-2. Relationship Between Severity of Effects, Source Distance, and Exposure Level

6.2.5.2 MMPA Level A and Level B Harassment

Categorizing potential effects as either physiological or behavioral effects allows them to be related to the harassment definitions. For military readiness activities, 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 previous rulings (NOAA, 2001 and 2002a), is the destruction or loss of biological tissue. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, the AFAST EIS/OEIS assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (NOAA, 2001), all injuries (slight to severe) are considered Level A harassment.

Public Law (PL) 108-136 (2004) amended the MMPA definitions 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 including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered.” Unlike Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause Level B harassment.

For example, some physiological effects can occur that are noninjurious but that can potentially disrupt the behavior of a marine mammal. These include temporary distortions in sensory tissue that alter physiological function but are fully recoverable without the requirement for tissue replacement or regeneration. For example, an animal that experiences a temporary reduction in hearing sensitivity 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.

The harassment status of slight behavior disruption has been addressed in workshops, previous actions, and rulings (NOAA, 1999 and 2001; DON, 2001b). The conclusion is that a momentary behavioral reaction of an animal to a brief, time-isolated acoustic activity 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).

Although the temporary lack of response discussed above may not result in abandonment or significant alteration of natural behavioral patterns, the acoustic effect inputs used in the acoustic model assume that temporary hearing impairment (slight to severe) is considered Level B harassment. These conclusions and definitions, including the 2004 amendments to the definitions of harassment, were considered in the context of the proposed AFAST activities in developing conservative thresholds for behavioral disruptions. As a result, the actual incidental harassment of marine mammals associated with this action may be less than that calculated.

6.2.5.3 MMPA Exposure Zones

Two acoustic modeling approaches are used to account for both physiological and behavioral effects to marine mammals. This subsection on exposure zones is specific to the modeling of total energy. When using a threshold of accumulated energy, the volumes of ocean in which Level A and Level B harassment are predicted to occur are called “exposure zones.” As a conservative estimate, all marine mammals predicted to be in a exposure zone are considered exposed to accumulated sound levels that may result in harassment within the applicable Level A or Level B harassment categories. Figure 6-3 illustrates exposure zones extending from a hypothetical, directional sound source.

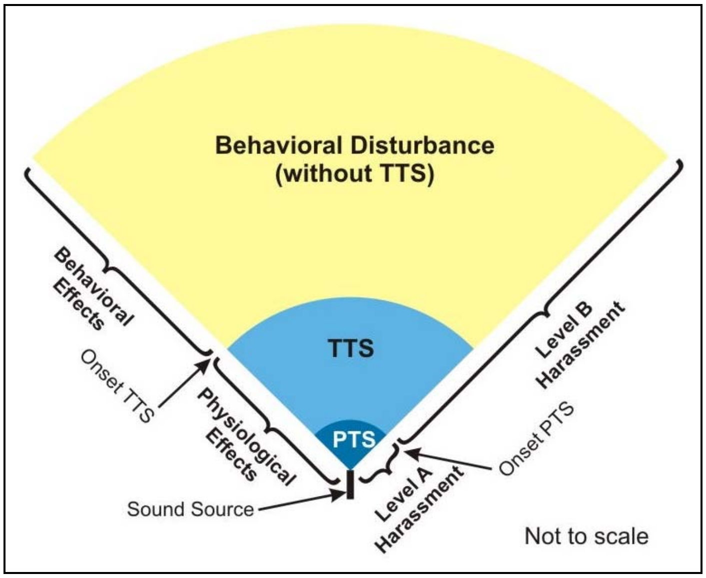

Figure 6-3. Exposure Zones Extending from a Hypothetical, Directional Sound Source
(This figure is not to scale and is intended to illustrate the general relationships between exposure zones and does not represent the sizes or shapes of the actual harassment zones)

The Level A exposure 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 exposure 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 exposure zone.

The Level B exposure zone begins just beyond the point of slightest injury and extends outward from that point to include all animals that may possibly experience Level B harassment. Physiological effects extend beyond the range of slightest injury to a point where slight temporary distortion of the most sensitive tissue occurs but without destruction or loss of that tissue. The animals predicted to be in this exposure zone are assumed to experience Level B harassment by virtue of temporary impairment of sensory function (altered physiological function) that can disrupt behavior.

6.2.5.4 Auditory Tissues as Indicators of Physiological Effects

Exposure to continuous-type sound may cause a variety of physiological effects in mammals. For example, exposure to very high sound levels may affect the function of the visual system, vestibular system, and internal organs (Ward, 1997). Exposure to high-intensity, continuous-type sounds of sufficient duration may cause injury to the lungs and intestines (e.g., Dalecki et al., 2002). Sudden, intense sounds may elicit a “startle” response and may be followed by an orienting reflex (Ward, 1997; Jansen, 1998). The primary physiological effects of sound, however, 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 middle ears to fluids within the inner ear, except in cetaceans. 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 sound exposure (Yost, 1994).

Very high sound levels may rupture the eardrum or damage the small bones in the middle ear (Yost, 1994). Lower level exposures of sufficient duration may cause permanent or temporary hearing loss; such an effect is called a noise-induced threshold shift, or simply a threshold shift (TS) (Miller, 1974). A TS may be either temporary (TTS) or permanent (PTS). PTS does not equal permanent hearing loss; more correctly, it is a permanent loss of hearing sensitivity, usually over a subset of the animal's hearing range. Similarly, TTS is a temporary hearing sensitivity loss, usually over a subset of the animal's hearing range. Still lower levels of sound may result in auditory masking, which may interfere with an animal’s ability to hear other concurrent sounds.

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 here as the biological indicators of physiological effects. TTS is the first indication of physiological noninjurious change and is not physical injury. The remainder of this section is, therefore, focused on TSs, including PTSs and TTSs. Since masking (without a resulting TS) is not associated with abnormal physiological function, it is not considered a physiological effect for this assessment but rather a potential behavioral effect.

6.2.5.4.1 Noise-Induced Threshold Shifts

The amount of TS depends on the amplitude, duration, frequency, and temporal pattern of the sound exposure. Threshold shifts generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward, 1997). For intermittent sounds, less TS occurs than from a continuous exposure with the same energy (some recovery will occur between exposures) (Kryter et al., 1966; Ward, 1997).

The magnitude of a TS normally decreases with the amount of time post-exposure (Miller, 1974). The amount of TS just after exposure is called the initial TS. If the TS activity returns to zero (the threshold returns to the pre-exposure value), the TS is a TTS. Since the amount of TTS depends on the time post-exposure, it is common to use a subscript to indicate the time in minutes after exposure (Quaranta et al., 1998). For example, TTS_2 means a TTS measured two minutes after exposure. If the TS does not return to zero but leaves some finite amount of TS, then that remaining TS is a PTS. The distinction between PTS and TTS is based on whether there is a complete recovery of a TS following a sound exposure. Figure 6-4 shows two hypothetical TSs: one that completely recovers (a TTS) and one that does not completely recover, leaving some PTS.

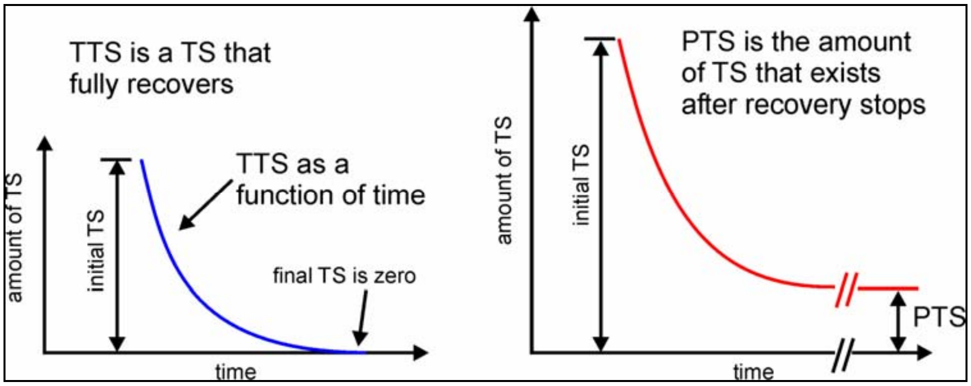

Figure 6-4. Hypothetical Temporary and Permanent Threshold Shifts

6.2.5.4.2 PTS, TTS, and Exposure Zones

PTS is nonrecoverable and therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA. 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 exposure zone.

TTS is recoverable and, as in recent rulings (NOAA, 2001; 2002a), is considered to result from the temporary, noninjurious distortion of hearing-related tissues. In the AFAST Study Area, the smallest measurable amount of TTS (onset-TTS) is taken as the best indicator for slight temporary sensory impairment. Because it is considered noninjurious, the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the Level B exposure zone attributable to physiological effects. This follows from the concept that hearing loss potentially affects an animal’s ability to react normally to the sounds around it. Therefore, the potential for TTS is considered as a Level B harassment that is mediated by physiological effects upon the auditory system.

6.2.5.5 Summary

The volumes of ocean in which Level A and Level B harassment are predicted to occur are described as exposure zones. The exposure zone for Level A harassment extends from the source out to the distance and exposure where onset-PTS is predicted to occur. The exposure zone for Level B harassment 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 exposure zone for Level B harassment includes both behavioral effects and physiological effects, and includes the region in which TTS is predicted to occur.

6.2.6 Criteria and Thresholds for Physiological Effects (Active Sonar)

This section presents the effect criteria and thresholds for physiological effects of sound leading to injury and behavioral disturbance as a result of sensory impairment. The tissues of the ear are 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. This section is, therefore, focused on criteria and thresholds to predict PTS and TTS in marine mammals.

The most appropriate information from which to develop PTS/TTS criteria for marine mammals are experimental measurements of PTS and TTS from marine mammal species of interest. TTS data exist for several marine mammal species and may be used to develop meaningful TTS criteria and thresholds. PTS data do not exist for marine mammals and are unlikely to be obtained. Therefore, PTS criteria must be developed from TTS criteria and estimates of the relationship between TTS and PTS.

This section begins with a review of the existing marine mammal TTS data. The review is followed by a discussion of the relationship between TTS and PTS. The specific criteria and thresholds for TTS and PTS used in the analyses are then presented. This is followed by discussions of sound energy flux density level (EL), the relationship between EL and SPL, and the use of SPL and EL in previous environmental compliance documents.

6.2.6.1 Energy Flux Density Level and Sound Pressure Level

EL is a measure of the sound energy flow per unit area expressed in dB. EL is stated in dB decibels referenced to 1 micropascal squared second (dB re 1 µPa^2-s) for underwater sound and dB re 20 µPa^2-s for airborne sound.

SPL is a measure of the root-mean square, or “effective,” sound pressure in decibels. SPL is expressed in dB re 1 µPa for underwater sound and dB re 20 µPa for airborne sound.

6.2.6.2 TTS in Marine Mammals

A number of investigators have measured TTS in marine mammals. These studies measured hearing thresholds in trained marine mammals 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 (e.g., Schlundt et al., 2000). The existing marine mammal TTS data are summarized in the following bullets.

- **Schlundt** et al. **(2000)** reported the results of TTS experiments conducted with bottlenose dolphins and white whales exposed to one second tones. This paper also includes a re-analysis of preliminary TTS data released in a technical report by Ridgway et al. (1997). At frequencies of 3, 10, and 20 kilohertz (kHz), SPLs necessary to induce measurable amounts (6 dB or more) of TTS were between 192 and 201 dB re 1 µPa (EL = 192 to 201 dB re 1 µPa^2-s). The mean exposure SPL and EL for onset-TTS were 195 dB re 1 µPa and 195 dB re 1 µPa^2-s, respectively. The sound exposure stimuli (tones) and relatively large number of test subjects (five dolphins and two white whales) make the Schlundt et al. (2000) data the most directly relevant TTS information for the scenarios described in this LOA.

- **Finneran** et al. **(2001, 2003, 2005)** described TTS experiments conducted with bottlenose dolphins exposed to 3 kHz tones with durations of 1, 2, 4, and 8 seconds. Small amounts of TTS (3 to 6 dB) were observed in one dolphin after exposure to ELs between 190 and 204 dB re 1 µPa^2-s. These results were consistent with the data of Schlundt et al. (2000) and showed that the Schlundt et al. (2000) data were not significantly affected by the masking sound used. These results also confirmed that, for tones with different durations, the amount of TTS is best correlated with the exposure EL rather than the exposure SPL.

- **Nachtigall** et al. **(2003a, 2004)** measured TTS in a bottlenose dolphin exposed to octave-band sound centered at 7.5 kHz. Nachtigall et al. (2003a) reported TTSs of about 11 dB measured 10 to 15 minutes after exposure to 30 to 50 minutes of sound with SPL 179 dB re 1 µPa (EL about 213 dB re µPa^2-s). No TTS was observed after exposure to the same sound at 165 and 171 dB re 1 µPa. Nachtigall et al. (2004) reported TTSs of around 4 to 8 dB 5 minutes after exposure to 30 to 50 minutes of sound with SPL 160 dB re 1 µPa (EL about 193 to 195 dB re 1 µPa^2-s). The difference in results was attributed to faster post-exposure threshold measurement; TTS may have recovered before being detected by Nachtigall et al. (2003a). These studies showed that, for long-duration exposures, lower sound pressures are required to induce TTS than are required for short-duration tones. These data also confirmed that, for the cetaceans studied, EL is the most appropriate predictor for onset-TTS.

- **Finneran** et al. **(2000, 2002)** conducted TTS experiments with dolphins and white whales exposed to impulsive sounds similar to those produced by distant underwater explosions and seismic waterguns. These studies showed that, for very short-duration impulsive sounds, higher sound pressures were required to induce TTS than for longer-duration tones.

- **Kastak** et al. **(1999, 2005)** conducted TTS experiments with three species of pinnipeds, California sea lion, northern elephant seal, and a Pacific harbor seal exposed to continuous underwater sounds at levels of 80 and 95 dB Sensation Level (SL) at 2.5 and 3.5 kHz for up to 50 minutes. Mean TTS shifts of up to 12.2 dB occurred with the harbor seals showing the largest shift of 28.1 dB. Increasing the sound duration had a greater effect on TTS than increasing the sound level from 80 to 95 dB.

Figure 6-5 shows the existing TTS data for cetaceans (dolphins and white whales). Individual exposures are shown in terms of SPL versus exposure duration (upper panel) and EL versus exposure duration (lower panel). Exposures that produced TTS are shown as filled symbols. Exposures that did not produce TTS are represented by open symbols. The squares and triangles represent impulsive test results from Finneran et al., 2000 and 2002, respectively. The circles show the 3, 10, and 20 kHz data from Schlundt et al. (2000) and the results of Finneran et al. (2003). The inverted triangle represents data from Nachtigall et al. (2004).

Figure 6-5 illustrates that the effects of the different sound exposures depend on the SPL and duration. As the duration decreases, higher SPLs are required to cause TTS. In contrast, the ELs required for TTS do not show the same type of variation with exposure duration.

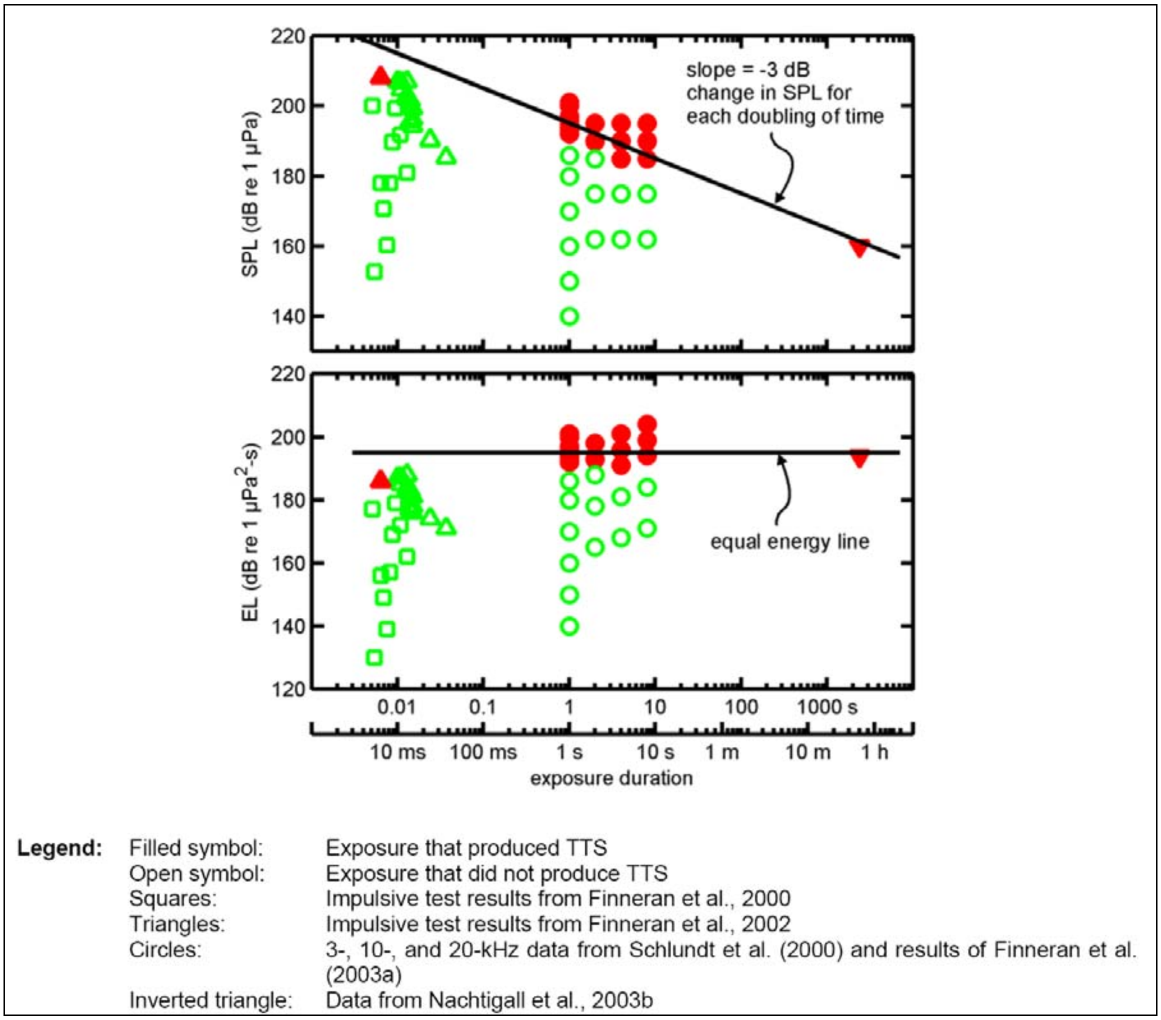

Figure 6-5. Existing TTS Data for Cetaceans

The solid line in the upper panel of Figure 6-5 has a slope of -3 dB per doubling of time. This line passes through the point where the SPL is 195 dB re 1 µPa and the exposure duration is 1 second. Since EL = SPL + 10 $\log_{10}$(duration), doubling the duration *increases* the EL by 3 dB. Subtracting 3 dB from the SPL *decreases* the EL by 3 dB. The line with a slope of -3 dB per doubling of time, therefore, represents an *equal energy line* – all points on the line have the same EL, which is, in this case, 195 dB re 1 µPa^2-s. This line appears in the lower panel as a horizontal line at 195 dB re 1 µPa^2-s. The equal energy line at 195 dB re 1 µPa^2-s fits the tonal and sound data (the nonimpulsive data) very well, despite differences in exposure duration, SPL, experimental methods, and subjects.

In summary, the existing marine mammal TTS data show that, for the species studied and sounds (nonexplosive) of interest, the following is true:

- **The growth and recovery of TTS are comparable 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 between exposures) (Ward, 1997).
- **SPL by itself is not a good predictor of onset-TTS**, since the amount of TTS depends on both SPL and duration.
- **Exposure EL is correlated with the amount of TTS** and is a good predictor for onset-TTS for single, continuous exposures with different durations. This agrees with human TTS data presented by Ward et al. (1958 and 1959). An EL of 195 dB re 1 µPa^2-s is the most appropriate predictor for onset-TTS from a single, continuous exposure.

6.2.6.3 Relationship Between TTS and PTS

Since marine mammal PTS data do not exist, onset-PTS levels for these animals must be estimated using TTS data and relationships between TTS and PTS. Much of the early human TTS work was directed towards relating TTS$_2$ after 8 hours of sound exposure to the amount of PTS that would exist after years of similar daily exposures (e.g., Kryter et al., 1966). Although it is now acknowledged that susceptibility to PTS cannot be reliably predicted from TTS measurements, TTS data do provide insight into the amount of TS that may be induced without a PTS. Experimental studies of the growth of TTS may also be used to relate changes in exposure level to changes in the amount of TTS induced. Onset-PTS exposure levels may therefore be predicted by:

- 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 that, again, may be induced without PTS. This is equivalent to estimating the growth rate of TTS—how much additional TTS is produced by an increase in exposure level.

Experimentally induced TTSs in marine mammals have generally been limited to around 2 to 10 dB, well below TSs that result in some PTS. Experiments with terrestrial mammals have used much larger TSs and provide more guidance on how high a TS may rise before some PTS results. Early human TTS studies reported complete recovery of TTSs as high as 50 dB after exposure to broadband sound (Ward, 1960; Ward et al., 1958 and 1959). Ward et al. (1959) also reported slower recovery times when TTS$_2$ approached and exceeded 50 dB, suggesting that 50 dB of TTS$_2$ may represent a “critical” TTS. Miller et al. (1963) found PTS in cats after exposures that were only slightly longer in duration than those causing 40 dB of TTS. Kryter et al. (1966) stated: “A TTS_2 that approaches or exceeds 40 dB can be taken as a signal that danger to hearing is imminent.” These data 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.

The small amounts of TTS produced in marine mammal studies also limit the applicability of these data to estimates of the growth rate of TTS. Fortunately, data do exist for the growth of TTS in terrestrial mammals. For moderate exposure durations (a few minutes to hours), TTS_2 varies with the logarithm of exposure time (Ward et al., 1958 and 1959; Quaranta et al., 1998). For shorter exposure durations, the growth of TTS with exposure time appears to be less rapid (Miller, 1974; Keeler, 1976). For very long-duration exposures, increasing the exposure time may fail to produce any additional TTS, a condition known as asymptotic threshold shift (Saunders et al., 1977; Mills et al., 1979).

Ward et al. (1958 and 1959) provided detailed information on the growth of TTS in humans. Ward et al. presented the amount of TTS measured after exposure to specific SPLs and durations of broadband sound. Since the relationship between EL, SPL, and duration is known, these same data could be presented in terms of the amount of TTS produced by exposures with different ELs. Figure 6-6 shows results from Ward et al. (1958 and 1959) plotted as the amount of TTS_2 versus the exposure EL. The data in Figure 6-6(a) are from broadband (75 hertz [Hz] to 10 kHz) sound exposures with durations of 12 to 102 minutes (Ward et al., 1958). The symbols represent mean TTS_2 for 13 individuals exposed to continuous sound. The solid line is a linear regression fit to all but the two data points at the lowest exposure EL. The experimental data are fit well by the regression line (R2 = 0.95). These data are important for two reasons: (1) they confirm that the amount of TTS is correlated with the exposure EL; and (2) the slope of the line allows one to estimate the additional amount of TTS produced by an increase in exposure. For example, the slope of the line in Figure 6-6(a) is approximately 1.5 dB TTS_2 per dB of EL. This means that each additional dB of EL produces 1.5 dB of additional TTS_2.

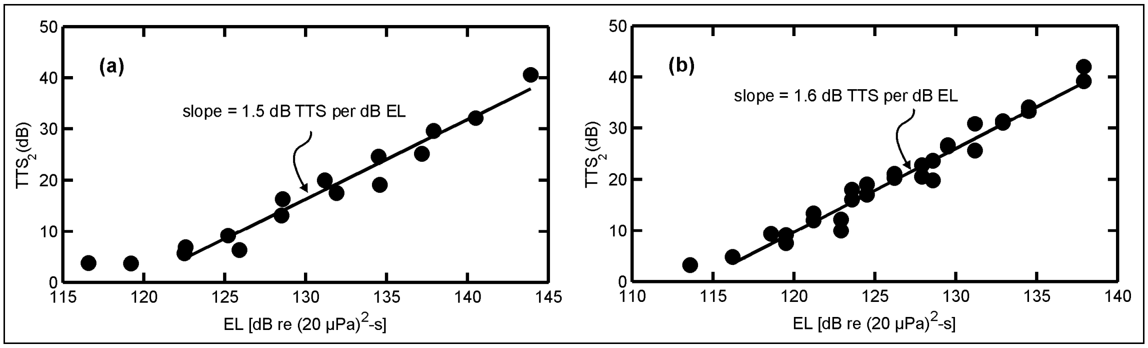

Figure 6-6a (left) and Figure 6-6b (right). Growth of TTS Versus the Exposure EL
(from Ward et al., 1958 and 1959)

The data in Figure 6-6(b) are from octave-band sound exposures (2.4 to 4.8 kHz) with durations of 12 to 102 minutes (Ward et al., 1959). The symbols represent mean TTS for 13 individuals exposed to continuous sound. The linear regression was fit to all but the two data points at the lowest exposure EL. The results are similar to those shown in Figure 6-6(a). The slope of the regression line fit to the mean TTS data was 1.6 dB TTS_2/dB EL. A similar procedure was carried out for the remaining data from Ward et al. (1959), with comparable results. Regression lines fit to the TTS versus EL data had slopes ranging from 0.76 to 1.6 dB TTS_2/dB EL, depending on the frequencies of the sound exposure and hearing test.

An estimate of 1.6 dB TTS_2 per dB increase in exposure EL is the upper range of values from Ward et al. (1958 and 1959) and gives the most conservative estimate—it predicts a larger amount of TTS from the same exposure compared to the lines with smaller slopes. The difference between onset-TTS (6 dB) and the upper limit of TTS before PTS (40 dB) is 34 dB. To move from onset-TTS to onset-PTS, therefore, requires an increase in EL of 34 dB divided by 1.6 dB/dB, or approximately 21 dB. An estimate of 20 dB between exposures sufficient to cause onset-TTS and those capable of causing onset-PTS is a reasonable approximation. To summarize:

- 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 growth rate of TTS, i.e., determining how much additional TTS is produced by an increase in exposure level.
- A variety of terrestrial mammal data sources point toward 40 dB as a reasonable estimate of the largest amount of TS that may be induced without PTS. A conservative estimate is that continuous-type exposures producing TSs of 40 dB or more always result in some amount of PTS.
- Data from Ward et al. (1958 and 1959) reveal a linear relationship between TTS2 and exposure EL. A 1.6 dB TTS2 per dB increase in EL is a conservative estimate of how much additional TTS is produced by an increase in exposure level for continuous-type sounds.
- 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 is therefore 34 dB divided by 1.6 dB/dB, or approximately 21 dB.
- Exposures with ELs 20 dB above those producing TTS may be assumed to produce a PTS. This number is used as a conservative simplification of the 21 dB number derived above.

6.2.6.4 Threshold Levels for Harassment from Physiological Effects

For this specified action, sound exposure thresholds for TTS and PTS are as presented in the following box:

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

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

Marine mammals predicted to receive a sound exposure with EL of 215 dB re 1 µPa^2-s or greater are assumed to experience PTS and are counted as Level A harassment exposures. Marine mammals 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 are assumed to experience TTS and are counted as Level B harassment exposures.

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. 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 short-duration tone data of Finneran et al. (2000 and 2003) and the long-duration sound data from Nachtigall et al. (2003a, 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 is conservative because: (1) 40 dB of TS is actually an upper limit for TTS used to approximate onset-PTS, and (2) the 1.6 dB/dB growth rate is the highest observed in the data from Ward et al. (1958 and 1959).

6.2.6.5 Use of EL for Physiological Effect Thresholds

Effect thresholds 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 of interest, 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:

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

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 mammalian TS data show less effect from intermittent exposures compared to continuous exposures with the same energy (Ward, 1997), basing the effect 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 effect of a particular exposure.

Therefore, estimates are conservative because recovery is not taken into account and intermittent exposures are considered comparable 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 second.
- A single ping with SPL = 192 dB re 1 µPa and duration = 2 seconds.
- Two pings with SPL = 192 dB re 1 µPa and duration = 1 second.
- Two pings with SPL = 189 dB re 1 µPa and duration = 2 seconds.

6.2.6.6 Comparison to Surveillance Towed Array Sensor System Low-Frequency Active Risk Functions

The physiological effect thresholds described in this LOA should not be confused with criteria and thresholds used for the Navy’s Surveillance Towed Array Sensor System Low-Frequency Active (SURTASS LFA) sonar. SURTASS LFA features pings lasting many tens of seconds. The sonars of concern for use during AFAST activities emit pings lasting a few seconds at most. SURTASS LFA risk functions were expressed in terms of the received “single ping equivalent” SPL. Physiological effect thresholds in this LOA are expressed in terms of the total received EL. The SURTASS LFA risk function parameters cannot be directly compared to the effect thresholds used in the AFAST EIS/OEIS. Comparisons must take into account the differences in ping duration, number of pings received, and method of accumulating effects over multiple pings.

6.2.6.7 Previous Use of EL for Physiological Effects

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, 1998 and 2001b). 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 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 one second tones. At the time, no impulsive test data for marine mammals were available and the one second 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., 2001 and 2003; Nachtigall et al., 2003a and 2004). The acoustical analyses 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. 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 exposures in future actions relies (in part) on using the EL at which onset-TTS will most likely occur. When that 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 exposures by onset-TTS over all of those exercises. Use of the minimum value would overestimate the number of exposures because many animals counted would not have experienced onset-TTS. Further, no logical limiting minimum value of the distribution would be obtained from continued successive testing. Continued testing and use of the minimum would produce more and more erroneous estimates.

6.2.6.8 Summary of Criteria and Thresholds for Physiological Effects

PTS and TTS are used as the criteria for physiological effects resulting in injury (Level A harassment) and 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.

6.2.7 Criteria and Thresholds for Behavioral Effects (Active Sonar)

This section presents the effect criterion and threshold for behavioral effects of sound leading to behavioral disturbance without accompanying physiological effects. Since TTS is used as the biological indicator for a physiological effect leading to behavioral disturbance, the behavioral effects discussed in this section may be thought of as behavioral disturbance occurring at exposure levels below those causing TTS.

6.2.7.1 History of Assessing Potential Harassment from Behavioral Effects

PTS and TTS are used as the criteria for physiological effects resulting in injury (Level A harassment) and disturbance (Level B harassment), respectively. Sound exposure thresholds for TTS and PTS are 195 dB re 1 µPa2-s received EL for TTS and 215 dB re 1 µPa2-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.

Behavioral observations of trained cetaceans exposed to intense underwater sound under controlled circumstances are an important data set in evaluating and developing a criterion and threshold for behavioral effects of sound. These behavioral response data are an important foundation for the scientific basis of the Navy's prior threshold of onset behavioral effects because of the: (1) finer control over acoustic conditions; (2) greater quality and confidence in recorded sound exposures; and (3) the exposure stimuli closely match those of interest for the mid-frequency active sonar used during AFAST activities. Since no comparable controlled exposure data for wild animals exist, or are likely to be obtained in the near-term, the relationship between the behavioral results reported by Finneran and Schlundt (2004) and wild animals is not known. Although experienced, trained subjects may tolerate higher sound levels than inexperienced animals, it is also possible that prior experiences and resultant expectations may have made some trained subjects less tolerant of sound exposures. However, in response to USWTR comments, potential differences between trained subjects and wild animals were considered by the Navy in conjunction with NMFS in the Navy's application for harassment authorization for RIMPAC 2006. At that time, NMFS recommended the Navy include analysis of this threshold based on NMFS' evaluation of behavioral observations of marine mammals under controlled conditions, plus NMFS' interpretation of two additional studies on reactions to vessel sound (Nowacek et al., 2004) and analysis for the U.S.S. SHOUP event (NMFS, 2005).

For that exercise, a conservative threshold for effect was derived compared to the regulatory definition of harassment, and the Navy agreed to the use of the 173 dB re 1 μPa^2-s threshold for the RIMPAC incidental harassment authorization (IHA) request. Rationale for using energy flux density for evaluation of behavioral effects included:

- **EL effect exposures account for both the exposure SPL and duration into account.** Both SPL and duration of exposure affect behavioral responses to sound, so a behavioral effect threshold based on EL accounts for exposure duration.
- **EL takes into account the effects of multiple pings.** Effect thresholds based on SPL predict the same effect regardless of the number of received sounds. Previous actions using SPL-based criteria included implicit methods to account for multiple pings, such as the single-ping equivalent used in the surveillance towed array sensor system low frequency active (SURTASS LFA) (DON, 2001b).
- **EL allows a rational ordering of behavioral effects with physiological effects.** The effect thresholds for physiological effects are stated in terms of EL because experimental data described above showed that the observed effects (TTS and PTS) are correlated best with the sound energy, not the SPL. Using EL for behavioral effects allows the behavioral and physiological effects to be placed on a single exposure scale, with behavioral effects occurring at lower exposures than physiological effects.

Subsequent to issuance of the RIMPAC IHA, additional public comments were received and considered. Based on this input, the Navy continued to coordinate with NMFS to determine whether an alternate approach to energy flux density could be used to evaluate when a marine mammal may behaviorally be affected by mid-frequency sonar sound exposures. Coordination between the Navy and NMFS produced the adoption of dose function for evaluation of behavioral effects. The dose function approach for evaluating behavioral effects is described below, and fully considers the controlled, tonal sound exposure data, in addition to comments received from regulatory agencies, the scientific community and the public regarding concerns with the use of EL for evaluating the effects of sound on wild animals.

6.2.7.2 Defining MMPA Level B Behavioral Harassment Using Risk Function

In the Hawaii Range Complex Draft EIS, the Navy presented a dose methodology to assess MMPA Level B behavioral harassment from the effects of mid-frequency active sonar on marine mammals. Based on comments received from the public and regulator on that document, the Navy now presents a more concise mathematical representation of a risk assessment to define behavioral harassment under the MMPA. The AFAST Draft EIS/OEIS explains the approach for assessing MMPA Level B behavioral harassment from the effects of MFA sonar on marine mammals using the mathematical function previously presented in the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) EIS (DON, 2001) and relied on in Supplemental SURTASS LFA EIS (DON, 2007) with input parameters modified for MFA sonar.

6.2.7.3 Summary of Potential Behavioral Effects of MFA Sonar

Based on the evidence available, 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:

- They will try to avoid exposure or continued exposure,
- They will experience behavioral disturbance (including distress or disruption of social or foraging activity),
- They will habituate to the sound,
- They will become sensitized to the sound, or
- They will not respond.

In experimental trials with trained marine mammals exposed to mid-frequency tones, behavioral changes typically involved 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., 2002). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa 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., 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al., 1997;Schlundt et al., 2000).

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), 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., 1995, Wartzok et al., 2003). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict.

Acoustic exposures can also result in noise induced reduction in hearing sensitivity that is a function of the interactions of several factors, including individual hearing sensitivity and exposure amplitude, exposure duration, frequency, and other variables that have not been studied extensively (e.g., kurtosis, temporal pattern, directionality). Reduction of hearing sensitivity is referred to as a “threshold shift.” The extent and duration of threshold shift depends on a combination of several acoustic features and is specific to particular species. A shift in hearing sensitivity may be temporary (temporary threshold shift or TTS) or it may be permanent (permanent threshold shift or PTS) depending on how the frequency, amplitude and duration of the exposure combine to produce damage and if that change is reversible.

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 of/factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira, Spain in 2000; and the Canary Islands in 2002 and 2004 (Advisory Committee Report, 2006). In these circumstances, exposure to acoustic energy has been considered an indirect cause of the death of marine mammals (Cox et al., 2006).

6.2.7.4 Methodology for Applying Risk Function

To assess the potential effects on marine mammals from active sonar used during training activities, the Navy together with the National Marine Fisheries Service (NMFS) first investigated a series of mathematical models and methodologies that estimate the number of times individuals of the different species of marine mammal might be exposed to MFA sonar at different received levels. These effects analyses assumed that the potential consequences of exposure to MFA sonar on individual animals would be a function of the intensity (measured in both sound pressure level (dB re 1 µPa) and frequency), duration, and how often the animal was exposed to the mid-frequency transmissions. These exposure analyses assume that MFA sonar poses no risk (i.e., does not constitute harassment) to marine mammals if they are exposed to sound pressure levels from the MFA sonar below some basement value. It may be possible active sonar could have various indirect, adverse effects on marine mammals, however, the Navy and NMFS did not identify situations where this concern might apply.

The second step of the assessment procedure requires the Navy and NMFS to identify how marine mammals are likely to respond when and if they are exposed to active sonar. Marine mammals can experience a variety of responses to sound including sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, social responses that might result in reducing the fitness of individual marine mammals, and social responses that won't result in reducing the fitness of individual marine mammals.

In the past, the Navy and NMFS have used "acoustic thresholds" to identify the number of marine mammals that might experience hearing sensitivity shifts or behavioral harassment upon being exposed to mid-frequency active sonar (see Figure 6.7 left panel). These acoustic 'thresholds" have been represented by either sound exposure level (related to sound energy, abbreviated as SEL), sound pressure level (abbreviated as SPL), or other metrics such as peak pressure level and acoustic impulse (not considered for sonar in this document). The general approach has been to apply these threshold functions such that a marine mammal is counted as behaviorally harassed or experiencing hearing a sensitivity shift (depending on which threshold) when exposed to received sound levels above the threshold and not counted as behaviorally harassed or experiencing hearing a sensitivity shift when exposed to received levels below that threshold. For example, previous Navy EISs, environmental assessments, permit applications, and a NMFS MMPA authorization used 195 dB re 1 μPa^2-s as the energy threshold level (i.e., SEL) for temporary hearing degradation for cetaceans. If the transmitted sonar accumulated energy received by a whale was above 195 dB re 1 μPa^2-s, then the animal was considered to have experienced a temporary shift in the sensitivity of its hearing. If the received accumulated energy level was below 195 dB re 1 μPa^2-s, then the animal was not treated as having experienced a temporary loss in the sensitivity of its hearing.

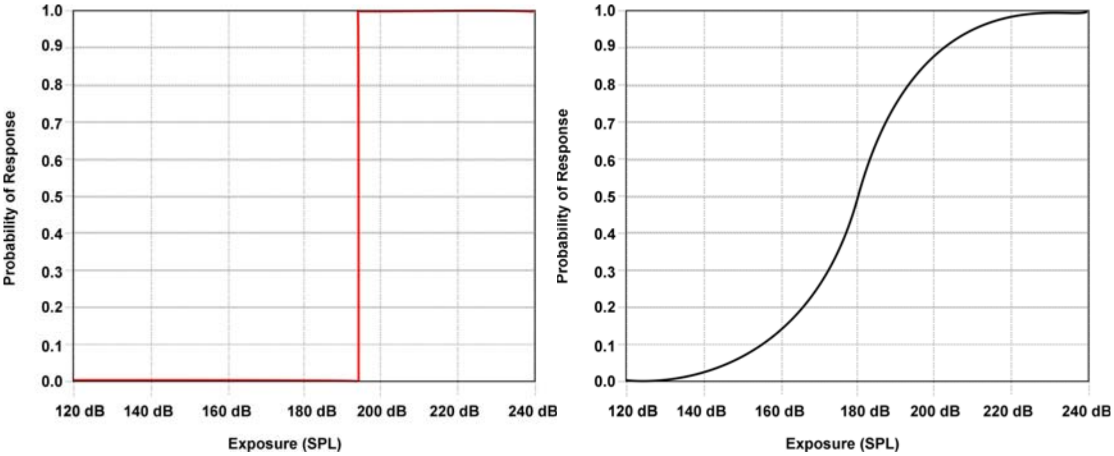

Figure 6-7. Typical Step Function and Typical Risk Continuum Function

The left panel in Figure 6-7 illustrates a typical step-function or threshold that might also relate a sonar exposure to the probability of a response. As this figure illustrates, acoustic thresholds the Navy and NMFS used in the past assumed that every marine mammal above a particular received level (for example, to the right of the red vertical line in the figure) would exhibit identical responses to a sonar exposure. This assumed that the responses of marine mammals would not be affected by differences in acoustic conditions, differences between species and populations, differences in gender, age, reproductive status, social behavior, or the prior experience of the individuals.

Both the Navy and NMFS agree that the studies of marine mammals in the wild and in experimental settings do not support these assumptions — different species of marine mammals and different individuals of the same species respond differently to sonar exposure. Additionally, there are specific geographic conditions that dictate the response of marine mammals to sonar that suggest that different populations may respond differently to sonar exposure. Further, studies of animal physiology suggest that gender, age, reproductive status, and social behavior, among other variables, probably affect how marine mammals respond to sonar exposures. However, neither agency previously had the data necessary to implement alternatives to discrete acoustic thresholds.

Over the past several years, the Navy and the NMFS have worked on developing a MFA sonar acoustic risk function to replace the acoustic thresholds used in the past to estimate the probability of marine mammals being behaviorally harassed by received levels of MFA sonar. The Navy and NMFS will continue to use acoustic thresholds to estimate the probability of temporary or permanent threshold shifts and for behavioral responses to explosives (multiple detonations) using SEL as the appropriate metric. Unlike acoustic thresholds, acoustic risk continuum functions (which are also called "exposure-response functions," "dose-response functions," or "stress-response functions" in other risk assessment contexts) assume that the probability of a response depends first on the "dose" (in this case, the received level of sound) and that the probability of a response increases as the "dose" increases. It is important to note that the probabilities associated with acoustic risk functions do not represent an individual's probability of responding. Rather, the probabilities identify the proportion of an exposed population that is likely to respond to an exposure.

The right panel in Figure 6-7 illustrates a typical acoustic risk function that might relate an exposure, as received sound pressure level in decibels referenced to 1 microPascal (1 μPa), to the probability of a response (proportion of population or density). As the exposed receive level increases in this figure, the probability increases as well but the relationship between an exposure and a response is "linear" only in the center of the curve (that is, unit increases in exposure would produce unit increases in the probability of a response only in the center of a risk function curve). In the "tails" of an acoustic risk function curve, unit increases in exposure produce smaller increases in the probability. Using the illustration as an example, increasing an exposure from 190 dB SPL to 200 dB SPL would have greater effect on the probability than increasing an exposure from 160 dB SPL to 170 dB SPL or from 210 dB SPL to 220 dB SPL (the upper and lower "tails" of the risk function, respectively). Based on observations of various animals, including humans, the relationship represented by an acoustic risk function is a more robust predictor of the probable behavioral responses of marine mammals to sonar and other acoustic sources.

The Navy and NMFS have used the acoustic risk function to estimate the probable responses of marine mammals to acoustic exposures for other training and research programs. Examples of previous application include the Navy FEISs on the Surveillance Towed Array Sonar System –

Low Frequency Active (SURTASS-LFA) (DON, 2001); the North Pacific Acoustic Laboratory (NPAL) experiments conducted off the Island of Kaua'i (ONR, 2001), and the Supplemental EIS for SURTASS LFA (DON, 2007).

The Navy and NMFS will use two metrics to estimate the number of marine mammals that might be "taken" by Level B harassment as defined by the MMPA during training exercises. The agencies will use acoustic risk functions with the metric of sound pressure level (dB re 1 µPa) to estimate the number of marine mammals that might be "taken" by MMPA Level B behavioral harassment as a result of being exposed to MFA sonar. The agencies will continue to use acoustic thresholds ("step-functions") with the metric of sound exposure level (dB re 1 μPa^2-s) to estimate the number of marine mammals that might be "taken" through sensory impairment (i.e., PTS and TTS) as a result of being exposed to mid-frequency active sonar and to estimate the number of marine mammals that might be "taken" during exercises that use explosives for MMPA Level A harassment and Level B TTS harassment (for example, sinking exercises).

Although the Navy has not used acoustic risk functions in previous MFA sonar assessments of the potential effects of MFA sonar on marine mammals, risk functions are not new concepts for risk assessments. Common elements are contained in the process used for developing criteria for air, water, radiation, and ambient noise and for assessing the effects of sources of air, water, and noise pollution. The Environmental Protection Agency uses dose-functions to develop water quality criteria and to regulate pesticide applications (EPA 1998); the Nuclear Regulatory Commission uses dose-functions to estimate the consequences of radiation exposures (see NRC 1997 and 10 CFR 20.1201); the Centers for Disease Control and Prevention and the Food and Drug Administration use dose-functions as part of their assessment methods (for example, see Centers for Disease Control and Prevention, 2003, FDA and others 2001); and the Occupational Safety and Health Administration uses dose-functions to assess the potential effects of noise and chemicals in occupational environments on the health of people working in those environments (for examples, see Federal Register 61:56746-56856, 1996; Federal Register 71:10099-10385, 2006).

6.2.7.4.1 Harbor Porpoises

The information currently available regarding these inshore species that inhabit shallow and coastal waters suggests a very low threshold level of response for both captive and wild animals. Threshold levels at which both captive (e.g. Kastelein et al., 2000; Kastelein et al., 2005; Kastelein et al., 2006) and wild harbor porpoises (e.g. Johnston, 2002) responded to sound (e.g. acoustic harassment devices (ADHs), acoustic deterrent devices (ADDs), or other non-pulsed sound sources) is very low (e.g. ~120 dB SPL), although the biological significance of the disturbance is uncertain. Therefore, Navy will not use the risk function curve as presented but will apply a step function threshold of 120 dB SPL to estimate take of harbor porpoises (i.e., assumes that all harbor porpoises exposed to 120 dB or higher MFAS will respond in a way NMFS considers behavioral harassment).

6.2.7.4.2 Risk Function Adapted from Feller (1968)

The particular acoustic risk function the Navy and NMFS developed for the AFAST Draft EIS/OEIS estimates behavioral responses that NMFS would classify as harassment for the purposes of the Marine Mammal Protection Act given exposure to specific received levels of MFA sonar. To define the appropriate mathematical function and applicable input parameters for the MFA risk function, NMFS and Navy considered several different means of assessing the probability of marine mammal responses to MFA sonar for the purposes of quantifying behavioral harassment from military readiness activities. The process resulted in two proposed functions that relate to acoustic "doses" (i.e. MFA exposures) to the probability of significant behavioral responses. As the regulating agency, NMFS reviewed the two proposed functions and presented the two methodologies to six scientists (both within and outside the federal government) for an independent, initial review for which would be the most applicable, scientifically valid MFA risk assessment function/approach. For the final determination, NMFS Office of Protected Resources considered the independent scientific reviews, the fact that the underlying data are limited, and past NMFS' rulings for a risk function in the SURTASS LFA FEIS (Federal Register (FR) 67:48145-48154, 2002; FR 72: 46846-46893, 2007) regarding which mathematical approach and input parameters to incorporate to determine the risk for MMPA Level B behavioral harassment from MFA sonar. Based on NMFS' guidance (NMFS, 2008), the Navy is implementing the mathematical function adapted from the solution in Feller (1968) as defined in the SURTASS LFA FOEIS/EIS (DON, 2001), and relied on in the Supplemental SURTASS LFA EIS (DON, 2007) 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 (except harbor porpoises), 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 functions (CDFs). 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 the 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 to 1.0);
L = Receive Level (RL) in dB;
B = basement RL in dB; (120 dB)
K = the RL increment above basement in dB at which there is 50 percent risk;
A = risk transition sharpness parameter (10)

In order to use this function, the values of the three parameters (B, K, and A) need to be established. The values used in the AFAST Draft EIS/OEIS analysis are based on three sources of data: temporary threshold shift experiments conducted at SPAWAR Systems Center and documented in Finneran, et al (2001, 2003, 2004 and 2005); reconstruction of sound fields produced by the USS Shoup associated with the behavioral responses of killer whales observed in Haro Strait and documented in DOC, 2005; DON, 2003; 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 the best available science at this time.

6.2.7.5 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. 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. NOAA Fisheries 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 datasets are most applicable for the direct use in the development of risk function parameters to describe what portion of a population exposed to specific levels of MFA sonar will respond in a manner that NMFS would classify as harassment. These datasets represent the only known data that specifically relate altered behavioral responses to exposure to MFA sound sources.

Data from Controlled Experiments: Most of the observations of the behavioral responses of toothed whales resulted from a series of controlled experiments conducted by researchers at the SPAWAR System Center facility in San Diego, CA (Finneran et al. 2000; Finneran et al. 2002, Finneran et al. 2004; 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-second 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-second tones. Schlundt et al. (2000) reported eight individual TTS experiments. Fatiguing stimuli durations were 1-second; 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 re 1 μPa/Hz), and no masking noise was used. Two separate experiments were conducted using 1-second 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 re 1 μPa were randomly presented.

<u>Data from Studies of Baleen (Mysticetes) Whale Responses</u>: The only Mysticete data available resulted from a field experiments in which baleen whales (mysticetes) were exposed to a range frequency sound sources from 120 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) document 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-minutes of exposure consisting of three 2-minute signals played sequentially three times over. The three signals had a 60% 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 4500 Hz to 500 Hz; and 3) a pair of low (1500 Hz)-high (2000 Hz) sine wave tones amplitude modulated at 120 Hz and each 1-sec long. The purpose of the alert signal was a) to provoke an action from the whales 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 the most strongly to the signal designed to elicit such behavior. Receive levels ranged from 133 to 148 dB re 1μPa.

<u>Reconstructed Sound Field from Observations in the Wild:</u> In May 2003, killer whales (*Orcinus orca*) were observed exhibiting behavioral responses while the 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 that may have been 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 mid-frequency sonar.

3. DOC (2005); DON (2003); Fromm (2004a, 2004b) documented reconstruction of sound fields produced by the 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 receive level to an unknown exact whale location ranging from 150 to 180 dB, with a mean value of 169.3 dB.

6.2.7.6 Input Parameters for the Risk Function

The values of B, K, and A need to be specified in order to utilize the risk function defined previously. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment (DON 2001, Appendix D). In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on an exposed population.

6.2.7.6.1 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 peer-reviewers, 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. However, the present convention of ending the risk calculation at 120 dB for MFA sonar has a negligible impact on the subsequent calculations, because the risk function does not attain appreciable values at received levels that low.

6.2.7.6.2 Risk Transition – The A Parameter

The 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 (except harbor porpoises), and pinnipeds (Figure 6-8) (NMFS, 2008). This is the same value of A that was used for the SURTASS LFA analysis. Based on NMFS' recommendation, Navy will use a value of A=8 for mysticetes to allow for greater consideration of potential harassment at the lower received levels based on Novacek et al, 2004 (Figure 6-9).

6.2.7.6.3 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 receive levels at which each individual responded with altered behavior to 3 kHz tones in the SSC dataset (185.3 dB SPL); (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 received levels: 150 – 180 dB); and (3) the mean of the 5 received levels at which Nowacek et al. (2004) observed significantly altered responses of right whales to the alert stimuli than to the control 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.

6.2.7.7 Risk Function Equation/Curves Used for MFA Sonar Behavioral Analysis

The mathematical function used to predict MMPA Level B behavioral harassment is adapted from the solution in Feller (1968) as used in DON (2001) and shown below.

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

Where: R = risk (0 – 1.0);
L = RL in dB;
B = basement RL in dB; (120 dB)
K = the RL increment above basement in dB at which there is 50 percent risk;
A = risk transition sharpness parameter (10)

The input parameters for the MFA sonar risk function were defined by NMFS Office of Protected Resources (NMFS, 2008). Figure 6-8 is the curve resulting from the risk function input parameter for odontocetes (except harbor porpoises) and pinnipeds. Figure 6-9 is the curve resulting from the risk function input parameters for mysticetes.

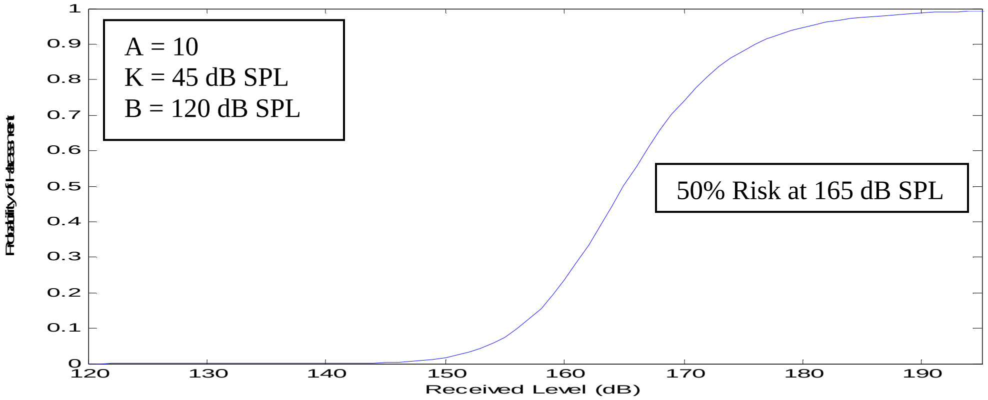

Figure 6-8. Risk Function Curve for Odontocetes (toothed whales except harbor porpoises) and Pinnipeds

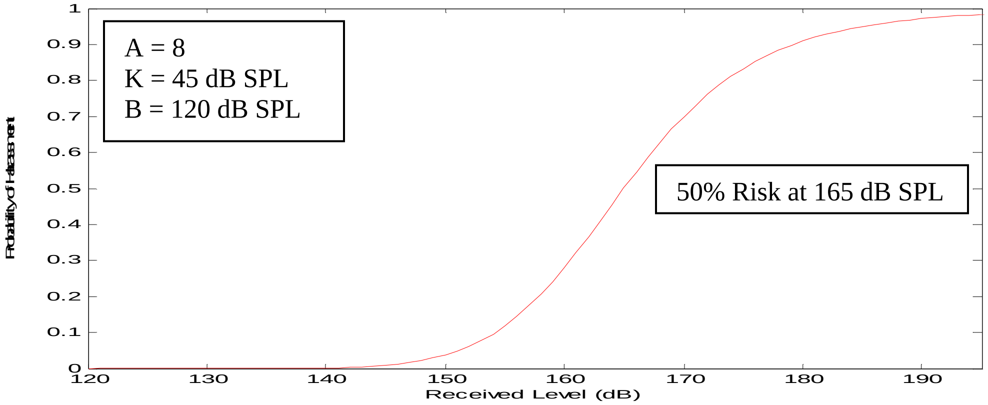

Figure 6-9. Risk Function Curve for Mysticetes (Baleen Whales)

The values obtained by applying this risk function represent the proportion of the exposed population that is likely to behaviorally respond in a manner that NMFS would classify as behavioral harassment.

6.2.8 Criteria and Thresholds for Small Explosives

Criteria and thresholds for estimating the exposures from a single explosive activity on marine mammals were established for the Seawolf Submarine Shock Test Final Environmental Impact Statement (FEIS) (“Seawolf”) and subsequently used in the USS Winston S. Churchill (DDG-81) Ship Shock FEIS (“Churchill”) (DON, 1998 and 2001b). NMFS adopted these criteria and thresholds in its Final Rule on unintentional taking of marine animals occurring incidental to

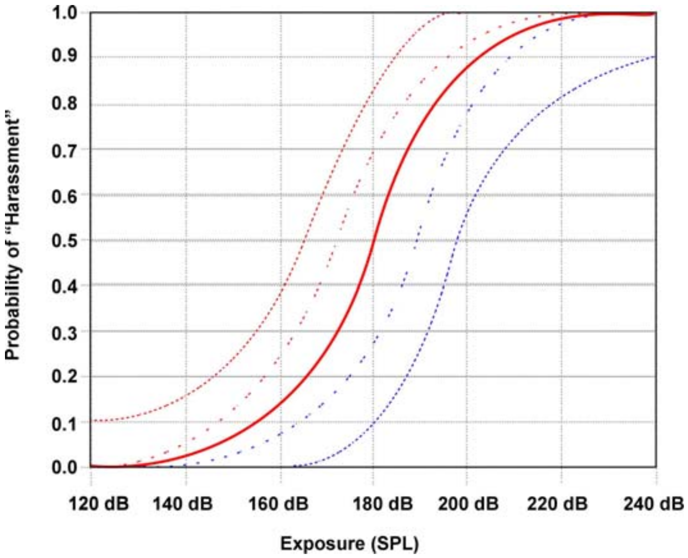

Figure 6-10. Dose-Function (Solid Line) with Uncertainty Factors (Dashed Lines) Applied

and thresholds in its Final Rule on unintentional taking of marine animals occurring incidental to the shock testing (NOAA, 1998). In addition, this section reflects a revised acoustic criterion for small underwater explosions (i.e., 23 pounds per square inch [psi] instead of previous acoustic criteria of 12 psi for peak pressure over all exposures), which is based on an incidental harassment authorization (IHA) issued to the U.S. Air Force (NOAA, 2006c).

6.2.8.1 Criteria and Thresholds for Injurious Physiological Effects

The approach to risk assessment for impulsive sound in the water was derived from the Seawolf/Churchill approach. Churchill used three criteria: eardrum rupture (i.e., tympanic-membrane [TM] rupture), onset of extensive lung injury, and onset of slight lung injury. The threshold for TM rupture corresponds to a 50 percent rate of rupture (i.e., 50 percent of animals exposed to the level are expected to suffer TM); this is stated in terms of an EL value of 1.17 inch pounds per square inch (in-lb/in^2) (about 205 dB re 1 μPa^2-s). This recognizes that TM rupture is not necessarily a serious or life-threatening injury, but it is a useful index of possible injury that is well correlated with measures of permanent hearing impairment (e.g., Ketten [1998] indicates a 30 percent incidence of PTS at the same threshold).

The criteria for mortality is the onset of extensive lung injury. For small mammals, the threshold is given in terms of the Goertner modified positive impulse, indexed to 30.5 pounds per square inch-millisecond (psi-ms). For medium and large mammals, the threshold is 73.9 and 111.7 psi-ms, respectively. In this assessment, all cetaceans were analyzed using the threshold for small mammals for extensive lung injury. The results of the analysis, therefore, are conservative.

The threshold for onset of slight lung injury was calculated for a calf dolphin (12.2 kg [27 lbs]) and an adult dolphin (174 kg [384 lbs]); it is given in terms of the Goertner modified positive impulse, indexed to 13 psi-ms and 32 psi-ms respectively. In this assessment, all cetaceans were analyzed using the threshold for a calf dolphin for onset slight lung injury. The results of the analysis, therefore, are conservative.

6.2.8.2 Criteria and Thresholds for Non-injurious Physiological Effects

The Churchill criterion for non-injurious harassment is TTS, which is a slight, recoverable loss of hearing sensitivity (DON, 2001b). In this case, there are two thresholds, one for energy and one for peak pressure.

6.2.8.3 TTS Energy Threshold

The TTS energy threshold is a 182 dB re 1 μPa^2-s maximum energy flux density level in any 1/3-octave band at frequencies above 0.1 kHz for toothed whales and in any 1/3-octave band above 0.010 kHz for baleen whales. For large explosives, the latter limits at 0.01 and 0.1 kHz make a difference in the range estimates. NMFS has defined large explosives in prior rulemaking as greater than 907 kg (2,000 lbs) Net Explosive Weight (NEW) (NMFS, 2006c). The Navy has defined small explosives as less than 680 kg (1,500 lbs) NEW per directive. For small explosives, the spectrum of the shot arrival is broad and there is essentially no difference in effects ranges for the two classes of animals.

6.2.8.4 TTS Peak Pressure Threshold

The TTS peak pressure threshold applies to all cetacean species and is stated in terms of peak pressure at 23 psi, which is based on an IHA issued to the Air Force for a similar action (NOAA, 2006c). This threshold is derived from the Churchill threshold. However, peak pressure and energy scale at different rates with charge weight, so that ranges based on the peak-pressure threshold are much greater than those for the energy metric when charge weights are small—even when source and animal are away from the surface. In order to more accurately estimate TTS for smaller shots while preserving the safety feature provided by the peak pressure threshold, the peak pressure threshold was appropriately scaled for small detonations. This scaling is based on the similitude formulas (e.g., Urick, 1983) used in virtually all compliance documents for short ranges. Further, the peak-pressure threshold for marine mammal TTS for explosives offers a safety margin for a source or an animal near the ocean surface.

6.2.8.5 Criteria and Thresholds for Behavioral Effects

Behavioral modification (sub-TTS) is only applied to successive detonations. For single detonations, behavioral disturbance is likely to be limited to a short-lived startle reaction; therefore, use of the TTS criterion is considered sufficient protection.

6.2.9 Summary of Criteria and Thresholds

Table 6-2 summarizes the effects, criteria, and thresholds used in the assessment to determine potential physiological effects from active sonar.

Tables 6-3 and 6-4 summarize the SPL risk-function parameters for behavioral response to active sonar.

Table 6-5 summarizes the effects, criteria, and thresholds used in the assessment for small explosives (i.e., explosive source sonobuoy [AN/SSQ-110A]).

Table 6-2. Effects, Criteria, and Thresholds to Active Sonar

Effect	Criteria	Threshold (dB 1 µPa^2-s)	MMPA Effect
Physiological	PTS	215	Level A Harassment
Physiological	TTS	195	Level B Harassment

dB 1 µPa^2-s = decibel referenced to 1 micropascal squared second; PTS = Permanent Threshold Shift; TTS = Temporary Threshold Shift

Table 6-3. SPL Risk-Function Parameters for Behavioral Response to Active Sonar

Animals	Risk-Function Mean (SPL)	Risk Transition Parameter	Basement Receive Level
Odontocetes (except harbor porpoises) and Pinnipeds	165 dB	10	120 dB
Mysticetes	165 dB	8	120 dB

dB = decibel

Table 6-4. Behavioral Response to Active Sonar (Harbor Porpoise)

Animals	Effect	Receive Level
Harbor Porpoise	Behavioral	Greater than 120 dB SPL re 1 µPa

dB = decibel; SPL re 1 µPa = sound pressurelevel referenced to 1 micropascal

Table 6-5. Effects, Criteria, and Thresholds for Small Explosives

Effect	Criteria	Metric	Threshold	MMPA Effect
Physiological	Onset extensive lung injury	Goertner modified positive impulse	30.5 psi-ms	Mortality
Physiological	50 percent TM rupture	Energy flux density	1.17 in-lb/in^2 (about 205 dB re 1 µPa^2-s)	Level A Harassment
Physiological	Onset slight lung injury	Goertner modified positive impulse	indexed to 13 psi-ms	Level A Harassment
Physiological	TTS for baleen whales	Greatest energy flux density level in any 1/3-octave band above 10 Hz for total energy over all exposures	182 dB re 1 µPa^2-s	Level B Harassment
Physiological	TTS for toothed whales and sea turtles	Greatest energy flux density level in any 1/3-octave band above 100 Hz for total energy over all exposures	182 dB re 1 µPa^2-s	Level B Harassment
Physiological	TTS	Peak pressure over all exposures	23 psi	Level B Harassment

dB 1 µPa^2-s = decibel referenced to 1 micropascal squared second; Hz = hertz; psi-ms = pounds per square inch-millisecond; TM = tympanic membrane; TTS = temporary threshold shift

6.2.10 Other Potential Acoustic Effects to Marine Mammals

6.2.10.1 Acoustically Mediated Bubble Growth

One suggested cause of injury to marine mammals is by rectified diffusion, which is the process of increasing the size of a bubble by exposing it to a sound field (Crum and Mao, 1996). This process is facilitated if the environment in which the ensonified bubbles exist is supersaturated with a gas, such as nitrogen which makes up approximately 78 percent of air (remainder of air is about 21 percent oxygen with some carbon dioxide). 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). Deeper and longer dives of some marine mammals (for example, beaked whales) are theoretically predicted to induce greater super saturation (Houser et al., 2001). Conversely, studies have shown that marine mammal lung structure (both pinnipeds and cetaceans) facilitates collapse of the lungs at depths below approximately 162 ft (50 m) (Kooyman et al., 1970). Collapse of the lungs would force air in to the non-air exchanging areas of the lungs (in to the bronchioles away from the alveoli) thus significantly decreasing nitrogen diffusion in to the body. Deep-diving pinnipeds such as the northern elephant (*Mirounga angustirostris*) and Weddell seals (*Leptonychotes weddellii*) typically exhale before long deep dives, further reducing air volume in the lungs (Kooyman et al., 1970). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue super saturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar 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 bubbles 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.

6.2.10.2 Decompression Sickness

Another hypothesis suggests 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). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation. Cox et al. (2006) with experts in the field of marine mammal behavior, diving, physiology, respiration physiology, pathology, anatomy, and bio-acoustics considered this to be a plausible hypothesis but requires further investigation. Conversely Fahlman et al., (2006) suggested that diving bradycardia (reduction in heart rate and circulation to the tissues), lung collapse and slow ascent rates would reduce nitrogen uptake and thus reduce the risk of decompression sickness by 50 percent in models of marine mammals. Zimmer and Tyack (2007) suggest that beaked whales avoid sonar sound by swimming deeper than 25 m and shallower than the depth of alveolar collapse. This avoidance mechanism continues until the sound no longer creates the response or the animal enters shallow water where it can no longer dive in this pattern. The evidence would support decompression sickness and is consistent with previous studies on avoidance, for example with ship noise (Zimmer and Tyack, 2007). Recent information on the diving profiles of Cuvier's (*Ziphius cavirostris*) and Blainvilles's (*Mesoplodon densirostris*) beaked whales (Baird et al., 2006) and in the Ligurian Sea in Italy (Tyack et al., 2006) showed that while these species do dive deeply (regularly exceed depths of 800 m [2,625 ft]) and for long periods (48-68 minutes), they have significantly slower ascent rates than descent rates. This fits well with Fahlman et al. (2006) model of deep and long duration divers that would have slower ascent rates to reduce nitrogen saturation and reduce the risk of decompression sickness. Therefore, if nitrogen saturation remains low, then a rapid ascent in response to sonar should not cause decompression sickness. Currently it is not known if beaked whales rapidly ascend in response to sonar or other disturbances. It may be that deep diving animals would be better protected diving to depth to avoid predators, such as killer whales, rather then ascending to the surface where they may be more susceptible to predators.

Although theoretical predictions suggest the possibility for acoustically mediated bubble growth, there is considerable disagreement among scientists as to its likelihood (Piantadosi and Thalmann, 2004; Evans and Miller, 2004). To date, ELs predicted to cause *in vivo* bubble formation within diving cetaceans have not been evaluated (NOAA, 2002b). Further, 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), there is no conclusive evidence of this and complicating factors associated with introduction of gas in to the venous system during necropsy. Because evidence supporting it is debatable, no marine mammals addressed in this LOA are given special treatment due to the possibility for acoustically mediated bubble growth. Beaked whales are, however, assessed differently from other species to account for factors that may have contributed to prior beaked whale strandings as set out in the previous section.

6.2.10.3 Resonance

Another suggested cause of injury in marine mammals is air cavity resonance due to sonar exposure. 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 U.S. Navy MFA sonar caused resonance effects in beaked whales that eventually led to their stranding (Department of Commerce and DON, 2001). The conclusions of that group were that resonance in air-filled structures the frequencies at which resonance were predicted to occur were below the frequencies utilized by the sonar systems employed. Furthermore, air cavity vibrations due to the resonance effect were not considered to be of sufficient amplitude to cause tissue damage. This LOA application assumes that similar phenomenon would not be problematic in other cetacean species.

6.2.10.4 Likelihood of Prolonged Exposure

ASW activities would not result in prolonged exposure because the vessels are constantly moving, and the flow of the activity when training occurs reduces the potential for prolonged exposure. The implementation of the mitigation measures described in Chapter 11 would further reduce the likelihood of any prolonged exposure.

6.2.10.5 Likelihood of Masking

Natural and artificial sounds can disrupt behavior by masking, or interfering with an animal's ability to hear other sounds. Masking occurs when the receipt of a sound is interfered with by a second sound at similar frequencies and at similar or higher levels. If the second sound were artificial, it could be potentially harassing if it disrupted hearing-related behavior such as communications or echolocation. It is important to distinguish TTS and PTS, which persist after the sound exposure, from masking, which occurs during the sound exposure.

Historically, principal masking concerns have been with prevailing background noise levels from natural and manmade sources (for example, Richardson et al., 1995). Dominant examples of the latter are the accumulated noise from merchant ships and noise of seismic surveys. Both cover a wide frequency band and are long in duration.

The majority of proposed AFAST activities are away from harbors or heavily traveled shipping lanes. The loudest mid-frequency underwater sounds in the Proposed Action area are those produced by hull-mounted mid-frequency active tactical sonar. The sonar signals are likely within the audible range of most cetaceans, but are very limited in the temporal and frequency domains. In particular, the pulse lengths are short, the duty cycle low, and these hull-mounted mid-frequency active tactical sonars transmit within a narrow band of frequencies (typically less than one-third octave). For the reasons outlined above, the chance of sonar operations causing masking effects is considered negligible.

6.2.10.6 Potential for Long Term Effects

Some AFAST training activities will be conducted in the same general areas, so marine mammal populations could be exposed to repeated activities over time. However, as described earlier, the acoustic analyses assumes that short-term noninjurious 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 significant effects.

6.2.11 Cetacean Stranding

When a live or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is termed a "stranding" (Geraci et al., 1999; Perrin and

Geraci, 2002; Geraci and Lounsbury, 2005; National Marine Fisheries Service [NMFS], 2007). The legal definition for a stranding within the United States is that "*a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance*." (16 United States Code [U.S.C.] 1421h).

The majority of animals that strand are dead or moribund (NMFS, 2007). For those that are alive, human intervention through medical aid and/or guidance seaward may be required for the animal to return to the sea. If unable to return to sea, rehabilitation at an appropriate facility may be determined as the best opportunity for animal survival. An event where animals are found out of their normal habitat is may be considered a stranding depending on circumstances even though animals do not necessarily end up beaching (Southhall, 2006).

Three general categories can be used to describe strandings: single, mass, and unusual mortality events. The most frequent type of stranding is a single stranding, which involves only one animal (or a mother/calf pair) (NMFS, 2007).

Mass stranding involves two or more marine mammals of the same species other than a mother/calf pair (Wilkinson, 1991), and may span one or more days and range over several miles (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; Walsh et al., 2001; Freitas, 2004). In North America, only a few species typically strand in large groups of 15 or more and include sperm whales, pilot whales, false killer whales, Atlantic white-sided dolphins, white-beaked dolphins, and rough-toothed dolphins (Odell 1987, Walsh et al., 2001). Some species, such as pilot whales, false-killer whales, and melon-headed whales occasionally strand in groups of 50 to 150 or more (Geraci et al. 1999). All of these normally pelagic off-shore species are highly sociable and usually infrequently encountered in coastal waters. Species that commonly strand in smaller numbers include pygmy killer whales, common dolphins, bottlenose dolphins, Pacific white-sided dolphin Frasier's dolphins, gray whale and humpback whale (West Coast only), harbor porpoise, Cuvier's beaked whales, California sea lions, and harbor seals (Mazzuca et al., 1999, Norman et al., 2004, Geraci and Lounsbury, 2005).

Unusual mortality events (UMEs) can be a series of single strandings or mass strandings, or unexpected mortalities (i.e., die-offs) that occur under unusual circumstances (Dierauf and Gulland, 2001; Harwood, 2002; Gulland, 2006; NMFS, 2007). These events may be interrelated; for instance, at-sea die-offs lead to increased stranding frequency over a short period of time, generally within 1 to 2 months. As published by NMFS, revised criteria for defining a UME include the following (Hohn et al., 2006b):

(1) A marked increase in the magnitude or a marked change in the nature of morbidity, mortality, or strandings when compared with prior records.

(2) A temporal change in morbidity, mortality, or strandings is occurring.

(3) A spatial change in morbidity, mortality, or strandings is occurring.

(4) The species, age, or sex composition of the affected animals is different than that of animals that are normally affected.

(5) Affected animals exhibit similar or unusual pathologic findings, behavior patterns, clinical signs, or general physical condition (e.g., blubber thickness).

(6) Potentially significant morbidity, mortality or stranding is observed in species, stocks or populations that are particularly vulnerable (e.g., listed as depleted, threatened or endangered, or declining). For example, stranding of three or four right whales may be cause for great concern, whereas stranding of a similar number of fin whales may not.

(7) Morbidity is observed concurrent with or as part of an unexplained continual decline of a marine mammal population, stock, or species.

UMEs are usually unexpected, infrequent, and may involve a significant number of marine mammal mortalities. As discussed below, unusual environmental conditions are probably responsible for most UMEs and marine mammal die-offs (Vidal and Gallo-Reynoso, 1996; Geraci et al., 1999; Walsh et al., 2001; Gulland and Hall, 2005).

6.2.11.1 United States Stranding Response Organization

Stranding events provide scientists and resource managers information not available from limited at-sea surveys, and may be the only way to learn key biological information about certain species, such as distribution, seasonal occurrence, and health (Rankin, 1953; Moore et al., 2004; Geraci and Lounsbury, 2005). Necropsies are useful in attempting to determine a reason for the stranding, and are performed on stranded animals when the situation and resources allow.

In 1992, Congress passed the Marine Mammal Health and Stranding Response Act (MMHSRA) which authorized the Marine Mammal Health and Stranding Response Program (MMHSRP) under authority of the Department of Commerce (DOC), NMFS. The MMHSRP was created out of concern that began in the 1980s for marine mammal mortalities, to formalize the response process, and to focus efforts being initiated from numerous local stranding organizations and public concern.

Major elements of the MMHSRP include the following (NMFS, 2007):

- National Marine Mammal Stranding Network
- Marine Mammal UME Program
- National Marine Mammal Tissue Bank (NMMTB) and Quality Assurance Program
- Marine Mammal Health Biomonitoring, Research, and Development
- Marine Mammal Disentanglement Network
- John H. Prescott Marine Mammal Rescue Assistance Grant Program (a.k.a. the Prescott Grant Program)

- Information Management and Dissemination

The United States has a well-organized network in the coastal states to respond to marine mammal strandings. Overseen by NMFS, The National Marine Mammal Stranding Network is comprised of smaller organizations manned by professionals and volunteers from nonprofit organizations, aquaria, universities, and state and local governments trained in stranding response. Currently, more than 400 organizations are authorized by NMFS to respond to marine mammal strandings (NMFS, 2007).

NMFS Regions and associated States and Territories include the following:

- NMFS Northeast Region- Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia
- NMFS Southeast Region- North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, Puerto Rico, Virgin Islands
- NMFS Southwest Region- California
- NMFS Northwest Region- Oregon, Washington
- NMFS Alaska Region- Alaska
- NMFS Pacific Islands Region- Hawaii, Guam, American Samoa, Commonwealth of the Northern Mariana Islands (CNMI)

Stranding reporting and response efforts over time have been inconsistent, although effort and data quality within the United States have been improving within the last 20 years (NMFS, 2007). Given the historical inconsistency in response and reporting, however, interpretation of long-term trends in marine mammal stranding is difficult (NMFS, 2007). As shown in Figure 6-11, during the past decade (1995 to 2004), approximately 40,000 stranded marine mammals have been reported by the regional stranding networks, averaging 3,600 strandings reported per year (NMFS, 2007). The highest number of strandings were reported between the years 1998 and 2003 (NMFS, 2007). Detailed regional stranding information including most commonly stranded species can be found in Zimmerman (1991), Geraci and Lounsbury (2005), and NMFS (2007).

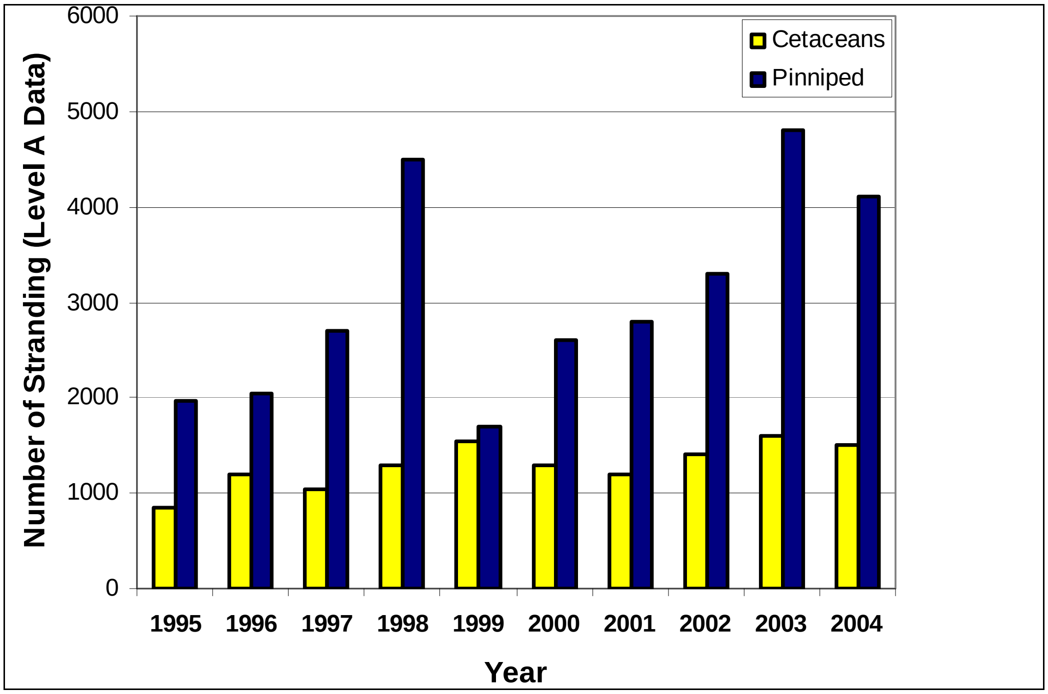

Figure 6-11. Annual Number of Reported Stranded Cetaceans and Pinnipeds in the United States from 1995 to 2004

Source: NMFS, 2007

6.2.11.2 Potential Causes of Marine Mammal Stranding

Reports of marine mammal strandings can be traced back to ancient Greece (Walsh et al., 2001). Like any wildlife population, normal background mortality rates influence marine mammal population dynamics including starvation, predation, aging, reproductive success, and disease (Geraci et al., 1999; Carretta et al., 2007). Strandings in and of themselves may be reflective of this natural cycle, or more recently, may be the result of anthropogenic sources (i.e., human effects). Current science suggests that multiple factors, both natural and man-made, may act alone or in combination to cause a marine mammal to strand (Geraci et al., 1999; Culik, 2002; Perrin and Geraci, 2002; Hoelzel, 2003; Geraci and Lounsbury, 2005; NRC, 2006). While post-stranding data collection and necropsies of dead animals are attempted in an effort to find a possible cause for the stranding, it is often difficult to pinpoint exactly one factor that can be blamed for any given stranding. An animal suffering from one ailment becomes susceptible to various other influences because of its weakened condition, making it difficult to determine a primary cause. In many stranding cases, scientists never learn the exact reason for the stranding.

Specific potential stranding causes can include both natural and human influenced (anthropogenic) causes listed below and described in the following sections:

- Natural Stranding Causes
    - Disease
    - Natural toxins

    - Weather and climatic influences
    - Navigation errors
    - Social cohesion
    - Predation

- Human Influenced (Anthropogenic) Stranding Causes
    - Fisheries interaction
    - Vessel strike
    - Pollution and ingestion
    - Noise

6.2.11.2.1 Causes of Natural Stranding

Overview

Significant natural causes of mortality, die-offs, and stranding discussed in the following sections include disease and parasitism, marine neurotoxins from algae, climatic influences, and navigation errors that lead to inadvertent stranding that impact the distribution and abundance of potential food resources (i.e., starvation). Other natural mortality not discussed in detail includes predation by other species such as sharks (Cockcroft et al., 1989; Heithaus, 2001), killer whales (Constantine et al., 1998; Guinet et al., 2000; Pitman et al., 2001), and some species of pinniped (Hiruki et al., 1999; Robinson et al., 1999).

Disease

Like other mammals, marine mammals frequently suffer from a variety of diseases of viral, bacterial, and fungal origin (Visser et al., 1991; Dunn et al., 2001; Harwood, 2002). Gulland and Hall (2005; 2007) provide a more detailed summary of individual and population effects of marine mammal diseases.

Microparasites such as bacteria, viruses, protozoans, and other microorganisms are commonly found in marine mammal habitats and usually pose little threat to a healthy animal (Geraci et al., 1999). For example, long-finned pilot whales that inhabit the waters off the northeastern coast of the U.S. are carriers of the morbillivirus, yet have grown resistant to its usually lethal effects (Geraci et al., 1999). Since the 1980s, however, virus infections have been strongly associated with marine mammal die-offs (Domingo et al., 1992; Geraci and Lounsbury, 2005). Morbillivirus is the most significant marine mammal virus. This virus suppresses a host’s immune system, increasing risk of secondary infection (Harwood, 2002). A bottlenose dolphin UME in 1993 and 1994 was caused by morbillivirus. Die-offs ranged from northwestern Florida to Texas, increasing in the number of deaths as it spread (NMFS, 2007). A 2004 UME in Florida was also associated with dolphin morbillivirus (NMFS, 2004). Influenza A was responsible for the first reported mass mortality in the United States, occurring along the coast of New England in 1979-1980 (Geraci et al., 1999; Harwood, 2002). Canine distemper virus has been responsible for large scale pinniped mortalities and die-offs (Grachev et al., 1989; Kennedy et al., 2000; Gulland and Hall, 2005), while a bacterium, *Leptospira pomona*, is responsible for periodic die-offs in California sea lions about every 4 years (Gulland et al., 1996; Gulland and Hall, 2005). It is difficult to determine if microparasites commonly act as a primary pathogen, or whether they show up as a secondary infection in an already weakened animal (Geraci et al., 1999). Most marine mammal die-offs from infectious disease in the last 25 years, however, were associated with viruses (Simmonds and Mayer, 1997; Geraci et al., 1999; Harwood, 2002).

Macroparasites are usually large parasitic organisms and include lungworms, trematodes (parasitic flatworms), and protozoans (Geraci and St.Aubin, 1987; Geraci et al., 1999). Marine mammals can carry many different types, and have shown a robust tolerance for sizeable infestation unless compromised by illness, injury, or starvation (Morimitsu et al., 1987; Dailey et al., 1991; Geraci et al., 1999). *Nasitrema*, a usually benign trematode found in the head sinuses of cetaceans (Geraci et al., 1999), can cause brain damage if it migrates (Ridgway and Dailey, 1972). As a result, this worm is one of the few macroparasites directly linked to stranding in the cetaceans (Dailey and Walker, 1978; Geraci et al., 1999).

Non-infectious disease, such as congenital bone pathology of the vertebral column (osteomyelitis, spondylosis deformans, and ankylosing spondylitis [AS]), has been described in several species of cetacean (Paterson, 1984; Alexander et al., 1989; Kompanje, 1995; Sweeny et al., 2005). In humans, bone pathology such as AS can impair mobility and increase vulnerability to further spinal trauma (Resnick and Niwayama, 2002). Bone pathology has been found in cases of single strandings (Paterson, 1984; Kompanje, 1995), and also in cetaceans prone to mass stranding (Sweeny et al., 2005), possibly acting as a contributing or causal influence in both types of events.

Naturally Occurring Marine Neurotoxins

Some single cell marine algae common in coastal waters, such as dinoflagellates and diatoms, produce toxic compounds that can accumulate (termed *bioaccumulation*) in the flesh and organs of fish and invertebrates (Geraci et al., 1999; Harwood, 2002). Marine mammals become exposed to these compounds when they eat prey contaminated by these naturally produced toxins (Van Dolah, 2005). Figure 6-12 shows U.S. animal mortalities from 1997 to 2006 resulting from toxins produced during harmful algal blooms. Table 6-6 lists the marine mammal unusual mortality events attributed to or suspected from natural causes.

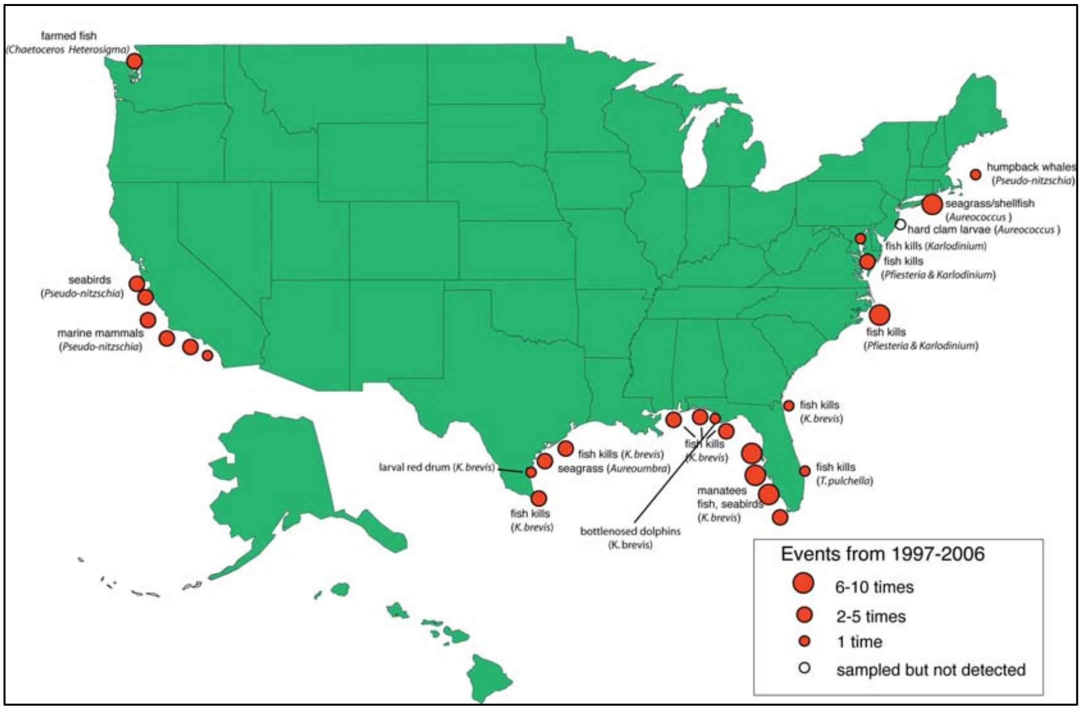

Figure 6-12. Animal and Plant Mortalities from Harmful Algal Blooms Within the United States from 1997 to 2006

Source: Woods Hole Oceanographic Institution (WHOI)

Table 6-6. Marine Mammal Unusual Mortality Events Attributed to or Suspected from Natural Causes (1978 to 2005)

Year	Species and number	Location	Cause
1978	Hawaiian monk seals (50)	NW Hawaiian Islands	Ciguatoxin and maitotoxin
1979-80	Harbor seals (400)	Massachusetts	Influenza A
1982	Harbor seals	Massachusetts	Influenza A
1983	Multiple pinniped species	West coast of U.S., Galapagos	El Nino
1984	California sea lions (226)	California	Leptospirosis
1987	Sea otters (34)	Alaska	Saxitoxin
1987	Humpback whales (14)	Massachusetts	Saxitoxin
1987-88	Bottlenose dolphins (645)	Eastern seaboard (New Jersey to Florida)	Morbillivirus; Brevetoxin
1987-88	Baikal seals (80-100,000)	Lake Baikal, Russia	Canine distemper virus
1988	Harbor seals (approx 18,000)	Northern Europe	Phocine distemper virus
1990	Stripped dolphins (550)	Mediterranean Sea	Dolphin morbillivirus
1990	Bottlenose dolphins (146)	Gulf Coast, U.S.	Unknown; unusual skin lesions observed
1994	Bottlenose dolphins (72)	Texas	Morbillivirus
1995	California sea lions (222)	California	Leptospirosis
1996	Florida manatees (149)	West Coast Florida	Brevetoxin
1996	Bottlenose dolphins (30)	Mississippi	Unknown; Coincident with algal bloom

Table 6-6. Marine Mammal Unusual Mortality Events Attributed to or Suspected from Natural Causes (1978 to 2005) Cont'd

Year	Species and number	Location	Cause
1997	Mediterranean monk seals (150)	Western Sahara, Africa	Harmful algal bloom; Morbillivirus
1997-98	California sea lions (100s)	California	El Nino
1998	California sea lions (70)	California	Domoic acid
1998	Hooker's sea lions (60% of pups)	New Zealand	Unknown, bacteria likely
1999	Harbor porpoises	Maine to North Carolina	Oceanographic factors suggested
2000	Caspian seals (10,000)	Caspian Sea	Canine distemper virus
1999-2000	Bottlenose dolphins (115)	Panhandle of Florida	Brevetoxin
1999-2001	Gray whales (651)	Canada, U.S. West Coast, Mexico	Unknown; starvation involved
2000	California sea lions (178)	California	Leptospirosis
2000	California sea lions (184)	California	Domoic acid
2000	Harbor seals (26)	California	Unknown; Viral pneumonia suspected
2001	Bottlenose dolphins (35)	Florida	Unknown
2001	Harp seals (453)	Maine to Massachusetts	Unknown
2001	Hawaiian monk seals (11)	NW Hawaiian Islands	Malnutrition
2002	Harbor seals (approx. 25,000)	Northern Europe	Phocine distemper virus
2002	Multispecies (common dolphins, California sea lions, sea otters) (approx. 500)	California	Domoic acid
2002	Hooker's sea lions	New Zealand	Pneumonia
2002	Florida manatee	West Coast of Florida	Brevetoxin
2003	Multispecies (common dolphins, California sea lions, sea otters) (approx. 500)	California	Domoic acid
2003	Beluga whales (20)	Alaska	Ecological factors
2003	Sea otters	California	Ecological factors
2003	Large whales (16 humpback, 1 fine, 1 minke, 1 pilot, 2 unknown)	Maine	Unknown; Saxitoxin and domoic acid detected in 2 of 3 humpbacks
2003-2004	Harbor seals, minke whales	Gulf of Maine	Unknown
2003	Florida manatees (96)	West Coast of Florida	Brevetoxin
2004	Bottlenose dolphins (107)	Florida Panhandle	Brevetoxin
2004	Small cetaceans (67)	Virginia	Unknown
2004	Small cetaceans	North Carolina	Unknown
2004	California sea lions (405)	Canada, U.S. West Coast	Leptospirosis
2005	Florida manatees, bottlenose dolphins (ongoing Dec 2005)	West Coast of Florida	Brevetoxin
2005	Harbor porpoises	North Carolina	Unknown
2005	California sea lions; Northern fur seals	California	Domoic acid
2005	Large whales	Eastern North Atlantic	Domoic acid suspected
2005-2006	Bottlenose dolphins	Florida	Brevetoxin suspected

Source: Data from Gulland and Hall, 2007

In the Gulf of Mexico and mid- to southern Atlantic states, “red tides,” a form of harmful algal bloom, are created by a dinoflagellate (*Karenia brevis*). *K. brevis* is found throughout the Gulf of Mexico, sometimes along the Atlantic coast (Van Dolah, 2005; NMFS, 2007), and produces a neurotoxin known as brevetoxin. Brevetoxin has been associated with several marine mammal UMEs within these areas (Geraci, 1989; Van Dolah et al., 2003; NMFS, 2004; Flewelling et al., 2005; Van Dolah, 2005; NMFS, 2007). On the U.S. West Coast and in the northeast Atlantic, several species of diatoms produce a toxin called domoic acid which has also been linked to marine mammal strandings (Figure 6-12) (Geraci et al., 1999; Van Dolah et al., 2003; Greig et al., 2005; Van Dolah, 2005; Brodie et al., 2006; NMFS, 2007). Other algal toxins associated with marine mammal strandings include saxitoxins and ciguatoxins, and are summarized by Van Dolah (2005).

Weather Events and Climate Influences

Severe storms, hurricanes, typhoons, and prolonged temperature extremes may lead to localized marine mammal strandings (Geraci et al., 1999; Walsh et al., 2001). Hurricanes may have been responsible for mass strandings of pygmy killer whales in the British Virgin Islands and Gervais’ beaked whales in North Carolina (Mignucci-Giannoni et al., 2000; Norman and Mead, 2001). Storms in 1982 and 1983 along the California coast led to deaths of 2,000 northern elephant seal pups (Le Boeuf and Reiter, 1991). Ice movement along southern Newfoundland has forced groups of blue whales and white-beaked dolphins ashore (Sergeant, 1982). Seasonal oceanographic conditions in terms of weather, frontal systems, and local currents may also play a role in stranding (Walker et al., 2005).

The effect of large scale climatic changes to the world’s oceans and how these changes impact marine mammals and influence strandings is difficult to quantify given the broad spatial and temporal scales involved, and the cryptic movement patterns of marine mammals (Moore, 2005; Learmonth et al., 2006). The most immediate, although indirect, effect is decreased prey availability during unusual conditions. This, in turn, results in increased search effort required by marine mammals, (Crocker et al., 2006), e.g., potential starvation if not successful, and stranding due directly to starvation or succumbing to disease or predation while in a more weakened, stressed state (Selzer and Payne, 1988; Geraci et al., 1999; Moore, 2005; Learmonth et al., 2006; Weise et al., 2006).

Two recent papers examined potential influences of climate fluctuation on stranding events in southern Australia including Tasmania, an area with a history of over 20 mass strandings since the 1920s (Evans et al., 2005; Bradshaw et al., 2006). These authors note that patterns in animal migration, survival, fecundity, population size, and strandings will revolve around the availability and distribution of food resources. In southern Australia movement of nutrient-rich waters pushed closer to shore by periodic meridinal winds (occurring about every 12 to 14 years) may be responsible for bringing marine mammals closer to land, thus increasing the probability of stranding (Bradshaw et al., 2006). The papers conclude, however, that while an overarching model can be helpful for providing insight into the prediction of strandings, the particular reasons for each one are likely to be quite varied.

Navigational Error

Geomagnetism - It has been hypothesized that marine mammals may be able to orient to the Earth's magnetic field as a navigational cue, like some land animals, and that areas of local magnetic anomalies may influence strandings (Bauer et al., 1985; Klinowska, 1985; Kirschvink et al., 1986; Klinowska, 1986; Walker et al., 1992; Wartzok and Ketten, 1999). In a plot of live stranding positions in Great Britain with magnetic field maps, Klinowska (1985 and 1986) observed an association between live stranding positions and magnetic field levels. In all cases, live strandings occurred at locations where magnetic minima, or lows in the magnetic fields, intersect the coastline. Kirschvink et al. (1986) plotted stranding locations on a map of magnetic data for the East Coast of the U.S., and was able to develop associations between stranding sites and locations where magnetic minima intersected the coast. The authors concluded that there were highly significant tendencies for cetaceans to beach themselves near these magnetic minima and coastal intersections. The results supported the hypothesis that cetaceans may have a magnetic sensory system similar to other migratory animals, and that marine magnetic topography and patterns may influence long-distance movements (Kirschvink et al., 1986). Walker et al. (1992) examined fin whale swim patterns off the northeastern U.S. continental shelf, and reported that migrating animals aligned with lows in the geometric gradient or intensity. While a similar pattern between magnetic features and marine mammal strandings at New Zealand stranding sites was not seen (Brabyn and Frew, 1994), mass strandings in Hawaii have typically occurred within a narrow range of magnetic anomalies (Mazzuca et al., 1999).

Echolocation Disruption in Shallow Water - Some researchers believe stranding may result from reductions in the effectiveness of echolocation within shallow water, especially with the pelagic species of odontocetes who may be less familiar with coastline (Dudok van Heel, 1966; Chambers and James, 2005). For an odontocete, echoes from echolocation signals contain important information on the location and identity of underwater objects and the shoreline. The authors postulate that the gradual slope of a beach may present difficulties to the navigational systems of some cetaceans, since it is common for live strandings to occur along beaches with shallow, sandy gradients (Brabyn and McLean, 1992; Mazzuca et al., 1999; Maldini et al., 2005; Walker et al., 2005). A contributing factor to echolocation interference in turbulent, shallow water is the presence of microbubbles from the interaction of wind, breaking waves, and currents. Additionally, ocean water near the shoreline can have an increased turbidity (e.g., floating sand or silt, particulate plant matter, etc.) due to the run-off of fresh water into the ocean from rainfall or from freshwater outflows (e.g., rivers and creeks). Collectively, these factors can reduce and scatter the sound energy within echolocation signals and reduce the perceptibility of returning echoes of interest.

Social Cohesion

Many pelagic species such sperm whale, pilot whales, melon-head whales, and false killer whales, and some dolphins occur in large groups with strong social bonds between individuals. When one or more animals strand due to any number of causative events, then the entire pod may follow suit out of social cohesion (Geraci et al., 1999; Conner, 2000; Perrin and Geraci, 2002; NMFS, 2007).

6.2.11.2.2 Anthropogenic Causes of Stranding

With the exception of historic whaling in the 19th and early part of the 20th century, over the past few decades there has been an increase in marine mammal mortalities associated with a variety of human activities (Geraci et al., 1999; NMFS, 2007), including fisheries interactions (bycatch and directed catch) and pollution (marine debris, toxic compounds). Other mortality not discussed in detail includes habitat modification (degradation, prey reduction), vessel strikes (Laist et al., 2001), and gunshots. Figure 6-13 describes potential threats worldwide to small toothed cetaceans, by source.

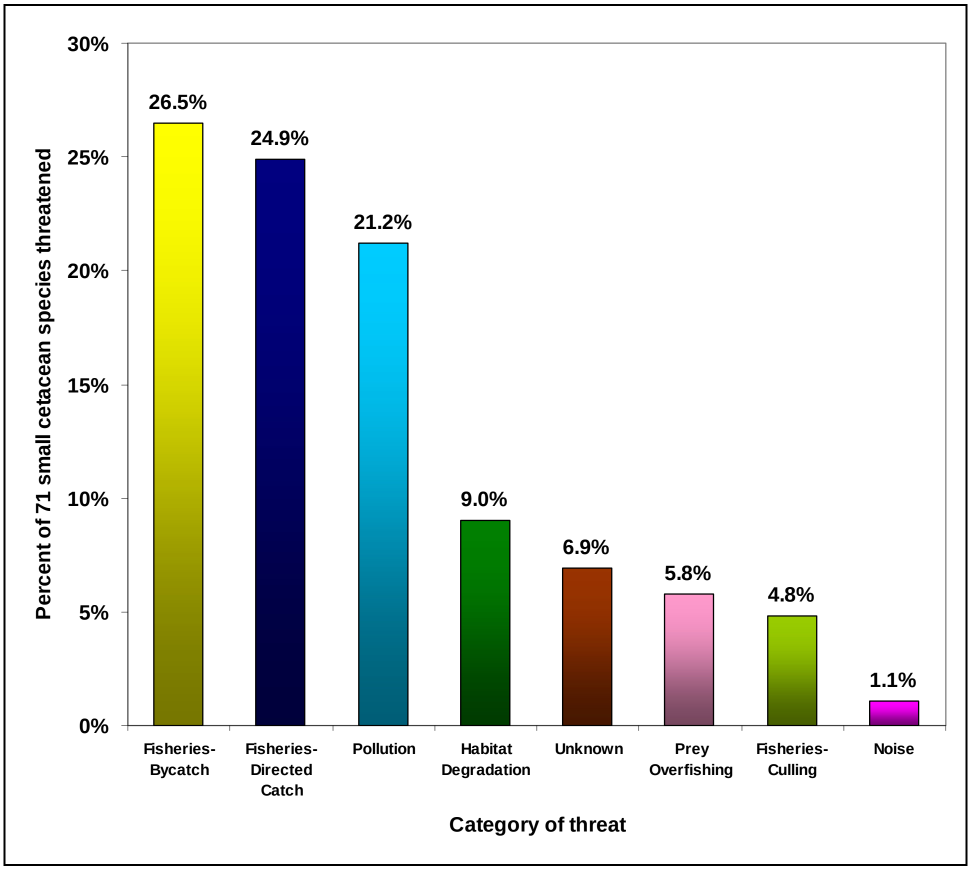

Figure 6-13. Human Threats to World-wide Small Cetacean Populations*

(Source: Culik, 2002)

*The Navy realizes that the total percentages add up to 100.2 percent;
however this figure is referenced directly from the aforementioned report.

Fisheries Interaction: By-Catch, Directed Catch, and Entanglement

The incidental catch of marine mammals in commercial fisheries is a significant threat to the survival and recovery of many populations of marine mammals (Geraci et al., 1999; Baird, 2002; Culik, 2002; Carretta et al., 2004; Geraci and Lounsbury, 2005; NMFS, 2007). Interactions with fisheries and entanglement in discarded or lost gear continue to be a major factor in marine mammal deaths worldwide (Geraci et al., 1999; Nieri et al., 1999; Geraci and Lounsbury, 2005; Read et al., 2006; Zeeber et al., 2006). For instance, baleen whales and pinnipeds have been found entangled in nets, ropes, monofilament line, and other fishing gear that has been discarded out at sea (Geraci et al., 1999; Campagna et al., 2007).

Bycatch- Bycatch is the catching of non-target species within a given fishing operation and can include non-commercially used invertebrates, fish, sea turtles, birds, and marine mammals (NRC, 2006). Read et al. (2006) attempted to estimate the magnitude of marine mammal bycatch in U.S. and global fisheries. Data on marine mammal bycatch within the United States was obtained from fisheries observer programs, reports of entangled stranded animals, and fishery logbooks, and was then extrapolated to estimate global bycatch by using the ratio of U.S. fishing vessels to the total number of vessels within the world's fleet (Read et al., 2006). Within U.S. fisheries, between 1990 and 1999 the mean annual bycatch of marine mammals was 6,215 animals, with a standard error of +/- 448 (Read et al., 2006). Eight-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read et al., 2006). Over the decade there was a 40 percent decline in marine mammal bycatch, which was significantly lower from 1995-1999 than it was from 1990-1994 (Read et al., 2006). Read et al. (2006) suggests that this is primarily due to effective conservation measures that were implemented during this time period.

Read et al. (2006) then extrapolated this data for the same time period and calculated an annual estimate of 653,365 of marine mammals globally, with most of the world's bycatch occurring in gill-net fisheries. With global marine mammal bycatch likely to be in the hundreds of thousands every year, bycatch in fisheries will be the single greatest threat to many marine mammal populations around the world (Read et al., 2006).

Entanglement- Entanglement in active fishing gear is a major cause of death or severe injury among the endangered whales in the action area. Entangled marine mammals may die as a result of drowning, escape with pieces of gear still attached to their bodies, or manage to be set free either of their own accord or by fishermen. Many large whales carry off gear after becoming entangled (Read et al., 2006). Many times when a marine mammal swims off with gear attached, the end result can be fatal. The gear may be become too cumbersome for the animal, or it can be wrapped around a crucial body part and tighten over time. Stranded marine mammals frequently exhibit signs of previous fishery interaction, such as scarring or gear attached to their bodies, and the cause of death for many stranded marine mammals is often attributed to such interactions (Baird and Gorgone, 2005). Because marine mammals that die or are injured in fisheries may not wash ashore and not all animals that do wash ashore exhibit clear signs of interactions, stranding data probably underestimate fishery-related mortality and serious injury (NMFS, 2005a).

From 1993 through 2003, 1,105 harbor porpoises were reported stranded from Maine to North Carolina, many of which had cuts and body damage suggestive of net entanglement (NMFS, 2005d). In 1999 it was possible to determine that the cause of death for 38 of the stranded porpoises was from fishery interactions, with one additional animal having been mutilated (right flipper and fluke cut off) (NMFS, 2005d). In 2000, one stranded porpoise was found with monofilament line wrapped around its body (NMFS, 2005d). And in 2003, nine stranded harbor porpoises were attributed to fishery interactions, with an additional three mutilated animals

(NMFS, 2005d). An estimated 78 baleen whales were killed annually in the offshore southern California/Oregon drift gillnet fishery during the 1980s (Heyning and Lewis 1990).

Ship Strike

Vessel strikes to marine mammals are another cause of mortality and stranding (Laist et al. 2001; Geraci and Lounsbury, 2005; de Stephanis and Urquiola, 2006). An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus, 2001; Laist et al., 2001; Vanderlaan and Taggart 2007).

An examination of all known ship strikes from all shipping sources (civilian and military) indicates vessel speed is a principal factor in whether a vessel strike results in death (Knowlton and Kraus 2001; Laist et al. 2001, Jensen and Silber 2003; Vanderlaan and Taggart 2007). Jensen and Silber (2003) detailed 292 records of known or probable ship strikes of all large whale species from 1975 to 2002. Of these, vessel speed at the time of collision was reported for 58 cases. Of these cases, 39 (or 67%) resulted in serious injury or death (19 or 33% resulted in serious injury as determined by blood in the water, propeller gashes or severed tailstock, and fractured skull, jaw, vertebrae, hemorrhaging, massive bruising or other injuries noted during necropsy and 20 or 35% resulted in death). Operating speeds of vessels that struck various species of large whales ranged from 2 to 51 knots. The majority (79%) of these strikes occurred at speeds of 13 knots or greater. The average speed that resulted in serious injury or death was 18.6 knots. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 percent to 75 % as vessel speed increased from 10 to 14 knots, and exceeded 90% at 17 knots. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death by pulling whales toward the vessel. Computer simulation modeling showed that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne 1999, Knowlton et al. 1995).

The growth in civilian commercial ports and associated commercial vessel traffic is a result in the globalization of trade. The Final Report of the NOAA International Symposium on "Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology" stated that the worldwide commercial fleet has grown from approximately 30,000 vessels in 1950 to over 85,000 vessels in 1998 (NRC, 2003; Southall, 2005). Between 1950 and 1998, the U.S. flagged fleet declined from approximately 25,000 to less than 15,000 and currently represents only a small portion of the world fleet. From 1985 to 1999, world seaborne trade doubled to 5 billion tons and currently includes 90 percent of the total world trade, with container shipping movements representing the largest volume of seaborne trade. It is unknown how international shipping volumes and densities will continue to grow. However, current statistics support the prediction that the international shipping fleet will continue to grow at the current rate or at greater rates in the future. Shipping densities in specific areas and trends in routing and vessel design are as, or more, significant than the total number of vessels. Densities along existing coastal routes are expected to increase both domestically and internationally. New routes are also expected to develop as new ports are opened and existing ports are expanded. Vessel propulsion systems are also advancing toward faster ships operating in higher sea states for lower operating costs; and container ships are expected to become larger along certain routes (Southall, 2005). While there are reports and statistics of whales struck by vessels in U.S. waters, the magnitude of the risks of commercial ship traffic poses to marine mammal populations is difficult to quantify or estimate. In addition, there is limited information on vessel strike interactions between ships and marine mammals outside of U.S. waters (de Stephanis and Urquiola, 2006). Laist et al. (2001) concluded that ship collisions may have a negligible effect on most marine mammal populations in general, except for regional based small populations where the significance of low numbers of collisions would be greater given smaller populations or populations segments.

The DON vessel traffic is a small fraction of the overall U.S. commercial and fishing vessel traffic. While DON vessel movements may contribute to the ship strike threat, given the lookout and mitigation measures adopted by the DON, probability of vessel strikes is greatly reduced. Furthermore, actions to avoid close interaction of DON ships and marine mammals and sea turtles, such as maneuvering to keep away from any observed marine mammal and sea turtle are part of existing at-sea protocols and standard operating procedures. Navy ships have up to three or more dedicated and trained lookouts as well as two to three bridge watchstanders during at-sea movements who would be searching for any whales, sea turtles, or other obstacles on the water surface. Such lookouts are expected to further reduce the chances of a collision.

Ingestion of Plastic Objects and Other Marine Debris and Toxic Pollution Exposure

For many marine mammals, debris in the marine environment is a great hazard and can be harmful to wildlife. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (NMFS, 2007b). There are certain species of cetaceans, along with Florida manatees, that are more likely to eat trash, especially plastics, which is usually fatal for the animal (Geraci et al., 1999).

Between 1990 through October 1998, 215 pygmy sperm whales stranded along the U.S. Atlantic coast from New York through the Florida Keys (NMFS, 2005a). Remains of plastic bags and other debris were found in the stomachs of 13 of these animals (NMFS, 2005a). During the same time period, 46 dwarf sperm whale strandings occurred along the U.S. Atlantic coastline between Massachusetts and the Florida Keys (NMFS, 2005c). In 1987 a pair of latex examination gloves was retrieved from the stomach of a stranded dwarf sperm whale (NMFS, 2005c). 125 pygmy sperm whales were reported stranded from 1999 – 2003 between Maine and Puerto Rico; in one pygmy sperm whale found stranded in 2002, red plastic debris was found in the stomach along with squid beaks (NMFS, 2005a).

Sperm whales have been known to ingest plastic debris, such as plastic bags (Evans and Hindell, 2004; Whitehead 2003). While this has led to mortality, the scale to which this is affecting sperm whale populations is unknown, but Whitehead (2003) suspects it is not substantial at this time. High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events.

NMFS takes part in a marine mammal bio-monitoring program not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains and marine ecosystem health. Using strandings and bycatch animals, the program provides tissue/serum archiving, samples for analyses, disease monitoring and reporting, and additional response during disease investigations (NMFS, 2007).

The impacts of these activities are difficult to measure. However, some researchers have correlated contaminant exposure to possible adverse health effects in marine mammals. Contaminants such as organochlorines do not tend to accumulate in significant amounts in invertebrates, but do accumulate in fish and fish-eating animals. Thus, contaminant levels in planktivorous mysticetes have been reported to be one to two orders of magnitude lower compared to piscivorous odontocetes (Borell 1993; O'Shea and Brownell 1994; O'Hara and Rice 1996; O'Hara et al. 1999).

The manmade chemical PCB (polychlorinated biphenyl), and the pesticide DDT (dichlorodiphyenyltrichloroethane), are both considered persistent organic pollutants that are currently banned in the United States for their harmful effects in wildlife and humans (NMFS, 2007a). Despite having been banned for decades, the levels of these compounds are still high in marine mammal tissue samples taken along U.S. coasts (NMFS, 2007a). Both compounds are long-lasting, reside in marine mammal fat tissues (especially in the blubber), and can be toxic causing effects such as reproductive impairment and immunosuppression (NMFS, 2007a).

Both long-finned and short-finned pilot whales have a tendency to mass strand throughout their range. Short-finned pilot whales have been reported as stranded as far north as Rhode Island, and long-finned pilot whales as far south as South Carolina (NMFS, 2005b). For U.S. east coast stranding records, both species are lumped together and there is rarely a distinction between the two because of uncertainty in species identification (NMFS, 2005b). Since 1980 within the Northeast region alone, between 2 and 120 pilot whales have stranded annually either individually or in groups (NMFS, 2005b). Between 1999 and 2003 from Maine to Florida, 126 pilot whales were reported to be stranded, including a mass stranding of 11 animals in 2000 and another mass stranding of 57 animals in 2002, both along the Massachusetts coast (NMFS, 2005b).

It is unclear how much of a role human activities play in these pilot whale strandings, and toxic poisoning may be a potential human-caused source of mortality for pilot whales (NMFS, 2005b). Moderate levels of PCBs and chlorinated pesticides (such as DDT, DDE, and dieldrin) have been found in pilot whale blubber (NMFS, 2005b). Bioaccumulation levels have been found to be more similar in whales from the same stranding event than from animals of the same age or sex (NMFS, 2005b). Numerous studies have measured high levels of toxic metals (mercury, lead, and cadmium), selenium, and PCBs in pilot whales in the Faroe Islands (NMFS, 2005b). Population effects resulting from such high contamination levels are currently unknown (NMFS, 2005b).

Habitat contamination and degradation may also play a role in marine mammal mortality and strandings. Some events caused by man have direct and obvious effects on marine mammals, such as oil spills (Geraci et al., 1999). But in most cases, effects of contamination will more than likely be indirect in nature, such as effects on prey species availability, or by increasing disease susceptibility (Geraci et al., 1999).

DON vessel operation between ports and exercise locations has the potential for release of small amounts of pollutant discharges into the water column. DON vessels are not a typical source, however, of either pathogens or other contaminants with bioaccumulation potential such as pesticides and PCBs. Furthermore, any vessel discharges such as bilgewater and deck runoff associated with the vessels would be in accordance with international and U.S. requirements for eliminating or minimizing discharges of oil, garbage, and other substances, and not likely to contribute significant changes to ocean water quality.

Anthropogenic Sound

As one of the potential stressors to marine mammal populations, noise and acoustic influences may disrupt marine mammal communication, navigational ability, and social patterns, and may or may not influence stranding. Many marine mammals use sound to communicate, navigate, locate prey, and sense their environment. Both anthropogenic and natural sounds may cause interference with these functions, although comprehension of the type and magnitude of any behavioral or physiological responses resulting from man-made sound, and how these responses may contribute to strandings, is rudimentary at best (NMFS, 2007). Marine mammals may respond both behaviorally and physiologically to anthropogenic sound exposure, (e.g., Richardson et al., 1995; Finneran et al., 2000; Finneran et al., 2003; Finneran et al., 2005, NRC, 2005); however, the range and magnitude of the behavioral response of marine mammals to various sound sources is highly variable (Richardson et al., 1995; NRC 2005) and appears to depend on the species involved, the experience of the animal with the sound source, the motivation of the animal (e.g., feeding, mating), and the context of the exposure.

The marine mammals are regularly exposed to several sources of natural and anthropogenic sounds. Anthropogenic noise that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which, can contribute to the total noise at any one place and time. These noises include: transportation; dredging; construction; oil, gas, and mineral exploration in offshore areas; geophysical (seismic) surveys; sonar; explosions; and ocean research activities (Richardson et al., 1995). Commercial fishing vessels, cruise ships, transport boats, recreational boats, and aircraft, all contribute sound into the ocean (NRC, 2003; NRC, 2006). Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994, 1996, 2000, 2003, 2005; Richardson et al., 1995; Jasny et al., 2005; McDonald et al., 2006). Much of this increase is due to increased shipping due to ships becoming more numerous and of larger tonnage (NRC, 2003; McDonald et al., 2006). Andrew et al. (2002) compared ocean ambient sound from the 1960s with the 1990s for a receiver off the California coast. The data showed an increase in ambient noise of approximately 10 dB in the frequency range of 20 to 80 Hz and 200 and 300 Hz, and about 3 dB at 100 Hz over a 33-year period.

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather, are the primary causes of deep-water ambient noise. The ambient noise frequency spectrum can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick, 1983). For example, for frequencies between 100 and 500 Hz, Urick (1983) estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas. In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, marine animals (Urick, 1983). At any give time and place, the ambient noise is a mixture of all of these noise variables. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sounds levels tend to be higher, then when the bottom is absorptive.

Most observations of behavioral responses of marine mammals to the sounds produced have been limited to short-term behavioral responses, which included the cessation of feeding, resting, or social interactions. Carretta et al. (2001) and Jasny et al. (2005) identified increasing levels of anthropogenic noise as a habitat concern for whales and other marine mammals because of its potential effect in their ability to communicate. Acoustic devices have also been used in fisheries nets to prevent marine mammal entanglement (Goodson 1997; NMFS 1997; MMC 1999) and to deter seals from salmon cages (Johnson and Woodley 1998), little is known about their effects on non-target species

Noise from Aircraft and Vessel Movement- Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans and may contribute to over 75% of all human sound in the sea (Simmonds and Hutchinson 1996, ICES, 2005b). The Navy estimated that the 60,000 vessels of the world's merchant fleet, annually emit low frequency sound into the world's oceans for the equivalent of 21.9 million days, assuming that 80 percent of the merchant ships are at sea at any one time (U.S. Department of Navy 2001). Ross (1976) has estimated that between 1950 and 1975, shipping had caused a rise in ambient noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century. The National Resource Council (1997) estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships. Michel et al. (2001) suggested an association between long-term exposure to low frequency sounds from shipping and an increased incidence of marine mammal mortalities caused by collisions with ships.

Airborne sound from a low-flying helicopter or airplane may be heard by marine mammals and turtles while at the surface or underwater. Due to the transient nature of sounds from aircraft involved in at-sea operations, such sounds would not likely cause physical effects but have the potential to affect behaviors. Responses by mammals and turtles could include hasty dives or turns, or decreased foraging (Soto et al., 2006). Whales may also slap the water with flukes or flippers, swim away from the aircraft track.

Sound emitted from large vessels, particularly in the course of transit, is the principal source of noise in the ocean today, primarily due to the properties of sound emitted by civilian cargo vessels (Richardson et al., 1995; Arveson and Vendittis, 2000). Ship propulsion and electricity generation engines, engine gearing, compressors, bilge and ballast pumps, as well as hydrodynamic flow surrounding a ship's hull and any hull protrusions contribute to a large vessels' noise emission into the marine environment. Prop-driven vessels also generate noise through cavitation, which accounts much of the noise emitted by a large vessel depending on its travel speed. Military vessels underway or involved in naval operations or exercises, also introduce anthropogenic noise into the marine environment. Noise emitted by large vessels can be characterized as low-frequency, continuous, and tonal. The sound pressure levels at the vessel will vary according to speed, burden, capacity and length (Richardson et al., 1995; Arveson and Vendittis, 2000). Vessels ranging from 135 to 337 meters generate peak source sound levels from 169- 200 dB between 8 Hz and 430 Hz, although Arveson and Vendittis (2000) documented components of higher frequencies (10-30 kHz) as a function of newer merchant ship engines and faster transit speeds.

Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away from a vessel. Unfortunately, it is not always possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a vessel transit through an area.

Vessel noise primarily raises concerns for masking of environmental and conspecific cues. However, exposure to vessel noise of sufficient intensity and/or duration can also result in temporary or permanent loss of sensitivity at a given frequency range, referred to as temporary or permanent threshold shifts (TTS or PTS). Threshold shifts are assumed to be possible in marine mammal species as a result of prolonged exposure to large vessel traffic noise due to its intensity, broad geographic range of effectiveness, and constancy.

Collectively, significant cumulative exposure to individuals, groups, or populations can occur if they exhibit site fidelity to a particular area; for example, whales that seasonally travel to a regular area to forage or breed may be more vulnerable to noise from large vessels compared to transiting whales. Any permanent threshold shift in a marine animal's hearing capability, especially at particular frequencies for which it can normally hear best, can impair its ability to perceive threats, including ships. Whales have variable responses to vessel presence or approaches, ranging from apparent tolerance to diving away from a vessel. It is not possible to determine whether the whales are responding to the vessel itself or the noise generated by the engine and cavitation around the propeller. Apart from some disruption of behavior, an animal may be unable to hear other sounds in the environment due to masking by the noise from the vessel.

Most observations of behavioral responses of marine mammals to human generated sounds have been limited to short-term behavioral responses, which included the cessation of feeding, resting, or social interactions. Nowacek et al. (2007) provide a detailed summary of cetacean response to underwater noise.

Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139-463 kilometers away (Ross 1976 in Polefka 2004). DON vessels, however, have incorporated significant underwater ship quieting technology to reduce their acoustic signature (as compared to a similarly-sized vessel) in order to reduce their vulnerability to detection by enemy passive acoustics (Southall, 2005). Therefore, the potential for TTS or PTS from DON vessel and aircraft movement is extremely low given that the exercises and training events are transitory in time, with vessels moving over large area of the ocean. A marine mammal or sea turtle is unlikely to be exposed long enough at high levels for TTS or PTS to occur. Any masking of environmental sounds or conspecific sounds is expected to be temporary, as noise dissipates with a DON vessel transiting through an area. If behavioral disruptions result from the presence of aircraft or vessels, it is expected to be temporary. Animals are expected to resume their migration, feeding, or other behaviors without any threat to their survival or reproduction. However, if an animal is aware of a vessel and dives or swims away, it may successfully avoid being struck.

Navy Sonar- Naval sonars are designed for three primary functions: submarine hunting, mine hunting, and shipping surveillance. There are two classes of sonars employed by the DON: active sonars and passive sonars. Most active military sonars operate in a limited number of areas, and are most likely not a significant contributor to a comprehensive global ocean noise budget (ICES 2005b).

The effects of mid-frequency active naval sonar on marine wildlife have not been studied as extensively as the effects of air-guns used in seismic surveys (Madsen et al., 2006; Stone and Tasker, 2006; Wilson et al., 2006; Palka and Johnson, 2007; Parente et al., 2007). Maybaum (1989, 1993) observed changes in behavior of humpbacks during playback tapes of the M-1002 system (using 203 dB re 1 µPa-m for study); specifically, a decrease in respiration, submergence, and aerial behavior rates; and an increase in speed of travel and track linearity. Direct comparisons of Maybaum's results, however, with U.S Navy mid-frequency active sonar are difficult to make. Maybaum's signal source, the commercial M-1002, is not similar to how naval mid-frequency sonar operates. In addition, behavioral responses were observed during playbacks of a control tape, (i.e. a tape with no sound signal) so interpretation of Maybaum's results are inconclusive.

Research by Nowacek, et al. (2004) on North Atlantic right whales using a whale alerting signal designed to alert whales to human presence suggests that received sound levels of only 133 to 148 pressure level (decibel [dB] re 1 microPascals per meter [µPa-m]) for the duration of the sound exposure may disrupt feeding behavior. The authors did note, however, that within minutes of cessation of the source, a return to normal behavior would be expected. Direct comparison of the Nowacek et al. (2004) sound source to MFA sonar, however, is not possible given the radically different nature of the two sources. Nowacek et al.'s source was a series of non-sonar like sounds designed to purposely alert the whale, lasting several minutes, and covering a broad frequency band. Direct differences between Nowacek et al. (2004) and MFA sonar is summarized below from Nowacek et al. (2004) and Nowacek et al. (2007):

1. Signal duration: Time difference between the two signals is significant, 18-minute signal used by Nowacek et al. verses < 1-sec for MFA sonar.
2. Frequency modulation: Nowacek et al. contained three distinct signals containing frequency modulated sounds:
    a. 1st - alternating 1-sec pure tone at 500 and 850 Hz
    b. 2nd - 2-sec logarithmic down-sweep from 4500 to 500 Hz
    c. 3rd - pair of low-high (1500 and 2000 Hz) sine wave tones amplitude modulated at 120 Hz
3. Signal to noise ratio: Nowacek et al.'s signal maximized signal to noise ratio so that it would be distinct from ambient noise and resist masking.
4. Signal acoustic characteristics: Nowacek et al.'s signal comprised of disharmonic signals spanning northern right whales' estimated hearing range.

Given these differences, therefore, the exact cause of apparent right whale behavior noted by the authors can not be attributed to any one component since the source was such a mix of signal types.

6.2.11.3 Stranding Analysis

Over the past two decades, several mass stranding events involving beaked whales have been documented. While beaked whale strandings have occurred since the 1800s (Geraci and Lounsbury, 1993; Cox et al., 2006; Podesta et al., 2006), several mass strandings since have been associated with naval operations that may have included mid-frequency sonar (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998; Jepson et al., 2003; Cox et al., 2006). As Cox et al. (2006) concludes, the state of science can not yet determine if a sound source such as mid-frequency sonar alone causes beaked whale strandings, or if other factors (acoustic, biological, or environmental) must co-occur in conjunction with a sound source.

A review of historical data (mostly anecdotal) maintained by the Marine Mammal Program in the National Museum of Natural History, Smithsonian Institution reports 49 beaked whale mass stranding events between 1838 and 1999. The largest beaked whale mass stranding occurred in the 1870s in New Zealand when 28 Gray's beaked whales (*Mesoplodon grayi*) stranded. Blainsville's beaked whale (*Mesoplodon densirostris*) strandings are rare, and records show that they were involved in one mass stranding in 1989 in the Canary Islands. Cuvier's beaked whales (*Ziphius cavirostris*) are the most frequently reported beaked whale to strand, with at least 19 stranding events from 1804 through 2000 (DoC and DoN, 2001; Smithsonian Institution, 2000). By the nature of the data, much of the historic information on strandings over the years is anecdotal, which has been condensed in various reports, and some of the data have been altered or possibly misquoted.

The discussion below centers on those worldwide stranding events that may have some association with naval operations, and global strandings that the DON feels are either inconclusive or can not be associated with naval operations.

6.2.11.3.1 Naval Association Stranding Events – Case Studies

In the following sections, specific stranding events that have been putatively linked to potential sonar operations are discussed. Of note, these events represent a small overall number of animals over an 11 year period (40 animals) and not all worldwide beaked whale strandings can be linked to naval activity (ICES, 2005a; 2005b; Podesta et al., 2006). Four of the five events occurred during NATO exercises or events where DON presence was limited (Greece, Portugal, Spain). One of the five events involved only DON ships (Bahamas).

Beaked whale stranding events associated with potential naval operations include the following:

- 1996 May Greece (NATO/US)
- 2000 March Bahamas (US)
- 2000 May Portugal, Madeira Islands (NATO/US)
- 2002 September Spain, Canary Islands (NATO/US)
- 2006 January Spain, Mediterranean Sea coast (NATO/US)

1996 Greece Beaked Whale Mass Stranding (May 12 – 13, 1996)

Description

Twelve Cuvier’s beaked whales (*Ziphius cavirostris*) stranded along a 38.2-kilometer strand of the coast of the Kyparissiakos Gulf on May 12 and 13, 1996 (Frantzis, 1998). From May 11 through May 15, the NATO research vessel Alliance was conducting sonar tests with signals of 600 Hz and 3 kHz and root-mean-squared (rms) sound pressure levels (SPL) of 228 and 226 dB re: 1µPa, respectively (D'Amico and Verboom, 1998; D’Spain et al., 2006). The timing and the location of the testing encompassed the time and location of the whale strandings (Frantzis, 1998).

Findings

Partial necropsies of eight of the animals were performed, including external assessments and the sampling of stomach contents. No abnormalities attributable to acoustic exposure were observed, but the stomach contents indicated that the whales were feeding on cephalods soon before the stranding event. No unusual environmental events before or during the stranding event could be identified (Frantzis, 1998).

Conclusions

The timing and spatial characteristics of this stranding event were atypical of stranding in Cuvier’s beaked whale, particularly in this region of the world. No natural phenomenon that might contribute to the stranding event coincided in time with the mass stranding. Because of the rarity of mass strandings in the Greek Ionian Sea, the probability that the sonar tests and stranding coincided in time and location, while being independent of each other, was estimated as being extremely low (Frantzis, 1998). However, because information for the necropsies was incomplete and inconclusive, the cause of the stranding cannot be precisely determined.

2000 Bahamas Marine Mammal Mass Stranding (March 15-16, 2000)

Description

Seventeen marine mammals comprised of Cuvier's beaked whales, Blainville's beaked whales (*Mesoplodon densirostris*), minke whale (*Balaenoptera acutorostrata*), and one spotted dolphin (*Stenella frontalis*), stranded along the Northeast and Northwest Providence Channels of the Bahamas Islands on March 15-16, 2000 (Evans and England, 2001). The strandings occurred over a 36-hour period and coincided with DON use of mid-frequency active sonar within the channel. Navy ships were involved in tactical sonar exercises for approximately 16 hours on March 15. The ships, which operated the AN/SQS-53C and AN/SQS-56, moved through the channel while emitting sonar pings approximately every 24 seconds. The timing of pings was staggered between ships and average source levels of pings varied from a nominal 235 dB SPL (AN/SQS-53C) to 223 dB SPL (AN/SQS-56). The center frequency of pings was 3.3 kHz and 6.8 to 8.2 kHz, respectively.

Seven of the animals that stranded died, while ten animals were returned to the water alive. The animals known to have died included five Cuvier's beaked whales, one Blainville's beaked whale, and the single spotted dolphin. Six necropsies were performed and three of the six necropsied whales (one Cuvier's beaked whale, one Blainville's beaked whale, and the spotted dolphin) were fresh enough to permit identification of pathologies by computerized tomography (CT). Tissues from the remaining three animals were in a state of advanced decomposition at the time of inspection.

Findings

The spotted dolphin demonstrated poor body condition and evidence of a systemic debilitating disease. In addition, since the dolphin stranding site was isolated from the acoustic activities of Navy ships, it was determined that the dolphin stranding was unrelated to the presence of Navy active sonar.

All five necropsied beaked whales were in good body condition and did not show any signs of external trauma or disease. In the two best preserved whale specimens, hemorrhage was associated with the brain and hearing structures. Specifically, subarachnoid hemorrhage within the temporal region of the brain and intracochlear hemorrhages were noted. Similar findings of bloody effusions around the ears of two other moderately decomposed whales were consistent with the same observations in the freshest animals. In addition, three of the whales had small hemorrhages in their acoustic fats, which are fat bodies used in sound production and reception (i.e., fats of the lower jaw and the melon). The best-preserved whale demonstrated acute hemorrhage within the kidney, inflammation of the lung and lymph nodes, and congestion and mild hemorrhage in multiple other organs. Other findings were consistent with stresses and injuries associated with the stranding process. These consisted of external scrapes, pulmonary edema and congestion.

Conclusions

The post-mortem analyses of stranded beaked whales lead to the conclusion that the immediate cause of death resulted from overheating, cardiovascular collapse and stresses associated with being stranded on land. However, the presence of subarachnoid and intracochlear hemorrhages were believed to have occurred prior to stranding and were hypothesized as being related to an acoustic event. Passive acoustic monitoring records demonstrated that no large scale acoustic activity besides the Navy sonar exercise occurred in the times surrounding the stranding event. The mechanism by which sonar could have caused the observed traumas or caused the animals to strand was undetermined. The spotted dolphin was in overall poor condition for examination, but showed indications of long-term disease. No analysis of baleen whales (minke whale) was conducted. Baleen whale stranding events have not been associated with either low-frequency or mid-frequency sonar use (ICES, 2005a, 2005b).

2000 Madeira Island, Portugal Beaked Whale Strandings (May 10 – 14, 2000)

Description

Three Cuvier’s beaked whales stranded on two islands in the Madeira Archipelago, Portugal, from May 10 – 14, 2000 (Cox et al., 2006). A joint NATO amphibious training exercise, named “Linked Seas 2000,” which involved participants from 17 countries, took place in Portugal during May 2 – 15, 2000. The timing and location of the exercises overlapped with that of the stranding incident.

Findings

Two of the three whales were necropsied. Two heads were taken to be examined. One head was intact and examined grossly and by CT; the other was only grossly examined because it was partially flensed and had been seared from an attempt to dispose of the whale by fire (Ketten, 2005).

No blunt trauma was observed in any of the whales. Consistent with prior CT scans of beaked whales stranded in the Bahamas 2000 incident, one whale demonstrated subarachnoid and peribullar hemorrhage and blood within one of the brain ventricles. Post-cranially, the freshest whale demonstrated renal congestion and hemorrhage, which was also consistent with findings in the freshest specimens in the Bahamas incident.

Conclusions

The pattern of injury to the brain and auditory system were similar to those observed in the Bahamas strandings, as were the kidney lesions and hemorrhage and congestion in the lungs (Ketten, 2005). The similarities in pathology and stranding patterns between these two events suggested a similar causative mechanism. Although the details about whether or how sonar was used during "Linked Seas 2000" is unknown, the presence of naval activity within the region at the time of the strandings suggested a possible relationship to Navy activity.

2002 Canary Islands Beaked Whale Mass Stranding (24 September 2002)

Description

On September 24, 2002, 14 beaked whales stranded on Fuerteventura and Lanzaote Islands in the Canary Islands (Jepson et al., 2003). Seven of the 14 whales died on the beach and the 7 were returned to the ocean. Four beaked whales were found stranded dead over the next three days either on the coast or floating offshore (Fernández et al., 2005). At the time of the strandings, an international naval exercise called Neo-Tapon involving numerous surface warships and several submarines was being conducted off the coast of the Canary Islands. Tactical mid-frequency active sonar was utilized during the exercises, and strandings began within hours of the onset of the use of mid-frequency sonar (Fernández et al., 2005).

Findings

Eight Cuvier's beaked whales, one Blainville's beaked whale, and on Gervais' beaked whale were necropsied; six of them within 12 hours of stranding (Fernández et al., 2005). The stomachs of the whales contained fresh and undigested prey contents. No pathogenic bacteria were isolated from the whales, although parasites were found in the kidneys of all of the animals. The head and neck lymph nodes were congested and hemorrhages were noted in multiple tissues and organs, including the kidney, brain, ears, and jaws. Widespread fat emboli were found throughout the carcasses, but no evidence of blunt trauma was observed in the whales. In addition, the parenchyma of several organs contained macroscopic intravascular bubbles and lesions, putatively associated with nitrogen off-gassing.

Conclusions

The association of NATO mid-frequency sonar use close in space and time to the beaked whale strandings, and the similarity between this stranding event and previous beaked whale mass strandings coincident with sonar use, suggests that a similar scenario and causative mechanism of stranding may be shared between the events. Beaked whales stranded in this event demonstrated brain and auditory system injuries, hemorrhages, and congestion in multiple organs, similar to the pathological findings of the Bahamas and Madeira stranding events. In addition, the necropsy results of Canary Islands stranding event lead to the hypothesis that the presence of disseminated and widespread gas bubbles and fat emboli were indicative of nitrogen bubble formation, similar to what might be expected in decompression sickness (Jepson et al., 2003; Fernández et al., 2005). Whereas gas emboli would develop from the nitrogen gas, fat emboli would enter the blood stream from ruptured fat cells (presumably where nitrogen bubble formation occurs) or through the coalescence of lipid bodies within the blood stream.

The possibility that the gas and fat emboli found by Fernández et al. (2005) was due to nitrogen bubble formation has been hypothesized to be related to either direct activation of the bubble by sonar signals or to a behavioral response in which the beaked whales flee to the surface following sonar exposure. The first hypothesis is related to rectified diffusion (Crum and Mao, 1996), the process of increasing the size of a bubble by exposing it to a sound field. This process 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). Deeper and longer dives of some marine mammals, such as those conducted by beaked whales, are theoretically predicted to induce greater levels of supersaturation (Houser et al., 2001). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness. It is unlikely that the short duration of sonar 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 bubbles 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. The second hypothesis speculates 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; Fernández et al., 2005). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Although theoretical predictions suggest the possibility for acoustically mediated bubble growth, there is considerable disagreement among scientists as to its likelihood (Piantadosi and Thalmann, 2004). Sound exposure levels predicted to cause in vivo bubble formation within diving cetaceans have not been evaluated and are suspected as needing to be very high (Evans, 2002; Crum et al., 2005). Moore and Early (2004) reported that in analysis of sperm whale bones spanning 111 years, gas embolism symptoms were observed indicating that sperm whales may be susceptible to decompression sickness due to natural diving behavior. Further, 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), there is no conclusive evidence supporting this hypothesis and there is concern that at least some of the pathological findings (e.g., bubble emboli) are artifacts of the necropsy. Currently, stranding networks in the United States have agreed to adopt a set of necropsy guidelines to determine, in part, the possibility and frequency with which bubble emboli can be introduced into marine mammals during necropsy procedures (Arruda et al., 2007).

2006 Spain, Gulf of Vera Beaked Whale Mass Stranding (26-27 January 2006)

Description

The Spanish Cetacean Society reported an atypical mass stranding of four beaked whales that occurred January 26 to 28, 2006, on the southeast coast of Spain near Mojacar (Gulf of Vera) in the Western Mediterranean Sea. According to the report, two of the whales were discovered the evening of January 26 and were found to be still alive. Two other whales were discovered during the day on January 27, but had already died. A following report stated that the first three animals were located near the town of Mojacar and were examined by a team from the University of Las Palmas de Gran Canarias, with the help of the stranding network of Ecologistas en Acción Almería-PROMAR and others from the Spanish Cetacean Society. The fourth animal was found dead on the afternoon of May 27, a few kilometers north of the first three animals.

From January 25-26, 2006, a NATO surface ship group (seven ships including one U.S. ship under NATO operational command) conducted active sonar training against a Spanish submarine within 50 nm of the stranding site.

Findings

Veterinary pathologists necropsied the two male and two female beaked whales (*Z. cavirostris*).

Conclusions

According to the pathologists, a likely cause of this type of beaked whale mass stranding event may have been anthropogenic acoustic activities. However, no detailed pathological results confirming this supposition have been published to date, and no positive acoustic link was established as a direct cause of the stranding.

Even though no causal link can be made between the stranding event and naval exercises, certain conditions may have existed in the exercise area that, in their aggregate, may have contributed to the marine mammal strandings (Freitas, 2004):

- Operations were conducted in areas of at least 1,000 m (3,281 ft) in depth near a shoreline where there is a rapid change in bathymetry on the order of 1,000 to 6,000 m (3,281 to 19,685 ft) occurring a cross a relatively short horizontal distance (Freitas, 2004).
- Multiple ships, in this instance, five MFA sonar equipped vessels, were operating in the same area over extended periods of time (20 hours) in close proximity.
- Exercises took place in an area surrounded by landmasses, or in an embayment. Operations involving multiple ships employing mid-frequency active sonar near land may produce sound directed towards a channel or embayment that may cut off the lines of egress for marine mammals (Freitas, 2004).

6.2.11.3.2 Other Global Stranding Events – Case Studies

In the following sections, stranding events that have been linked to DON activity in popular press are presented. As detailed in the individual case study conclusions, the DON believes that there is enough to evidence available to refute allegations of impacts from mid-frequency sonar, or at least indicate that a substantial degree of uncertainty in time and space that preclude a meaningful scientific conclusion.

2003 Washington State Harbor Porpoise Strandings (May 2 – June 2 2003)

Description

At 1040 hours on May 5, 2003, the USS Shoup began the use of mid-frequency tactical active sonar as part of a naval exercise. At 1420, the USS Shoup entered the Haro Strait and terminated active sonar use at 1438, thus limiting active sonar use within the strait to less than 20 minutes. Between May 2 and June 2, 2003, approximately 16 strandings involving 15 harbor porpoises (*Phocoena phocoena*) and one Dall's porpoise (*Phocoenoides dalli*) were reported to the Northwest Marine Mammal Stranding Network. A comprehensive review of all strandings and the events involving USS Shoup on 5 May 2003 were presented in U.S. Department of Navy (2004). Given that the USS Shoup was known to have operated sonar in the strait on May 5, and that supposed behavioral reactions of killer whales (*Orcinus orca*) had been putatively linked to these sonar operations (NMFS Office of Protected Resources, 2005), the NMFS undertook an analysis of whether sonar caused the strandings of the harbor porpoises.

Whole carcasses of ten of harbor porpoises and the head of an additional porpoise were collected for analysis. Necropsies were performed on ten of the harbor porpoises and six whole carcasses and two heads were selected for CT imaging. Gross examination, histopathology, age determination, blubber analysis, and various other analyses were conducted on each of the carcasses (Norman et al., 2004).

Findings

Post-mortem findings and analysis details are found in Norman et al. (2004). All of the carcasses suffered from some degree of freeze-thaw artifact that hampered gross and histological evaluations. At the time of necropsy, three of the porpoises were moderately fresh, whereas the remainder of the carcasses was considered to have moderate to advanced decomposition. None of the 11 harbor porpoises demonstrated signs of acoustic trauma. In contrast, a putative cause of death was determined for 5 of the porpoises; 2 animals had blunt trauma injuries and 3 animals had indication of disease processes (fibrous peritonitis, salmonellosis, and necrotizing pneumonia). A cause of death could not be determined in the remaining animals, which is consistent with expected percentage of marine mammal necropsies conducted within the northwest region. It is important to note, however, that these determinations were based only on evidence from the necropsy so as not to be biased with regard to determinations of the potential presence or absence of acoustic trauma. The result was that other potential causal factors, such as one animal (Specimen 33NWR05005) found tangled in a fishing net, were unknown to the investigators in their determination regarding the likely cause of death.

Conclusions

The NMFS concluded from a retrospective analysis of stranding events that the number of harbor porpoise stranding events in the approximate month surrounding the USS SHOUP use of sonar was higher than expected based on annual strandings of harbor porpoises (Norman et al., 2004). In this regard, it is important to note that the number of strandings in the May-June timeframe in

2003 was also higher for the outer coast, indicating a much wider phenemona than use of sonar by USS Shoup in Puget Sound for one day in May. This conclusion by NMFS that the number of strandings in 2003 was higher is also different from that of The Whale Museum, which has documented and responded to harbor porpoise strandings since 1980 (Osborne, 2003). According to The Whale Museum, the number of strandings as of May 15, 2003, was consistent with what was expected based on historical stranding records and was less than that occurring in certain years. For example, since 1992 the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997 there were 12 strandings in the San Juan Islands with more than 30 strandings throughout the general Puget Sound area. Disregarding the discrepancy in the historical rate of porpoise strandings and its relation to the USS Shoup, NMFS acknowledged that the intense level of media attention focused on the strandings likely resulted in an increased reporting effort by the public over that which is normally observed (Norman et al., 2004). NMFS also noted in its report that the "sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings."

Seven of the porpoises collected and analyzed died prior to SHOUP departing to sea on May 5, 2003. Of these seven, one, discovered on May 5, 2003, was in a state of moderate decomposition, indicating it died before May 5; the cause of death was determined to be due, most likely, to salmonella septicemia. Another porpoise, discovered at Port Angeles on May 6, 2003, was in a state of moderate decomposition, indicating that this porpoise also died prior to May 5. One stranded harbor porpoise discovered fresh on May 6 is the only animal that could potentially be linked in time to the USS Shoup's May 5 active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. The remaining eight strandings were discovered one to three weeks after the USS Shoup's May 5 transit of the Haro Strait, making it difficult to causally link the sonar activities of the USS Shoup to the timing of the strandings. Two of the eight porpoises died from blunt trauma injury and a third suffered from parasitic infestation, which possibly contributed to its death (Norman et al., 2004). For the remaining five porpoises, NMFS was unable to identify the causes of death.

The speculative association of the harbor porpoise strandings to the use of sonar by the USS Shoup is inconsistent with prior stranding events linked to the use of mid-frequency sonar. Specifically, in prior events, the stranding of whales occurred over a short period of time (less than 36 hours), stranded individuals were spatially co-located, traumas in stranded animals were consistent between events, and active sonar was known or suspected to be in use. Although mid-frequency active sonar was used by the USS SHOUP, the distribution of harbor porpoise strandings by location and with respect to time surrounding the event do not support the suggestion that mid-frequency active sonar was a cause of harbor porpoise strandings. Rather, a complete lack of evidence of any acoustic trauma within the harbor porpoises, and the identification of probable causes of stranding or death in several animals, further supports the conclusion that harbor porpoise strandings were unrelated to the sonar activities of the USS Shoup.

Additional allegations regarding USS Shoup use of sonar having caused behavioral effects to Dall's porpoise, orca, and a minke whale also arose in association with this event (see U.S. Department of Navy 2004 for a complete discussion).

Dall's porpoise: Information regarding the observation of Dall's porpoise on 5 May 2003 came from the operator of a whale watch boat at an unspecified location. This operator reported Dall's porpoise were seen "going north" when the Shoup was estimated by him to be 10 miles away. Potential reasons for the Dall's movement include the pursuit of prey, the presence of harassing resident orca or predatory transient orca, vessel disturbance from one of many whale watch vessels, or multiple other unknowable reasons, including the use of sonar by USS Shoup. In short, there was nothing unusual in the observed behavior of the Dall's porpoise on May 5, 2003 and no way to assess if the otherwise normal behavior was in reaction to the use of sonar by USS Shoup, any other potential causal factor, or a combination of factors.

Orca: Observer opinions regarding orca J-Pod behaviors on May 5, 2003 were inconsistent, ranging from the orca being "at ease with the sound" or "resting" to their being "annoyed." One witness reported observing "low rates of surface active behavior" on behalf of the orca J-Pod, which is in conflict with that of another observer who reported variable surface activity, tail slapping and spyhopping. Witnesses also expressed the opinion that the behaviors displayed by the orca on 5 May 2003 were "extremely unusual," although those same behaviors are observed and reported regularly on the Orca Network Website, and are behaviors listed in general references as being part of the normal repertoire of orca behaviors. Given the contradictory nature of the reports on the observed behavior of the J-Pod orca, it is impossible to determine if any unusual behaviors were present. In short, there is no way to assess if any unusual behaviors were present or if present they were in reaction to vessel disturbance from one of many nearby whale watch vessels, use of sonar by USS Shoup, any other potential causal factor, or a combination of factors.

Minke whale: A minke whale was reported porpoising in Haro Strait on May 5, 2003, which is a rarely observed behavior. The cause of this behavior is indeterminate given multiple potential causal factors, including but not limited to, the presence of predatory transient orca, possible interaction with whale watch boats, other vessels, or Shoup's use of sonar. The behavior of the minke whale was the only unusual behavior clearly present on May 5, 2003, however, given the existing information there is no way to tell if the unusual behavior observed was in reaction to the use of sonar by USS Shoup, any other potential causal factor, or a combination of factors.

2004 Hawai'i Melon-Headed Whale Mass Stranding (July 3-4 2004)

Description

The majority of the following information is taken from the NMFS report on the stranding event (Southall et al., 2006). On the morning of July 3, 2004, between 150-200 melon-headed whales (*Peponocephala electra*) entered Hanalei Bay, Kauai. Individuals attending a canoe blessing ceremony observed the animals entering the bay at approximately 7:00 a.m. The whales were reported entering the bay in a "wave" as if they were chasing fish" (Braun 2005). At 6:45 a.m. on July 3, 2004, approximately 25 nm north of Hanalei Bay, active sonar was tested briefly prior to the start of an anti-submarine warfare exercise.

The whales stopped in the southwest portion of the bay, grouping tightly, and displayed spy-hopping and tail-slapping behavior. As people went into the water among the whales, the pod separated into as many as four groups, with individual animals moving among the clusters. This continued through most of the day, with the animals slowly moving south and then southeast within the bay. By about 3 p.m., police arrived and kept people from interacting with the animals. At 4:45 p.m. on July 3, 2004, the RIMPAC Battle Watch Captain received a call from a National Marine Fisheries representative in Honolulu, Hawaii, reporting the sighting of as many as 200 melon-headed whales in Hanalei Bay. At 4:47 p.m. the Battle Watch Captain directed all ships in the area to cease active sonar transmissions.

At 7:20 p.m. on July 3, 2004, the whales were observed in a tight single pod 75 yards from the southeast side of the bay. The pod was circling in a group and displayed frequent tail slapping and whistle vocalizations and some spy hopping. No predators were observed in the bay and no animals were reported as having fresh injuries. The pod stayed in the bay through the night of July 3, 2004. On the morning of July 4, 2004, the whales were observed to still be in the bay and collected in a tight group. A decision was made at that time to attempt to herd the animals out of the bay. A 700-to-800-foot rope was constructed by weaving together beach morning glory vines. This vine rope was tied between two canoes and with the assistance of 30 to 40 kayaks, was used to herd the animals out of the bay. By approximately 11:30 a.m. on July 4, 2004, the pod was coaxed out of the bay.

A single neonate melon-headed whale was observed in the bay on the afternoon of July 4, after the whale pod had left the bay. The following morning on July 5, 2004, the neonate was found stranded on Lumahai Beach. It was pushed back into the water but was found stranded dead between 9 and 10 a.m. near the Hanalei pier. NMFS collected the carcass and had it shipped to California for necropsy, tissue collection, and diagnostic imaging.

Following the stranding event, NMFS undertook an investigation of possible causative factors of the stranding. This analysis included available information on environmental factors, biological factors, and an analysis of the potential for sonar involvement. The latter analysis included vessels that utilized mid-frequency active sonar on the afternoon and evening of July 2. These vessels were to the southeast of Kauai, on the opposite side of the island from Hanalei Bay.

Findings

NMFS concluded from the acoustic analysis that the melon-headed whales would have had to have been on the southeast side of Kauai on July 2 to have been exposed to sonar from naval vessels on that day (Southall et al., 2006). There was no indication whether the animals were in that region or whether they were elsewhere on July 2. NMFS concluded that the animals would have had to swim from 1.4-4.0 m/s for 6.5 to 17.5 hours after sonar transmissions ceased to reach

Hanalei Bay by 7:00 a.m. on July 3. Sound transmissions by ships to the north of Hanalei Bay on July 3 were produced as part of exercises between 6:45 a.m. and 4:47 p.m. Propagation analysis conducted by the 3rd Fleet estimated that the level of sound from these transmissions at the mouth of Hanalei Bay could have ranged from 138-149 dB re: 1 μPa.

NMFS was unable to determine any environmental factors (e.g., harmful algal blooms, weather conditions) that may have contributed to the stranding. However, additional analysis by Navy investigators found that a full moon occurred the evening before the stranding and was coupled with a squid run (ref). In addition, a group of 500-700 melon-headed whales were observed to come close to shore and interact with humans in Sasanhaya Bay, Rota, on the same morning as the whales entered Hanalei Bay (Jefferson et al., 2006). Previous records further indicated that, though the entrance of melon-headed whales into the shallows is rare, it is not unprecedented. A pod of melon-headed whales entered Hilo Bay in the 1870s in a manner similar to that which occurred at Hanalei Bay in 2004.

The necropsy of the melon-headed whale calf suggested that the animal died from a lack of nutrition, possibly following separation from its mother. The calf was estimated to be approximately one week old. Although the calf appeared not to have eaten for some time, it was not possible to determine whether the calf had ever nursed after it was born. The calf showed no signs of blunt trauma or viral disease and had no indications of acoustic injury.

Conclusions

Although it is not impossible, it is unlikely that the sound level from the sonar caused the melon-headed whales to enter Hanalei Bay. This conclusion is based on a number of factors:

1. The speculation that the whales may have been exposed to sonar the day before and then fled to the Hanalei Bay is not supported by reasonable expectation of animal behavior and swim speeds. The flight response of the animals would have had to persist for many hours following the cessation of sonar transmissions. Such responses have not been observed in marine mammals and no documentation of such persistent flight response after the cessation of a frightening stimulus has been observed in other mammals. The swim speeds, though feasible for the species, are highly unlikely to be maintained for the durations proposed, particularly since the pod was a mixed group containing both adults and neonates. Whereas adults may maintain a swim speed of 4.0 m/s for some time, it is improbable that a neonate could achieve the same for a period of many hours.

2. The area between the islands of Oahu and Kauai and the PMRF training range have been used in RIMPAC exercises for more than 20 years, and are used year-round for ASW training using mid frequency active sonar. Melon-headed whales inhabiting the waters around Kauai are likely not naive to the sound of sonar and there has never been another stranding event associated in time with ASW training at Kauai or in the Hawaiian Islands. Similarly, the waters surrounding Hawaii contain an abundance of marine mammals, many of which would have been exposed to the same sonar operations that were speculated to have affected the melon-headed whales. No other strandings were reported coincident with the RIMPAC exercises. This leaves it uncertain as to why

melon-headed whales, and no other species of marine mammal, would respond to the sonar exposure by stranding.

3. At the nominal swim speed for melon-headed whales, the whales had to be within 1.5 to 2 nm of Hanalei Bay before sonar was activated on July 3. The whales were not in their open ocean habitat but had to be close to shore at 6:45 a.m. when the sonar was activated to have been observed inside Hanalei Bay from the beach by 7:00 am (Hanalei Bay is very large area). This observation suggests that other potential factors could be causative of the stranding event (see below).

4. The simultaneous movement of 500-700 melon-headed whales and Risso's dolphins into Sasanhaya Bay, Rota, in the Northern Marianas Islands on the same morning as the 2004 Hanalei stranding (Jefferson et al., 2006) suggests that there may be a common factor which prompted the melon-headed whales to approach the shoreline. A full moon occurred the evening before the stranding and a run of squid was reported concomitant with the lunar activity (ref). Thus, it is possible that the melon-headed whales were capitalizing on a lunar event that provided an opportunity for relatively easy prey capture. A report of a pod entering Hilo Bay in the 1870s indicates that on at least one other occasion, melon-headed whales entered a bay in a manner similar to the occurrence at Hanalei Bay in July 2004. Thus, although melon-headed whales entering shallow embayments may be an infrequent event, and every such event might be considered anomalous, there is precedent for the occurrence.

5. The received noise sound levels at the bay were estimated to range from roughly 95 – 149 dB re: 1 μPa. Received levels as a function of time of day have not been reported, so it is not possible to determine when the presumed highest levels would have occurred and for how long. However, received levels in the upper range would have been audible by human participants in the bay. The statement by one interviewee that he heard "pings" that lasted an hour and that they were loud enough to hurt his ears is unreliable. Received levels necessary to cause pain over the duration stated would have been observed by most individuals in the water with the animals. No other such reports were obtained from people interacting with the animals in the water.

Although NMFS concluded that sonar use was a "plausible, if not likely, contributing factor in what may have been a confluence of events (Southall et al., 2006)," this conclusion was based primarily on the basis that there was an absence of any other compelling explanation. The authors of the NMFS report on the incident were unaware, at the time of publication, of the simultaneous event in Rota. In light of the simultaneous Rota event, the Hanalei stranding does not appear as anomalous as initially presented and the speculation that sonar was a causative factor is weakened. The Hanalei Bay incident does not share the characteristics observed with other mass strandings of whales coincident with sonar activity (e.g., specific traumas, species composition, etc.). In addition, the inability to conclusively link or exclude the impact of other environmental factors makes a causal link between sonar and the melon-headed whale strandings highly speculative at best.

1980- 2004 Beaked Whale Strandings in Japan (Brownell et al. 2004)

Description

Brownell et al. (2004) compare the historical occurrence of beaked whale strandings in Japan (where there are U.S. Naval bases) with strandings in New Zealand (which lacks a U.S. Naval base) and concluded the higher number of strandings in Japan may be related to the presence of the US. Navy vessels using mid-frequency sonar. While the dates for the strandings were well documented, the authors of the study did not attempt to correlate the dates of any navy activities or exercises with the dates of the strandings.

To fully investigate the allegation made by Brownell et al. (2004), the Center for Naval Analysis (CNA) looked at the past U.S. Naval exercise schedules from 1980 to 2004 for the water around Japan in comparison to the dates for the strandings provided by Brownell et al. (2004). None of the strandings occurred during or within weeks after any DON exercises. While the CNA analysis began by investigating the probabilistic nature of any co-occurrences, the results were a 100 percent probability the strandings and sonar use were not correlated by time. Given there there was no instance of co-occurrence in over 20 years of stranding data, it can be reasonably postulated that sonar use in Japanese waters by DON vessels did not lead to any of the strandings documented by Brownell et al. (2004).

2004 Alaska Beaked Whale Strandings (7-16 June 2004)

Description

In the timeframe between June 17 and July 19, 2004, five beaked whales were discovered at various locations along 1,600 miles of the Alaskan coastline, and one was found floating (dead) at sea. Because the DON exercise Alaska Shield/Northern Edge 2004 occurred within the approximate timeframe of these strandings, it has been alleged that sonar may have been the probable cause of these strandings.

The Alaska Shield/Northern Edge 2004 exercise consisted of a vessel tracking event followed by a vessel boarding search and seizure event. There was no ASW component to the exercise, no use of mid-frequency sonar, and no use of explosives in the water. There were no events in the Alaska Shield/Northern Edge exercise that could have caused any of the strandings over this 33 day period covering 1,600 miles of coastline.

2005 North Carolina Marine Mammal Mass Stranding Event (January 15-16, 2005)

Description

On January 15 and 16, 2005, 36 marine mammals consisting of 33 short-finned pilot whales, 1 minke whale, and 2 dwarf sperm whales stranded alive on the beaches of North Carolina (Hohn et al., 2006a). The animals were scattered across a 111-km area from Cape Hatteras northward. Because of the live stranding of multiple species, the event was classified as a UME (Unusual Mortality Event). It is the only stranding on record for the region in which multiple offshore species were observed to strand within a two- to three-day period.

The DON indicated that from January 12-14 some unit level training with mid-frequency active sonar was conducted by vessels that were 93 to 185 km (50 to 100 NM) from Oregon Inlet. An expeditionary strike group was also conducting exercises to the southeast, but the closest point of active sonar transmission to the inlet was 650 km away. The unit level operations were not unusual for the area or time of year and the vessels were not involved in antisubmarine warfare exercises. Marine mammal observers on board the vessels did not detect any marine mammals during the period of unit level training. No sonar transmissions were made on January 15-16.

The National Weather Service reported that a severe weather event moved through North Carolina on January 13 and 14 (Figure 6-14). The event was caused by an intense cold front that moved into an unusually warm and moist air mass that had been persisting across the eastern United States for about a week. The weather caused flooding in the western part of the state, considerable wind damage in central regions of the state, and at least three tornadoes that were reported in the north central part of the state. Severe, sustained (one to four days) winter storms are common for this region.

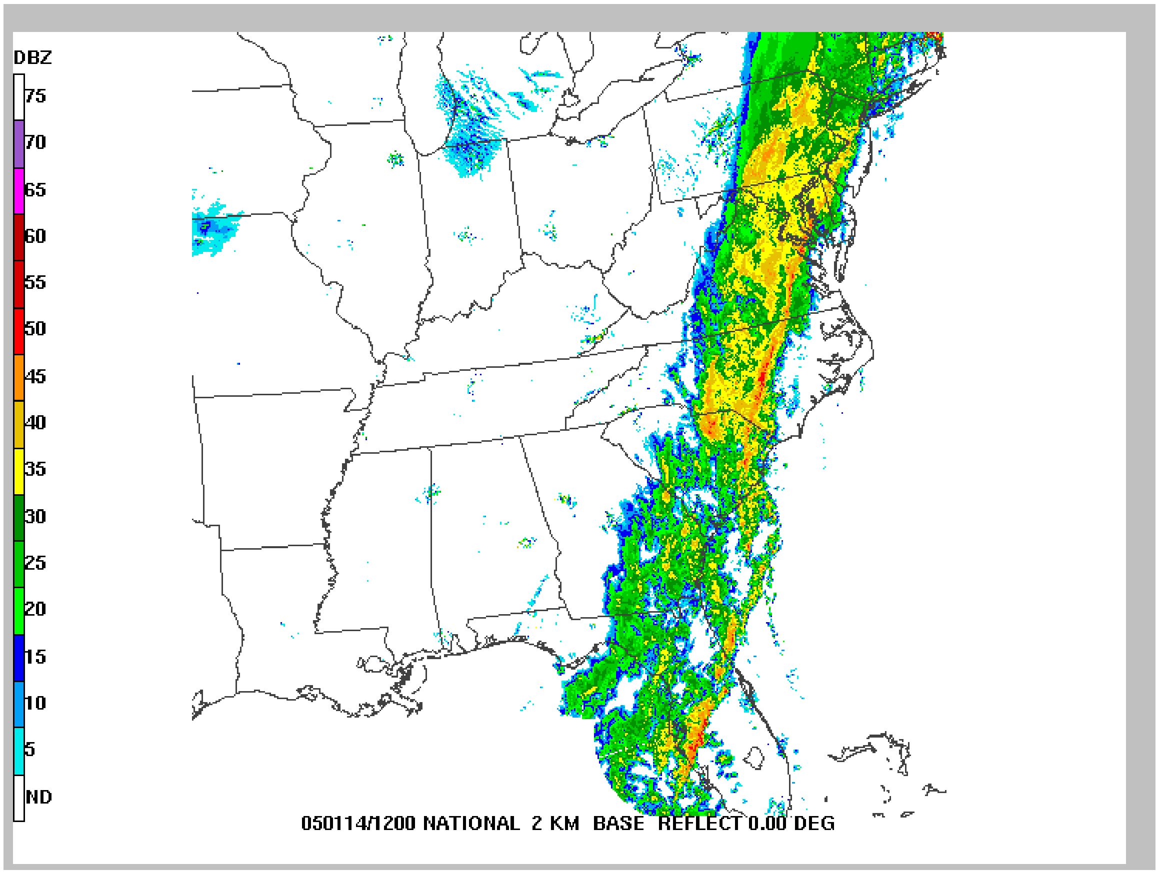

Figure 6-14. Regional Radar Imagery for the East Coast (Including North Carolina) on 14 January 2005

(The time of the image is approximately 0700.)

Over a two-day period (January 16-17), 2 dwarf sperm whales, 27 pilot whales, and the minke whale were necropsied and tissue samples collected. Twenty-five of the stranded cetacean heads were examined; two pilot whale heads and the heads of the dwarf sperm whales were analyzed by CT.

Findings

The pilot whales and dwarf sperm whale were not emaciated, but the minke whale, which was believed to be a dependent calf, was emaciated. Many of the animals were on the beach for an extended period of time prior to necropsy and sampling, and many of the biochemical abnormalities noted in the animals were suspected of being related to the stranding and prolonged time on land. Lesions were observed in all of the organs, but there was no consistency across species. Musculoskeletal disease was observed in two pilot whales and cardiovascular disease was observed in one dwarf sperm whale and one pilot whale. Parasites were a common finding in the pilot whales and dwarf sperm whales but were considered consistent with the expected parasite load for wild odontocetes. None of the animals exhibited traumas similar to those observed in prior stranding events associated with mid-frequency sonar activity. Specifically, there was an absence of auditory system trauma and no evidence of distributed and widespread bubble lesions or fat emboli, as was previously observed (Fernández et al., 2005).

Sonar transmissions prior to the strandings were limited in nature and did not share the concentration identified in previous events associated with mid-frequency active sonar use (Evans and England, 2001). The operational/environmental conditions were also dissimilar (e.g., no constrictive channel and a limited number of ships and sonar transmissions). NMFS noted that environmental conditions were favorable for a shift from up-welling to down-welling conditions, which could have contributed to the event. However, other severe storm conditions existed in the days surrounding the strandings and the impact of these weather conditions on at-sea conditions is unknown. No harmful algal blooms were noted along the coastline.

Conclusions

All of the species involved in this stranding event are known to occasionally strand in this region. Although the cause of the stranding could not be determined, several whales had preexisting conditions that could have contributed to the stranding. Cause of death for many of the whales was likely due to the physiological stresses associated with being stranded. A consistent suite of injuries across species, which was consistent with prior strandings where sonar exposure is expected to be a causative mechanism, was not observed.

NMFS was unable to determine any causative role that sonar may have played in the stranding event. The acoustic modeling performed, as in the Hanalei Bay incident, was hampered by uncertainty regarding the location of the animals at the time of sonar transmissions. However, as in the Hanalei Bay incident, the response of the animals following the cessation of transmissions would imply a flight response that persisted for many hours after the sound source was no longer operational. In contrast, the presence of a severe weather event passing through North Carolina during January 13 and 14 is a possible, if not likely, contributing factor to the North Carolina UME of January 15.

6.2.11.4 Stranding Section Conclusions

Marine mammal strandings have been a historic and ongoing occurrence attributed to a variety of causes. Over the last fifty years, increased awareness and reporting has lead to more information about species effected and raised concerns about anthropogenic sources of stranding. While there has been some marine mammal mortalities potentially associated with mid-frequency sonar effects to a small number of species (primarily limited numbers of certain species of beaked whales), the significance and actual causative reason for any impacts is still subject to continued investigation.

By comparison and as described previously, potential impacts to all species of cetaceans worldwide from fishery related mortality can be orders of magnitude more significant (100,000s of animals versus 10s of animals) (Culik, 2002; ICES, 2005b; Read et al., 2006). This does not negate the influence of any mortality or additional stressor to small, regionalized sub-populations which may be at greater risk from human related mortalities (fishing, vessel strike, sound) than populations with larger oceanic level distribution or migrations. ICES (2005a) noted, however, that taken in context of marine mammal populations in general, sonar is not a major threat, or significant portion of the overall ocean noise budget.

In conclusion, a constructive framework and continued research based on sound scientific principles is needed in order to avoid speculation as to stranding causes, and to further our understanding of potential effects or lack of effects from military mid-frequency sonar (Bradshaw et al., 2006; ICES 2005b; Barlow and Gisiner, 2006; Cox et al. 2006).

6.2.11.5 Potential for Mortality

In a October 2006 letter from NMFS to the Navy, NMFS recommended that Section 101(a)(5)(A) authorization is appropriate for mid-frequency active sonar activities because such requests would allow NMFS to consider the potential for incidental mortality due to scientific uncertainty. Given the frequency of naturally occurring marine mammal strandings (e.g., natural mortality), it is conceivable that a stranding could co-occur within the timeframe of a Navy exercise even though the stranding is otherwise unrelated to and not caused by Navy activities. In accordance with NMFS' recommendation and the frequency of naturally occurring strandings, the Navy's LOA request will include incidental mortalities. This request will be made even though sound exposure analyses and almost 40 years of conducting similar exercises without incident indicate that injury or strandings are not expected to occur as a result of Navy activities. The Navy's LOA application requests the take, by serious injury or mortality, of 10 beaked whales. This approach overestimates the potential effects to marine mammals associated with Navy sonar training in the AFAST Study Area, as no mortality or serious injury of any species is anticipated.

6.2.12 Acoustic Effects Analysis

6.2.12.1 Acoustic Sources

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. See Table H-1 for a description of sources modeled. 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, an average over several frequency samples may be appropriate.
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). This calculation assumes that the animals are evenly distributed throughout the grid.

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.

6.2.12.2 Small Explosives (Explosive Source Sonouboy [AN/SSQ-110A])

The impact of explosive sources on marine wildlife is measured by three different metrics, each with its own threshold(s). The energy metric, peak one-third octave, is treated in similar fashion as the energy metric used for the active sonars, including the summation of energy if there are multiple source emissions. The other two, peak pressure and positive impulse, are not accumulated; rather, the maximum levels are stored.

6.2.12.2.1 Peak One-Third Octave Energy Metric

The computation of impact volumes for the energy metric follows closely the approach taken to model the energy metric for the active sonars. The only significant difference is that energy flux density is sampled at several frequencies in one-third-octave bands and only the peak one third-octave level is accumulated.

6.2.12.2.2 Peak Pressure Metric

The peak pressure metric is a simple, straightforward calculation. At each range/animal depth combination, transmission ratio modified by the source level in a one-octave band and beam pattern is averaged across frequency on an eigenray-by-eigenray basis. This averaged transmission ratio (normalized by the broadband source level) is then compared across all eigenrays with the maximum designated as the peak arrival. Peak pressure at that range/animal depth combination is then simply the product of:

- The square root of the averaged transmission ratio of the peak arrival,
- The peak pressure at a range of 1 m, and
- The similitude correction.

If the peak pressure for a given grid point is greater than the specified threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

6.2.12.2.3 "Modified" Positive Impulse Metric

The modeling of positive impulse follows the work of Goertner. The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. To be conservative, the Navy will assume the animal weight is that of a calf dolphin, with an average mass of 12.2 kg (27 lb).

Although the thresholds are a function of depth and animal weight, sometimes they are summarized as their value at the sea surface for a typical calf dolphin (with an average mass of 12.2 kg [27 lb]). For the onset of slight lung injury, the threshold at the surface is approximately 13 psi ms; for the onset of extensive lung hemorrhaging (1 percent mortality), the threshold at the surface is approximately 31 psi-ms.

6.2.13 Acoustic Effects Results

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 querying the data from the marine mammal density and acoustic footprint databases, large buffer areas around the training areas are applied; this can hide small geographic differences in the alternatives within the model (e.g. Alternative 3 versus the No Action Alternative) that still may provide significant environmental differences.

Additionally, marine species density models are based on the best available science, but are often compiled from small datasets and are only as good as the limited survey information used to build the models. Single hotspots in the density databases can be an artifact of a single data point, and can drive the density estimate for an entire area beyond what is probable or realistic.

Quantitative analysis alone should not be relied upon for a complete assessment of the alternatives presented in the AFAST Draft EIS/OEIS, although the quantitative acoustic analysis can help to inform the decision making process.

6.2.13.1 Species with Possible Occurrence but Not Modeled

Exposure numbers for four species occurring within the AFAST Study Area could not be calculated due to the lack of appropriate data needed to generate density estimates. However, potential effects to these species were qualitatively analyzed in Sections 6.2.14 and 6.2.15. These four species include the following:

- Blue whale
- White-beaked dolphin
- Hooded seal
- Harp seal

Exposure numbers for the manatees occurring in the southeast could not be calculated due to the lack of acoustic exposure criteria and lack of available density information.

In addition, three species have no density estimate since their occurrence is considered extralimital throughout the AFAST Study Area. Therefore, these species have a functional density of zero; therefore, no potential effects are predicted. These species include the following:

- Beluga whale
- Ringed seal

- Walrus

6.2.13.2 Modeling Results for Acoustic Sources

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 near land are not reduced to account for the land mass where marine mammals would not occur.
- 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.
- Marine mammal densities were averaged across specific active sonar activity areas and, therefore, are evenly distributed without consideration for animal grouping or patchiness.
- 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.

Due to the modeling and ecological limitation discussed above, and because AFAST activities would be conducted at different times throughout the year and in various geographical locations within and adjacent to East Coast and Gulf of Mexico OPAREAs, long-term effects to individuals, populations, or stocks are unlikely. The Navy is working through the MMPA regulatory process to discuss the mitigation measures and their potential to reduce the likelihood for incidental harassment of marine mammals.

Annual exposure estimates for the Preferred Alternative are presented in Tables 6-7 through 6-10. Exposures numbers were rounded to “1” if the result was equal to or greater than 0.5. Even though an exposure number may have rounded to “0” in an individual analysis area, when summed with all other results for other analysis areas within the AFAST Study Area, an exposure of “1” is possible.

6.2.14 Summary of Potential Effects to ESA-Listed Species

6.2.14.1 North Atlantic Right Whale

Acoustic analysis indicates that up to 555 exposures of North Atlantic right whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no right whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to right whales.

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 of 6 or less is 0.90 or 90 percent (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 North Atlantic right whale exposures indicated by the acoustic analysis is likely a conservative overestimate of actual exposures. Additionally, even though the right whales 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 made although a right 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 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 stock assessment reports by NMFS. Approximately 350 individuals, including about 70 mature females, are thought to occur in the western North Atlantic (Kraus et al., 2005). The most recent stock assessment report states that in a review of the photo-id recapture database for October 2005, 306 individually recognized whales were known to be alive during 2001 (Waring et al., 2007). This number represents a minimum population size, and no abundance estimate with an associated coefficient of variation has been calculated for this population (Waring et al., 2007). Right whales are not expected to occur in the Gulf of Mexico.

Critical habitat for the North Atlantic right whale exists along the U.S. East Coast. The following three areas occur in U.S. waters and were designated by NMFS as critical habitat in June 1994:

1. Coastal Florida and Georgia (Sebastian Inlet, Florida, to the Altamaha River, Georgia)
2. The Great South Channel, east of Cape Cod
3. Cape Cod and Massachusetts Bays

In the southeast North Atlantic right whale critical habitat, activities could include object detection/navigational sonar training and maintenance activities for surface ships and submarines

Table 6-7. Estimated Marine Mammal Exposures from ULT, RDT&E, and Maintenance Active Sonar Activities Under the No Action Alternative

Species	Atlantic Ocean, Offshore of the Southeastern United States												Northeast				Gulf of Mexico			
	VACAPES OPAREA				CHPT OPAREA				JAX/CHASN OPAREA				Northeast OPAREA				GOMEX			
	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function
North Atlantic right whale*	0	0	0	35	0	0	0	13	0	0	3	189	0	0	0	231	0	0	0	0
Humpback whale*	0	0	3	519	0	0	3	613	0	0	10	2120	0	0	0	1478	0	0	0	0
Minke whale	0	0	0	27	0	0	0	32	0	0	1	113	0	0	0	393	0	0	0	0
Bryde's whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Sei whale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2070	0	0	0	0
Fin whale*	0	0	1	65	0	0	0	0	0	0	0	0	0	0	0	1283	0	0	0	0
Sperm whale*	0	0	23	4688	0	0	1	332	0	0	6	1552	0	0	1	6442	0	0	0	38
Kogia spp.	0	0	4	544	0	0	5	649	0	0	14	2277	0	0	0	1031	0	0	0	26
Beaked whale	0	0	5	523	0	0	2	250	0	0	7	945	0	0	0	815	0	0	0	6
Rough-toothed dolphin	0	0	2	259	0	0	2	308	0	0	7	1082	0	0	0	487	0	0	0	188
Bottlenose dolphin	0	2	261	47505	0	3	358	71169	0	17	2954	400187	0	0	3	37834	0	0	14	7828
Pantropical spotted dolphin	0	1	80	11991	0	1	100	14287	0	2	317	50155	0	0	1	22553	0	0	11	4455
Atlantic spotted dolphin	0	7	884	138986	0	2	483	23553	0	6	1991	111824	0	0	2	27389	0	0	2	6267
Spinner dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1734
Clymene dolphin	0	0	38	5729	0	0	48	6826	0	1	151	23962	0	0	1	10775	0	0	7	1084
Striped dolphin	0	5	545	116150	0	0	0	61	0	0	0	0	0	1	15	232341	0	0	0	318
Common dolphin	0	3	689	52953	0	0	1	57	0	0	0	0	0	1	12	106105	0	0	0	0
Fraser's dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45
Risso's dolphin	0	0	63	10537	0	0	55	8467	0	2	288	58422	0	0	3	39245	0	0	1	151
Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	34165	0	0	0	0
Melon-headed whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	216
Pygmy killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31
False killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Pilot whales	0	1	101	19848	0	1	56	13593	0	3	327	81754	0	0	4	34233	0	0	0	0
Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	149
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	285124	0	0	0	0
Gray Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	37535	0	0	0	0
Harbor Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	69319	0	0	0	0

*Denotes species listed in accordance with the Endangered Species Act.

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Table 6-8. Estimated Marine Mammal Exposures from Coordinated ULT Active Sonar Activities Under the No Action Alternative

Species	Atlantic Ocean, Offshore of the Southeastern United States												Northeast				Gulf of Mexico			
	VACAPES OPAREA				CHPT OPAREA				JAX/CHASN OPAREA				Northeast OPAREA				GOMEX			
	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function
North Atlantic right whale*	0	0	0	2	0	0	0	1	0	0	2	56	0	0	0	1	0	0	0	0
Humpback whale*	0	0	1	24	0	0	1	33	0	0	7	459	0	0	0	5	0	0	0	0
Minke whale	0	0	0	1	0	0	0	2	0	0	0	25	0	0	0	1	0	0	0	0
Bryde's whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sei whale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0
Fin whale*	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Sperm whale*	0	0	4	195	0	0	0	14	0	0	4	284	0	0	0	23	0	0	0	2
Kogia spp.	0	0	1	24	0	0	1	33	0	0	10	470	0	0	0	4	0	0	0	1
Beaked whale	0	0	1	46	0	0	0	20	0	0	5	306	0	0	0	3	0	0	0	0
Rough-toothed dolphin	0	0	0	11	0	0	0	16	0	0	5	223	0	0	0	2	0	0	0	120
Bottlenose dolphin	0	0	47	2020	0	0	64	3378	0	10	2055	85392	0	0	0	136	0	0	2	3423
Pantropical spotted dolphin	0	0	14	519	0	0	18	728	0	1	220	10355	0	0	0	81	0	0	2	153
Atlantic spotted dolphin	0	1	159	6215	0	0	88	1923	0	3	1393	30979	0	0	0	98	0	0	0	1908
Spinner dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55
Clymene dolphin	0	0	7	248	0	0	9	348	0	1	105	4947	0	0	0	39	0	0	1	119
Striped dolphin	0	1	98	4853	0	0	0	3	0	0	0	0	0	0	0	835	0	0	0	7
Common dolphin	0	0	125	3061	0	0	0	5	0	0	0	0	0	0	0	381	0	0	0	0
Fraser's dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Risso's dolphin	0	0	11	466	0	0	10	427	0	1	200	11833	0	0	0	141	0	0	0	11
Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	123	0	0	0	0
Melon-headed whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
Pygmy killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
False killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Pilot whales	0	0	18	833	0	0	10	615	0	2	226	15702	0	0	0	123	0	0	0	0
Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1008	0	0	0	0
Gray Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	135	0	0	0	0
Harbor Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	249	0	0	0	0

*Denotes species listed in accordance with the Endangered Species Act.

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Table 6-9. Estimated Marine Mammal Exposures from Strike Group Active Sonar Exercises Under the No Action Alternative

Species	Atlantic Ocean, Offshore of the Southeastern United States												Northeast				Gulf of Mexico			
	VACAPES OPAREA				CHPT OPAREA				JAX/CHASN OPAREA				Northeast OPAREA				GOMEX			
	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function
North Atlantic right whale*	0	0	0	1	0	0	0	5	0	0	0	14	0	0	0	0	0	0	0	0
Humpback whale*	0	0	1	37	0	0	3	218	0	0	5	404	0	0	0	0	0	0	0	0
Minke whale	0	0	0	2	0	0	0	12	0	0	0	22	0	0	0	0	0	0	0	0
Bryde's whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
Sei whale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fin whale*	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sperm whale*	0	0	9	412	0	0	2	123	0	0	7	393	0	0	0	0	0	0	5	345
Kogia spp.	0	0	1	37	0	0	5	218	0	0	7	412	0	0	0	0	0	0	5	318
Beaked whale	0	0	2	77	0	0	3	135	0	0	7	370	0	0	0	0	0	0	2	150
Rough-toothed dolphin	0	0	0	18	0	0	2	104	0	0	4	196	0	0	0	0	0	0	10	685
Bottlenose dolphin	0	1	108	4593	0	3	379	20185	0	7	1129	58611	0	0	0	0	0	1	240	12085
Pantropical spotted dolphin	0	0	21	821	0	1	104	4799	0	1	164	9076	0	0	0	0	0	5	684	46916
Atlantic spotted dolphin	0	2	305	12451	0	1	337	7767	0	1	374	8475	0	0	0	0	0	1	154	4986
Spinner dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	290	19659
Clymene dolphin	0	0	10	392	0	0	50	2293	0	1	78	4336	0	0	0	0	0	1	106	7271
Striped dolphin	0	1	199	9047	0	0	0	26	0	0	0	0	0	0	0	0	0	0	58	3987
Common dolphin	0	1	159	4758	0	0	1	19	0	0	0	0	0	0	0	0	0	0	0	0
Fraser's dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	304
Risso's dolphin	0	0	21	876	0	0	54	2517	0	1	155	9427	0	0	0	0	0	0	20	1361
Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melon-headed whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	1446
Pygmy killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	208
False killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	435
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	56
Pilot whales	0	0	41	1789	0	1	69	4052	0	2	252	15851	0	0	0	0	0	0	0	0
Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	1000
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gray Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Harbor Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

*Denotes species listed in accordance with the Endangered Species Act.

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Table 6-10. Estimated Marine Mammal Exposures from ULT, RDT&E, Maintenance, Coordinated ULT, and Strike Group Active Sonar Activities Under the No Action Alternative

Species	Atlantic Ocean, Offshore of the Southeastern United States												Northeast				Gulf of Mexico			
	VACAPES OPAREA				CHPT OPAREA				JAX/CHASN OPAREA				Northeast OPAREA				GOMEX			
	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function	Mortality	PTS	TTS	Dose-Function
North Atlantic right whale*	0	0	1	38	0	0	1	19	0	0	5	259	0	0	0	232	0	0	0	0
Humpback whale*	0	0	4	581	0	0	7	865	0	0	23	2983	0	0	0	1483	0	0	0	0
Minke whale	0	0	0	30	0	0	0	46	0	0	1	160	0	0	0	394	0	0	0	0
Bryde's whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26
Sei whale*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2078	0	0	0	0
Fin whale*	0	0	1	75	0	0	0	0	0	0	0	0	0	0	0	1287	0	0	0	0
Sperm whale*	0	0	36	5296	0	0	4	470	0	0	17	2229	0	0	1	6465	0	0	5	386
Kogia spp.	0	0	5	605	0	0	10	899	0	0	32	3159	0	0	0	1035	0	0	5	345
Beaked whale	0	0	8	646	0	0	5	405	0	0	19	1621	0	0	0	818	0	0	2	156
Rough-toothed dolphin	0	0	3	288	0	0	5	427	0	0	15	1501	0	0	0	488	0	0	10	994
Bottlenose dolphin	0	3	416	54118	0	7	801	94732	0	34	6137	544190	0	0	3	37970	0	1	256	23337
Pantropical spotted dolphin	0	1	116	13330	0	2	223	19815	0	5	701	69586	0	0	1	22635	0	5	696	51524
Atlantic spotted dolphin	0	10	1349	157652	0	3	908	33243	0	10	3759	151279	0	0	2	27488	0	1	156	13162
Spinner dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	291	21447
Clymene dolphin	0	0	55	6369	0	1	106	9467	0	2	335	33245	0	0	1	10814	0	1	114	8474
Striped dolphin	0	7	842	130050	0	0	1	90	0	0	0	0	0	1	15	233176	0	0	58	4312
Common dolphin	0	4	972	60771	0	0	3	82	0	0	0	0	0	1	12	106486	0	0	0	0
Fraser's dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	354
Risso's dolphin	0	1	96	11879	0	1	119	11411	0	5	643	79682	0	0	3	39386	0	0	21	1524
Atlantic white-sided dolphin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	34288	0	0	0	0
Melon-headed whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	1685
Pygmy killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	242
False killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	507
Killer whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	65
Pilot whales	0	1	160	22469	0	1	135	18260	0	7	805	113307	0	0	4	34356	0	0	0	0
Short-finned pilot whale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	1166
Harbor porpoise	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	286132	0	0	0	0
Gray Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	37670	0	0	0	0
Harbor Seal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	69569	0	0	0	0

*Denotes species listed in accordance with the Endangered Species Act.

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while entering/exiting ports located in Kings Bay, Georgia, and Mayport, Florida. In addition, helicopter dipping sonar would occur off of Mayport, Florida in the established training areas within the right whale critical habitat. In the northeast North Atlantic right whale critical habitat, a limited number of TORPEXs would be conducted in August, September, and October per the Navy consultation with NMFS.

Based on best available science the Navy concludes that exposures to North Atlantic right whales due to AFAST activities would result in 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 North Atlantic right whales.

6.2.14.2 Humpback Whale

Acoustic analysis indicates that up to 5,946 exposures of humpback whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to 4 humpback whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to humpback whales. 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 μPa2-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).

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., 2007). Recent genetic analyses have also found significant differences in 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., 2007). The best abundance estimate for the Gulf of Maine humpback stock is 902 individuals (Waring et al., 2007). 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., 2007). 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 Mid-Atlantic and 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 AFAST activities would result in 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 humpback whales.

6.2.14.3 Sei Whale

Acoustic analysis indicates that up to 2,078 exposures of sei whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no sei whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to sei whales. Lookouts would likely detect sei whales at the surface because they have high likelihood of detection (0.90 in Beaufort Sea States 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., 2007). 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 includes the continental shelf waters of the northeastern United States and extends 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 ^{o} W (Warring et al., 1999). There are no recent abundance estimates for the Nova Scotia stock (Waring et al., 2007). 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 AFAST activities would result in 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 sei whales.

6.2.14.4 Fin Whale

Acoustic analysis indicates that up to 1,364 exposures of fin whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no fin whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to fin whales. Lookouts would likely detect a group of fin whales at the surface because they have a high likelihood of detection (0.90 in Beaufort Sea States 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 2,814 (Waring et al., 2007). The population is likely to be larger than the best estimate because as Waring et al. (2007) note dive times are extended for fin whales and the incorporation of a dive correction factor brings the estimate to 5,000 to 6,000 fin whales in the waters of the U.S. Atlantic (CETAP, 1982; Kenney et al., 1997). Fin whales are not expected to occur in the Gulf of Mexico.

Based on best available science the Navy concludes that exposures to the western North Atlantic fin whale stock due to AFAST 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 fin whales.

6.2.14.5 Blue Whale

Acoustic analysis is not available for blue whales due to the lack of abundance and density data for North Atlantic populations. Population estimates are available only for the Gulf of St. Lawrence area (off eastern Canada), where 308 individuals have been catalogued. This number is considered to be the minimum population estimate for the western North Atlantic stock. The entire population may total only in the hundreds, but no conclusive data exist to confirm or refute this estimate.

Blue whales occur primarily in deep offshore water, with occasional sightings on the continental shelf. This species is considered to occur only occasionally in the U.S. EEZ, and the northeastern EEZ may represent the southern limit of blue whale feeding grounds. There are a few records of blue whale occurrence in the Atlantic OPAREAs, and only two reliable records in the GOMEX.

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 AFAST activities would result in 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 blue whales.

6.2.14.6 Sperm Whale

Acoustic analysis indicates that up to 14,908 exposures of sperm whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that one sperm whale will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to sperm whales. Lookouts would likely detect a group of sperm whales at the surface because they have a high likelihood of detection (0.87 in Beaufort Sea States 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. NMFS provisionally considers the sperm whale population in the northern GOMEX, the Gulf of Mexico stock, distinct from the U.S. Atlantic stock (Waring et al., 2006). 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 best abundance estimate for sperm whales for the western North Atlantic is 4,804, with a minimum population estimate of 3,539 animals. The current best abundance estimate for sperm whales in the northern GOMEX is 1,349 individuals (Mullin and Fulling, 2004).

Based on best available science the Navy concludes that exposures to the western North Atlantic and Gulf of Mexico sperm whale stocks due to AFAST 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 sperm whales.

6.2.14.7 Manatee

With the exception of maintenance and ship object detection/navigational sonar training, no active sonar activity would be conducted within Florida manatee habitat. The manatee is considered to be an inshore species, with most sightings occurring in warm freshwater, estuarine, and extremely nearshore coastal waters. During winter, manatees are largely restricted to peninsular Florida in the Gulf of Mexico and to Florida and southeastern Georgia in the Atlantic Ocean. Distribution expands northward and eastward in warmer months. Exposure numbers for the manatees occurring in the southeast could not be calculated due to the lack of acoustic exposure criteria and lack of available density information.

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 seconds for 300 milliseconds (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 nornmal range of behaviors. Additionally, limited active sonar activities would take place in the vicinity of manatee habitat. Therefore, the Navy concludes that exposures to manatee stocks due to AFAST activities would likely not affect stocks, annual rates of recruitment, or survival.

6.2.15 Estimated Exposures for Non-ESA-Listed Species.

6.2.15.1 Minke Whale

Acoustic analysis indicates that up to 632 exposures of minke whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no minke whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to 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., 2007). Minke whales off the eastern United States are considered to be part of the Canadian East Coast stock which inhabits the area from the eastern half of the Davis Strait to 45ºW and south to the

Gulf of Mexico (Waring et al., 2007). The best available abundance estimate for minke whales from the Canadian East Coast stock is 2,998 animals (Waring et al., 2007). The minke whale is not expected in the Gulf of Mexico.

Based on best available science the Navy concludes that exposures to the Canadian East Coast minke whale stocks due to AFAST 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 minke whales.

6.2.15.2 Bryde's Whale

Acoustic analysis indicates that up to 27 exposure of Bryde's whales to sound levels likely to result in Level B harassment may occur. Acoustic analysis indicates that no Bryde's whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to Bryde's whales. Lookouts would likely detect a group of Bryde's whales at the surface because they have a high likelihood of detection (0.87 in Beaufort Sea States 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.

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. Bryde's whales are not expected in U.S. waters of the western North Atlantic. Bryde's whales are currently considered as a single, separate stock in the northern Gulf of Mexico. It has been suggested that the Bryde's whales found in the GOMEX may represent a resident stock (Schmidly, 1981), but there is no information on stock differentiation (Waring et al., 2006). The best abundance estimate for Bryde's whales within the northern Gulf of Mexico is 40, with a minimum population size estimate of 25 whales (Waring et al., 2006).

Based on best available science the Navy concludes that exposures to the northern Gulf of Mexico Bryde's whale stocks due to AFAST 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 Bryde's whales.

6.2.15.3 Pygmy and Dwarf Sperm Whales

Acoustic analysis indicates that up to 6,095 exposures of pygmy and dwarf sperm whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no pygmy and dwarf sperm whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to pygmy and dwarf sperm whales. Lookouts would likely detect a group of pygmy and dwarf sperm whales at the surface because of their large size (up to 14 m [46 ft]) and behavior of resting at the surface (Leatherwood and Reeves, 1982). Additionally, 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., 2007). The best abundance estimate for both species combined in the western North Atlantic is 395 individuals (Waring et al., 2007). Species-level abundance estimates cannot be calculated due to uncertainty of species identification at sea (Waring et al., 2007). There is currently no information to differentiate the Northern GOMEX stock from the Atlantic stock(s) (Waring et al., 2006). For pygmy and dwarf sperm whales in the Northern Gulf of Mexico, the best abundance estimate is 742 animals with a minimum population of 584 (Waring et al., 2006). A separate abundance estimate for the pygmy sperm whale or the dwarf sperm whale cannot be calculated due to uncertainty of species identification at sea (Waring et al., 2006).

Based on best available science the Navy concludes that exposures to the northern Gulf of Mexico pygmy and dwarf sperm whale stocks due to AFAST 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 pygmy and dwarf sperm whales.

6.2.15.4 Beaked Whales (various species)

Acoustic analysis indicates that up to 3,680 exposures of beaked whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no beaked whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to beaked whales.

Most beaked whale species are difficult to identify to the species level at sea; therefore, much of the available characterization for beaked whales is to genus level only *(Ziphius* and *Mesoplodon* species). Four species of *Mesoplodon*are found in the in the northwest Atlantic. These include True's beaked whale, *Mesoplodon mirus*; Gervais' beaked whale, *M. europaeus*; Blainville's beaked whale, *M.densirostris*; and Sowerby's beaked whale, *M. bidens* (Mead, 1989). Stock structure for each species is unknown (Waring et al., 2004).

The best abundance estimate for Cuvier’s beaked whales in the northern Gulf of Mexico is 95 individuals. The minimum population estimate for the northern Gulf of Mexico is 65 Cuvier’s beaked whales (Waring et al., 2006). The total number of Cuvier’s beaked whales off the eastern U.S. and Canadian Atlantic coast is unknown, but there have been several estimates of an undifferentiated grouping of beaked whales that includes both *Ziphius* and *Mesoplodon* species. The best abundance estimate for undifferentiated beaked whales (*Ziphius* and *Mesoplodon* species) in the Western North Atlantic is 3,513, with a minimum population estimate of 2,154 (Waring et al., 2006). It is not possible to determine the minimum population estimate of only Cuvier's beaked whales.

Identification of *Mesoplodon* to species in the Gulf of Mexico is very difficult, and in many cases, *Mesoplodon* and Cuvier's beaked whale (*Ziphius cavirostris*) cannot be distinguished; therefore, sightings of beaked whales (Family Ziphiidae) are identified as *Mesoplodon* sp., Cuvier's beaked whale, or unidentified Ziphiidae. The best abundance estimate for *Mesoplodon* species in the northern Gulf of Mexico is 106 animals. The minimum population estimate for *Mesoplodon* species in the northern Gulf of Mexico is 76 individuals (Waring et al., 2006). Present data are insufficient to calculate minimum population estimates for all *Mesoplodon* species in the western North Atlantic. The total number of northern bottlenose whales off the East Coast is unknown.

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 SAR by NMFS. Because many beaked whales are difficult to differentiate at sea, density estimates are only available for beaked whales as a group. It is possible to make some broad inferences about effects to individual species based on their generally accepted abundance estimates in each region but it is important to keep in mind the difficulty in identifying most individuals beyond the genus level.

Based on best available science the Navy concludes that exposures to beaked whales due to AFAST 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 beaked whales.

6.2.15.5 Rough-Toothed Dolphin

Acoustic analysis indicates that up to 3,731 exposures of rough-toothed dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no rough-toothed dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to rough-toothed dolphins. Lookouts would likely detect a group of rough-toothed dolphins at the surface because of their high probability of detection (0.76 in Beaufort Sea States 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 estimates are available for rough-toothed dolphins here. The best abundance estimate for rough-toothed dolphins is 2,223 in the northern Gulf of Mexico (Fulling et al., 2003; Mullin and Fulling, 2004; Waring et al., 2006) with a minimum population estimate of 1,595 rough-toothed animals.

Based on best available science the Navy concludes that exposures to rough-toothed dolphins due to AFAST 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 rough-toothed dolphins.

6.2.15.6 Bottlenose Dolphin

Acoustic analysis indicates that up to 761,961 exposures of bottlenose dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to 46 bottlenose dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to bottlenose dolphins. 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.

The Navy considered potential effects to stocks based on the best available data for each stock of marine mammal species, A number of stocks exist for the bottlenose dolphin in the western North Atlantic and the northern Gulf of Mexico. Therefore, the assessment focuses on the stocks that occur within the area for AFAST activities that have the potential to overlap the species' distributions.

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., 2007). 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 AFAST. The general distribution of AFAST training activities 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.

In the northern GOMEX, the stocks of concern include the continental shelf and oceanic stocks. The continental shelf stock is thought to overlap with both the oceanic stock as well as coastal stocks in some areas (Waring et al., 2007) however, the coastal stock is generally limited to less than 20 m (66 ft) water depths and therefore is not expected to be exposed to sonar from AFAST. The best abundance estimate for the continental shelf stock is 25,320 (Waring et al., 2007). The estimated abundance for bottlenose dolphins in oceanic waters, pooled from 1996 to 2001, is 2,239 (Mullin and Fulling, 2004). The oceanic stock is provisionally defined for bottlenose dolphins inhabiting waters greater than 200 m (656 ft) (Waring et al., 2007). While the two stocks may overlap to some degree the Navy estimates, based on the distribution of AFAST activities, that most of the predicted exposures will occur to the oceanic stock with the few remaining exposures applying to the continental stock.

Based on best available science the Navy concludes that exposures to both Atlantic and Gulf of Mexico bottlenose dolphins due to AFAST 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 bottlenose dolphins.

6.2.15.7 Pantropical Spotted Dolphins

Acoustic analysis indicates that up to 178,628 exposures of pantropical spotted dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to 12 pantropical spotted dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to pantropical spotted dolphins. 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 Beaufort Sea States 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).

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 stock assessment report by NMFS. In the western North Atlantic, the best abundance estimate for pantropical spotted dolphins is 4,439 with a minimum population estimate of 3,010 animals (Waring et al., 2006). The best abundance estimate for pantropical spotted dolphins in the northern Gulf of Mexico is 91,321, with a minimum population of 79,879 dolphins (Waring et al., 2006).

Based on best available science the Navy concludes that exposures to pantropical spotted dolphins due to AFAST 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 pantropical spotted dolphins.

6.2.15.8 Atlantic Spotted Dolphin

Acoustic analysis indicates that up to 388,997 exposures of Atlantic spotted dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to 24 Atlantic spotted dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to Atlantic spotted dolphins. Lookouts would likely detect a group of pantropical spotted dolphins at the surface because of their high probability of detection (1.00 in Beaufort Sea States 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 SAR by NMFS. In the North Atlantic, the best abundance estimate for Atlantic spotted dolphins is 50,978, with a minimum population estimate (based on the combined offshore and coastal abundance estimates) of 36,235 (Waring et al., 2006). The best abundance estimate for Atlantic spotted dolphins in the northern Gulf of Mexico is 30,947, with a minimum population estimate of 24,752 dolphins (Waring et al., 2006).

Based on best available science the Navy concludes that exposures to Atlantic spotted dolphins due to AFAST 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 Atlantic spotted dolphins.

6.2.15.9 Spinner Dolphin

Acoustic analysis indicates that up to 21,738 exposures of spinner dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to 2 spinner dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to spinner dolphins. Lookouts would likely detect a group of spinner dolphins at the surface because of their high probability of detection (1.00 in Beaufort Sea States 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.

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 report by NMFS. No best estimate is currently available for the western North Atlantic stock of spinner dolphins. Stock structure in the western North Atlantic is unknown (Waring et al., 2007). The best abundance estimate for spinner dolphins in the northern Gulf of Mexico is 11,971, with a minimum population of 6,990 spinner dolphins (Waring et al., 2006).

Based on best available science the Navy concludes that exposures to the northern Gulf of Mexico spinner dolphin stock due to AFAST 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.

6.2.15.10 Clymene Dolphin

Acoustic analysis indicates that up to 68,980 exposures of Clymene dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to four Clymene dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to Clymene dolphins. 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 stock assessment reports by NMFS. Clymene dolphins are currently considered as a single stock in the western North Atlantic; the northern Gulf of Mexico population is considered a single stock as well. North Atlantic and northern Gulf of Mexico populations are considered separate stocks for management purposes although there is currently not enough information to distinguish these stocks (Waring et al., 2007). The best abundance estimate for Clymene dolphins in the western North Atlantic is 6,086 animals, with a minimum population estimate of 3,132 Clymene dolphins (Waring et al., 2007). The best abundance estimate of Clymene dolphins in the northern Gulf of Mexico is 17,355, with a minimum population estimate of 10,528 dolphins (Waring et al., 2007).

Based on the best available science the Navy concludes that exposures to both Northwest Atlantic and Gulf of Mexico Clymene dolphin stocks due to AFAST 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 Clymene dolphins.

6.2.15.11 Striped Dolphin

Acoustic analysis indicates that up to 368,544 exposures of striped dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to nine striped dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to striped dolphins. 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 stock assessment reports by NMFS. Striped dolphins are currently considered as a single stock in the western North Atlantic; the northern Gulf of Mexico population is considered a single stock as well. North Atlantic and northern Gulf of Mexico populations are considered separate stocks for management purposes although there is currently not enough information to distinguish these stocks. The best abundance estimate for striped dolphins in the western North Atlantic is 94,462 animals, with a minimum population estimate of 68,558 striped dolphins (Waring et al., 2006). The best abundance estimate of striped dolphins in the northern Gulf of Mexico is 6,505, with a minimum population estimate of 4,599 dolphins (Waring et al., 2005).

Based on the best available science the Navy concludes that exposures to both Northwest Atlantic and Gulf of Mexico striped dolphin stocks due to AFAST 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 striped dolphins.

6.2.15.12 Common Dolphin

Acoustic analysis indicates that up to 168,325 exposures of common dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to five common dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to common dolphins. 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 stock assessment reports by NMFS. Currently, there is no conclusive information available for western North Atlantic common dolphin stock structure (Waring et al., 2007). The best abundance estimate for common dolphins in the western North Atlantic is 120,743 animals, with a minimum population estimate of 99,975 common dolphins (Waring et al., 200).

Based on the best available science the Navy concludes that exposures to Northwest Atlantic common dolphins due to AFAST 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 common dolphins.

6.2.15.13 Fraser's Dolphin

Acoustic analysis indicates that up to 359 exposures of Fraser's dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no Fraser's dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to Fraser's dolphins. 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 stock assessment reports by NMFS. Fraser's dolphins are currently considered as a single stock in the western North Atlantic; the northern Gulf of Mexico population is considered a single stock as well. No abundance estimate of Fraser's dolphins in the western North Atlantic is available (Waring et al., 2007). The best abundance estimate of Fraser's dolphins in the northern Gulf of Mexico is 726, with a minimum population estimate of 427 dolphins (Mullin and Fulling, 2004; Waring et al., 2006).

Based on the best available science the Navy concludes that exposures to both Northwest Atlantic and Gulf of Mexico Fraser's dolphin stocks due to AFAST 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 Fraser's dolphins.

6.2.15.14 Risso's Dolphin

Acoustic analysis indicates that up to 144,764 exposures of Risso's dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that up to 7 Risso's dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to Risso's dolphins. 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 stock assessment reports by NMFS. Risso's dolphins are currently considered as a single stock in the western North Atlantic; the northern Gulf of Mexico population is considered a single stock as well. The best abundance estimate for Risso's dolphins in the western North Atlantic is 20,479, with a minimum population estimate of 12,920 animals (Waring et al., 2007). The best estimate of abundance for Risso's dolphins in the northern Gulf of Mexico is 2,169, with a minimum population estimate of 1,668 Risso's dolphins (Waring et al., 2006).

Based on best available science the Navy concludes that exposures to both Northwest Atlantic and Gulf of Mexico Risso's dolphin stocks due to AFAST 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 Risso's dolphins.

6.2.15.15 Atlantic White-sided Dolphin

Acoustic analysis indicates that up to 34,290 exposures of Atlantic white-sided dolphins to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no Atlantic white-sided dolphins will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to Atlantic white-sided dolphins. Group size of Atlantic white-sided dolphins ranges from a few to a few hundred individuals and seems to vary geographically; the typical average group size is about 50 animals (CETAP, 1982; Weinrich et al., 2001; Perrin et al., 2002). Given their typical group size and level of surface activity, it is likely that lookouts would detect a group of Atlantic white-sided dolphins at the surface. Implementation of mitigation measures and probability of detecting large groups of white-sided dolphins reduce the likelihood of exposure. Thus, Atlantic white-sided 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 stock assessment reports by NMFS. Three stock units have been suggested for the Atlantic white-sided dolphin in the western North Atlantic: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea (Palka et al., 1997; Waring et al., 2004). However, recent mitochondrial DNA analysis indicates that no definite stock structure exists (Amaral et al., 2001). The best abundance estimate for Atlantic white-sided dolphins in the western North Atlantic is 51,640 animals, with a minimum population estimate of 37,904 dolphins (Waring et al., 2007). Atlantic white-sided dolphins are not expected to occur in the northern Gulf of Mexico.

Based on best available science the Navy concludes that exposures to Atlantic white-sided dolphin stocks due to AFAST 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 Risso's dolphins.

6.2.15.16 White-Beaked Dolphin

Acoustic analysis is not available for white-beaked dolphins due to the lack of abundance and density data. Although older population estimates are available for portions of this species' range, NMFS' Stock Assessment Reports conclude that data are insufficient to calculate a minimum population estimate in the U.S. EEZ. There are believed to be separate stocks in the eastern and western North Atlantic Ocean.

This species is typically found only in cold-temperate and sub-arctic waters in the North Atlantic. In the western North Atlantic, white-beaked dolphins occur from eastern Greenland and Davis Strait to southern New England. They are generally found in the northern portion of this range between spring and late fall, apparently wintering in the southern portion. Off the northeastern United States, white-beaked dolphin sightings are concentrated in the western Gulf of Maine and around Cape Cod. Prior to the 1970s, this species was found primarily over the continental shelf. However, since then, their distribution has shifted to waters over the continental slope.

An undetermined number of white-beaked dolphins could be exposed to sound levels likely to result in Level B harassment. Based on their northerly distribution, 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. Group size of up to 30 white-beaked dolphins is common, but groups of several hundred or thousands of animals have been recorded. This species is also typically active at the surface (Perrin et al., 2002). Therefore, lookouts would likely detect white-beaked dolphins at the surface, thus reducing the likelihood of exposure.

Based on best available science the Navy concludes that exposures to white-beaked dolphins due to AFAST activities would result in 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 white-beaked dolphins.

6.2.15.17 Melon-headed Whale

Acoustic analysis indicates that up to 1,708 exposures of melon-headed whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no melon-headed whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to melon-headed whales. 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 stock assessment reports by NMFS. Melon-headed whales are currently considered as a single stock in the western North Atlantic; the northern Gulf of Mexico population is considered a single stock as well. North Atlantic and northern Gulf of Mexico populations are considered separate stocks for management purposes although there is currently not enough information to distinguish these stocks. There are no abundance estimates for melon-headed whales in the western North Atlantic (Waring et al., 2007). The best estimate of abundance for melon-headed whales in the northern Gulf of Mexico is 3,451 individuals, with a minimum population estimate of 2,238 (Mullin and Fulling, 2004; Waring et al., 2006).

Based on best available science the Navy concludes that exposures to melon-headed whale stocks due to AFAST 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 melon-headed whales.

6.2.15.18 Pygmy Killer Whale

Acoustic analysis indicates that up to 245 exposures of pygmy killer whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no pygmy killer whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to pygmy killer whales. 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 stock assessment reports by NMFS. Pygmy killer whales are currently considered as a single stock in the western North Atlantic; the northern Gulf of Mexico population is considered a single stock as well. North Atlantic and northern Gulf of Mexico populations are considered separate stocks for management purposes although there is currently not enough information to distinguish these stocks. There is no estimate of abundances for pygmy killer whales in the western North Atlantic (Waring et al., 2007). The best estimate of abundance for pygmy killer whales in the northern Gulf of Mexico is 408 individuals, with a minimum population estimate of 256 (Mullin and Fulling, 2004; Waring et al., 2006).

Based on best available science the Navy concludes that exposures to pygmy killer whale stocks due to AFAST 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 pygmy killer whales.

6.2.15.19 False Killer Whale

Acoustic analysis indicates that up to 514 exposures of false killer whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no false killer whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to false killer whales. 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.

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. NMFS does not include false killer whales among those species having populations or stocks in the Western North Atlantic. False killer whales are currently considered as a single stock in the northern Gulf of Mexico. There is no estimate of abundances for false killer whales in the western North Atlantic (Waring et al., 2007). The best estimate of abundance for false killer whales in the northern Gulf of Mexico is 1,038 individuals, with a minimum population estimate of 606 (Mullin and Fulling, 2004; Waring et al., 2006).

Based on best available science the Navy concludes that exposures to false killer whale stocks due to AFAST 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 false killer whales.

6.2.15.20 Killer Whale

Acoustic analysis indicates that up to 66 exposures of killer whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no killer whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to killer whales. 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 stock assessment reports by NMFS. There are no estimates of abundance for killer whales in the western North Atlantic (Waring et al., 2007). Killer whales are currently considered as a single stock in the northern Gulf of Mexico. The best estimate of abundance for killer whales in the northern Gulf of Mexico is 133 individuals, with a minimum population estimate of 90 (Mullin and Fulling, 2004; Waring et al., 2006).

Based on best available science the Navy concludes that exposures to killer whale stocks due to AFAST 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 killer whales.

6.2.14.20 Long-finned and Short-finned Pilot Whales

Acoustic analysis indicates that up to 190,679 exposures of long-finned and short-finned pilot whales to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that 10 long-finned and short-finned pilot whales will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to long-finned and short-finned 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 stock assessment reports by NMFS. Pilot whales occur in both the western North Atlantic and northern Gulf of Mexico. Short-finned pilot whales occur in both water bodies, while long-finned pilot whales occur only in the North Atlantic. Fullard et al. (2000) proposed a stock structure for long-finned pilot whales in the North Atlantic that was correlated with sea-surface temperature. This involved a cold-water population west of the Labrador and North Atlantic current and a warm-water population that extended across the North Atlantic in the warmer water of the Gulf Stream. There is no information regarding genetic differentiation within the western North Atlantic stock (Waring et al., 2004). Short-finned pilot whales are currently considered as a single stock in the western North Atlantic; the northern Gulf of Mexico population is considered a single stock as well. North Atlantic and northern Gulf of Mexico populations are considered separate stocks for management purposes although there is currently not enough information to distinguish these stocks. The best estimate of abundance for pilot whales (combined short-finned and long-finned) in the western North Atlantic is 31,139 individuals, with a minimum population estimate of 24,866 (Waring et al., 2007). The best estimate of abundance for the short-finned pilot whale in the northern Gulf of Mexico is 2,388 individuals, with a minimum population estimate of 1,628 (Mullin and Fulling, 2004; Waring et al., 2006).

Based on best available science the Navy concludes that exposures to pilot whale stocks due to AFAST 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 pilot whales

6.2.14.21 Harbor Porpoise

Acoustic analysis indicates up to 286,132 exposures of a harbor porpoise to sound levels likely to result in Level B harassment may occur. Acoustic analysis indicates that no harbor porpoises will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to harbor porpoises. Implementation of mitigation measures would reduce the likelihood of exposure. Thus, harbor porpoise 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 stock assessment reports by NMFS. Harbor porpoises do not occur in the Gulf of Mexico. There are four proposed separate populations of harbor porpoises in the western North Atlantic: Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland (Gaskin, 1992). During summer, harbor porpoises are concentrated in the Gulf of Maine/Bay of Fundy region, generally in waters less than 150 m (492 ft) deep (Kraus et al., 1983; Palka, 1995a, b). During fall and spring, they are widely dispersed from New Jersey to Maine, with lower densities farther north and south. At this time, they occur from the coastline to deeper waters (greater than 1800 m [5,905 ft]) (Westgate et al., 1998). During winter, intermediate densities of harbor porpoises occur in waters off New Jersey to North Carolina, with lower densities off New York to New Brunswick, Canada. There does not appear to be coordinated migration or a specific migratory route to and from the Bay of Fundy region. The best abundance estimate for the Gulf of Maine/Bay of Fundy stock of harbor porpoises is 89,700 individuals, with a minimum population estimate of 74,695 (Waring et al., 2004). The best estimate of abundance for harbor porpoises in the northern Gulf of Mexico is 2,169, with a minimum population estimate of 1,668 harbor porpoises (Waring et al., 2006).

Based on best available science the Navy concludes that exposures to harbor porpoise stocks due to AFAST 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 harbor porpoises.

6.2.15.21 Hooded Seal

The best abundance estimate for hooded seals in the western North Atlantic Ocean is 592,100, with a minimum population estimate of 512,000. Present data are insufficient to calculate the minimum population estimate in U.S. waters. Acoustic analysis was not conducted for AFAST activities. Although individual hooded seals may travel far outside their typical range and have been sighted as far south as Puerto Rico and the Virgin Islands, they generally occur in the Atlantic region of the Arctic Ocean and in high latitudes of the North Atlantic near the outer edge of the pack ice. Hooded seals occur with regularity only in the Northeast OPAREA (from northern Maine to southern Delaware), primarily during winter. Sightings off the northeastern United States have generally increased in recent years. An undetermined number of hooded seals could be exposed to sound levels likely to result in Level B harassment. However, because on their distribution, the relative 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.

Based on best available science the Navy concludes that exposures to hooded seals due to AFAST activities would result in 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 hooded seals.

6.2.15.22 Harp Seal

The best abundance estimate for harp seals in the western North Atlantic Ocean is 5.9 million, with a minimum population estimate of 5.3 million. Present data are insufficient to calculate the minimum population estimate in U.S. waters. Acoustic analysis was not conducted for AFAST activities. Harp seals are closely associated with pack ice of the North Atlantic and Arctic Oceans, from Newfoundland and the Gulf of St. Lawrence to northern Russia. Most of the western North Atlantic harp seals congregate off the east coast of Newfoundland-Labrador to pup and breed; the remainder gather near the Magdalen Islands in the Gulf of St. Lawrence. This species undergoes extensive spring and fall migrations to and from summer feeding and pupping grounds in sub-arctic and arctic waters.

The number of sightings and strandings of harp seals off the northeastern United States has been increasing, particularly in winter and early spring when the western North Atlantic stock is at its southernmost distribution point. They may occur in the Northeast OPAREA, from the northern coast of Maine to the southern coast of Delaware during winter and spring, and from the southern coast of Maine to Long Island during fall. An undetermined number of harp seals could be exposed to sound levels likely to result in Level B harassment. This species' northerly distribution would result in relatively fewer exposures. No exposure of individuals to sound levels likely to result in Level A harassment is expected. No mortality due to explosive sonobuoys is expected.

Based on best available science the Navy concludes that exposures to harp seals due to AFAST activities would result in 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 harp seals.

6.2.15.23 Gray Seal

Acoustic analysis indicates that up to 37,673 exposures of gray seals to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Acoustic analysis indicates that no gray seals will be exposed to sound levels likely to result in Level A harassment. Modeling of the explosive sonobuoys predicts no potential for mortality to gray seals. Implementation of mitigation measures would reduce the likelihood of exposure. Thus, gray seal 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 stock assessment reports by NMFS. Gray seals do not occur in the Gulf of Mexico. There are at least three populations of gray seals in the North Atlantic Ocean: eastern North Atlantic, western North Atlantic, and Baltic (Boskovic et al., 1996). The western North Atlantic stock is equivalent to the eastern Canada breeding population (Waring et al., 2007). There are two breeding concentrations in eastern Canada: one at Sable Island and the other on the pack ice in the Gulf of St. Lawrence. These two breeding groups are treated as separate popuations for management purposes (Mohn and Bowen, 1996). Current estimates of the gray seal population in the western North Atlantic are not available, but in 1995 there were an estimated 195,000 individuals (DFO, 2003a). The herd on Sable Island is thought to be growing and may have more than doubled in number, but the Gulf of St. Lawrence population has changed little (DFO, 2003a). Present data are insufficient to calculate the minimum population estimate for U.S. waters (Baraff and Loughlin, 2000; Waring et al., 2004). A minimum of 1,000 pups were born in the northeastern United States during 2002 (Wood et al., 2003).

Based on best available science the Navy concludes that exposures to gray seal stocks due to AFAST 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 gray seals.

6.2.14.23 Harbor Seals

Acoustic analysis indicates that up to 69,572 exposures of harbor seals to sound levels likely to result in Level B harassment may occur. This estimate represents the total number of exposures and not necessarily the number of individuals exposed, as a single individual may be exposed multiple times over the course of a year. Modeling of the explosive sonobuoys (AN/SSQ-110A) predicts no potential for mortality to the harbor seal. Implementation of mitigation measures would reduce the likelihood of exposure. Thus, harbor seal 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 stock assessment reports by NMFS. Harbor seals do not occur in the Gulf of Mexico. Five species of harbor seals are recognized; *Phoca vitulina concolor* is the western North Atlantic subspecies (Rice, 1998). Currently, harbor seals that occur along the coast of the eastern United States and Canada are considered to be a single population (Waring et al., 2007). The best abundance estimate for harbor seals in the western North Atlantic is 99,340, with a minimum population estimate of 91,546 animals (Waring et al., 2007).

Based on best available science the Navy concludes that exposures to harbor seal stocks due to AFAST 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 harbor seals.

7. EFFECTS TO MARINE MAMMAL SPECIES OR STOCKS

Based on best available science the Navy concludes that exposures to marine mammal species and stocks due to AFAST activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival for the following reasons:

- Most acoustic exposures are within the non-injurious temporary threshold shift (TTS) or behavioral effects zones (Level B harassment).
- Although the numbers presented in Tables 6-7 through 6-10 represent estimated harassment under the Marine Mammal Protection Act (MMPA), as described above, they are conservative estimates of harassment, primarily by behavioral disturbance. 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 protective measures described in Chapter 11 are designed to reduce sound exposure of marine mammals to levels below those that may cause “behavioral disruptions” and to achieve the least practicable adverse effect on marine mammal species or stocks.

Consideration of negligible impact is required for the National Marine Fisheries Service (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). Based on each species’ life history information, the expected behavioral disturbance levels in the Atlantic Fleet Active Sonar Training (AFAST) Study Area, and an analysis of behavioral disturbance levels in comparison to the overall population, an analysis of the potential impacts of the Proposed Action on species recruitment or survival is presented in Sections 6.2.13 and 6.2.14 for each species. These species-specific analyses support the conclusion that proposed Atlantic Fleet training activities would have a negligible impact on marine mammals. The Navy concludes that exposures to the following marine mammal species due to AFAST 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
- Bryde’s whale
- Sei whale
- Fin whale
- Blue Whale
- Sperm whale
- Manatee
- Kogia spp.
- Beaked whale

- Rough-toothed dolphin
- Bottlenose dolphin
- Pantropical spotted dolphin
- Atlantic spotted dolphin
- Spinner dolphin
- Clymene dolphin
- Striped dolphin
- Common dolphin
- Fraser’s dolphin
- Risso’s dolphin
- Atlantic white-sided dolphin
- Atlantic white-beaked dolphin
- Melon-headed whale
- Pygmy killer whale
- False killer whale
- Killer whale
- Long-finned pilot whale
- Short-finned pilot whale
- Harbor porpoise
- Hooded Seal
- Harp Seal
- Gray Seal
- Harbor Seal

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8. MINIMIZATION OF ADVERSE EFFECTS TO SUBSISTENCE USE

Potential impacts resulting from the proposed activity will be limited to individuals of marine mammal species located off the East Coast of the U.S. and in the Gulf of Mexico, and will not affect Arctic marine mammals. Since the AFAST activities will not take place in Arctic waters, these activities 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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9. EFFECTS TO MARINE MAMMAL HABITAT AND THE LIKELIHOOD OF RESTORATION

The primary source of effects to marine mammal habitat is exposures resulting from Atlantic Fleet 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 Atlantic Fleet Active Sonar Training (AFAST) Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) and was determined to have no effect on marine mammal habitat. A summary of the conclusions are included in subsequent sections.

9.1 WATER QUALITY

The AFAST EIS/OEIS analyzed the potential effects to water quality from sonobuoy, Acoustic Device Countermeasures (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.

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, a gas that is highly soluble in water, is the major reactive component in the battery. The sulfur dioxide 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 United States 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.

9.2 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 and Gulf of Mexico;
- Operational parameters of the sonar operating during AFAST 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 AFAST 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 (U.S. Air Force, 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-year 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 United States has increased 2.45 percent each year over a 20-year 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 seconds, but for very deep water surveys, inter-shot times are as high as 42 seconds. 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 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 hours 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 signal, 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.

10. EFFECTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

Based on the previous discussion, there will be no effects to marine mammals resulting from loss or modification of marine mammal habitat.

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11. MEANS OF EFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS – MITIGATION MEASURES

Mitigation measures for the proposed action are addressed in this chapter. Specifically, Section 11.1 addresses mitigation with respect to active sonar effects on marine animals, Section 11.2 addresses mitigation with respect to explosive source sonobuoys (AN/SSQ-110A), and Section 11.3 addresses mitigation related to vessel transits during right whale migratory seasons near ports located in the Atlantic Ocean, offshore of the eastern U.S.

11.1 MITIGATION MEASURES RELATED TO ACOUSTIC EFFECTS

Effective training dictates that ship, submarine, and aircraft participants use their sensors and exercise weapons (i.e., torpedoes) to their optimum capabilities. The Navy recognizes that such use may cause behavioral disruption of some marine mammal species in the AFAST Study Area and is therefore seeking a Biological Opinion and incidental take statement from the National Marine Fisheries Service. This chapter describes the Navy's proposed mitigation measures that would be implemented to protect marine mammals during the proposed active sonar activities.

In addition, marine mammals may be exposed to sound energy levels sufficient to cause a physiological effect. As described in Section 6.2.4, certain received sound energy levels are associated with temporary threshold shift (TTS), a temporary hearing loss, or permanent threshold shift (PTS), a permanent hearing loss, over a subsection of an animal's hearing range. The mitigation measures described in this section will limit potential exposures within the range of sonar use that could result in physiological effects.

The typical ranges, or distances, from the most powerful and common active sonar sources used in Atlantic Fleet Active Sonar Training (AFAST) to received sound energy levels associated with TTS and PTS are shown in Table 11-1. Range to effects for explosive source sonobuoys (AN/SSQ-110A) are shown in Table 11-2. Due to spreading loss, sound attenuates logarithmically from the source, so the area in which an animal could be exposed to potential injury (PTS) is small. Because the most powerful sources would typically be used in deep water and the range to effect is limited, spherical spreading is assumed for 195 decibels referenced to 1 micro-Pascal squared second (dB re 1µPa^2-s) and above. Also, due to the limited ranges, interactions with the bottom or surface ducts are rarely an issue.

Table 11-1. Range to Effects for Active Sonar

Sonar Source	**215 dB re 1 µPa2-s received EL (PTS)**	**195 dB re 1 µPa2-s received EL (TTS)**
AN/SQS-53	10 meters	100 – 300 meters
AN/SQS-56 or AN/AQS-22	5 meters	30 – 60 meters
DICASS sonobuoy	never in a realistic operating environment	3 – 6 meters

Table 11-2. Range to Effects for Explosive Source Sonobuoys (AN/SSQ-110A)

Explosive Source	30.5 psi-ms impulse pressure (Morality)	205 dB re 1 µPa^2-s received EL in total spectrum (PTS)	23 psi (TTS)
AN/SSQ-110A	14 – 44 meters	27 – 77 meters	118 – 196 meters

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, to the Officer of the Deck, all objects found in the water. 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 Personal Qualification Standard (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 participate in the active sonar activities is a key element of the mitigation measures. The goal of this training is twofold: (1) that active sonar operators understand the details of the mitigation measures and be competent to carry out the mitigation measures, and (2) that key personnel onboard Navy platforms exercising in the various Navy Operating Areas (OPAREAs) 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 Marine Species Awareness Training (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 Anti-Submarine Warfare (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 who are participating in AFAST exercises 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 Mitigation Measures: Personnel Training:

- All lookouts aboard platforms involved in ASW training activities would review NMFS-approved MSAT material prior to using 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 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 being included in previous measures so 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 protective measures if marine species are spotted.

11.1.2.2 General Maritime Mitigation Measures: Lookout 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 above 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 MFA sonar, pedestal-mounted “Big Eye” (20 x 110) binoculars will be present and 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 the 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 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 Lookouts 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 Officer of the Deck 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

- Commanding Officers would make use of marine species detection cues and information to limit interaction with marine species 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 and sea turtles prior to commencement and during the use of active sonar.
- During operations involving 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 species of concern 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 meters (m) (200 yards [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 – These safety zones would prevent exposure to sound levels greater than the lowest mean of the dose-function criteria. 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 minutes, or the vessel has transited more than 914 m (1,000 yd) beyond the location of the last detection.
- Should a marine mammal be detected within or closing to inside 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 minutes, or the vessel has transited more than 914 m (1,000 yd) beyond the location of the last detection.
- Should the marine mammal be detected within or closing to inside 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 minutes, or the vessel has transited more than 914 m (1,000 yd) beyond the location of the last detection.
- If the need for power-down should arise, as detailed in "Safety Zones" 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 minutes 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 mid-frequency 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 would be necessary because dolphins are out of the main transmission axis of the active sonar while in the shallow-wave area of the vessel bow.

11.1.2.5 Potential Mitigation Under Development

The Navy is working to develop the capability to detect and localize vocalizing marine mammals using the installed sensors. Based on the current status of acoustic monitoring science, it is not yet possible to use installed systems as a mitigation tools; however, as this science develops, it will be incorporated into the AFAST 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 will continue to coordinate passive monitoring and detection research specific to the proposed use of active sonar. As technology and methodologies become available, their applicability and viability will be evaluated for incorporation into this mitigation plan.

11.1.3 Conservation Measures

In accordance with the MMPA and its implementing regulations, authorization under MMPA also requires that NMFS' regulations prescribe the monitoring and reporting of the activity that will be conducted. More details on the proposed monitoring and reporting programs will be developed by Navy and NMFS via the MMPA regulatory process, at this time, the long term monitoring program is described as a conservation measure.

Since the term "monitoring" can be used to describe both the immediate detection of marine mammals for the purpose of mitigating marine mammal sound exposures, the term "long-term monitoring" (LTM) is used here to describe monitoring as it relates to the four bulleted items, described below.

The Navy recognizes that ASW training activities have the potential to cause behavioral effects on marine mammals. Because data concerning behavioral effects and long-term modifications of habitat use are extremely limited at this time, the Navy would develop and implement a long-term monitoring program to assess potential effects on marine mammals at both the individual and population level. This long-term monitoring program is being developed as a conservation measure and would be developed in coordination with NMFS and include the following:

- Coordinating with NMFS to conduct visual and acoustic surveys within the selected OPAREA as part of a baseline monitoring program in advance of training operations;
- Implementing a long-term monitoring program of marine mammal populations to assess trends in distribution, abundance, and habitat use over time;
- Continuing to support vital research and contribute to university/external research efforts to improve the state of the science regarding marine species biology/ecology and acoustic effects; and
- Sharing data with NMFS and coordinating opportunities for research and development efforts.

11.1.4 Coordination and Reporting

The Navy would coordinate with NMFS Stranding Coordinators for any unusual marine mammal behavior. This includes any stranding, beached live/dead, or floating marine mammals that may occur coincident with Navy training activities.

These mitigation measures have been developed in full consideration of the recommendations of the joint National Oceanic and Atmospheric Administration / Navy report on the Bahamas marine mammal stranding event (Department of Commerce and Department of the Navy [DON], 2001).

11.2 MITIGATION MEASURES RELATED TO EXPLOSIVE SOURCE SONOBUOY ACTIVITIES

- Crews will conduct visual reconnaissance of the drop area prior to laying their intended sonobuoy pattern. This search should be conducted below 457 m (1,500 ft) at a slow speed, if operationally feasible and weather conditions permitting. In dual aircraft operations, crews are allowed to conduct coordinated area clearances.
- Crews shall conduct a minimum of 30 minutes of visual and aural monitoring of the search area prior to commanding the first post detonation. This 30-minute observation period may include pattern deployment time.
- For any part of the briefed pattern where a post (source/receiver sonobuoy pair) will be deployed within 914 m (3,000 ft) of observed marine mammal activity, deploy the receiver ONLY and monitor while conducting a visual search. When marine mammals are no longer detected within 914 m (3,000 ft) of the intended post position, co-locate the SSQ-110A sonobuoy (source) with the receiver.

- When able, crews will conduct continuous visual and aural monitoring of marine mammal activity. This is to include monitoring of own-aircraft sensors from first sensor placement to checking off station and out of RF range of these sensors.
- Aural Detection:
    - If the presence of marine mammals is detected aurally, then that should cue the aircrew to increase the diligence of their visual surveillance. Subsequently, if no marine mammals are visually detected, then the crew may continue multi-static active search.
- Visual Detection:
    - If marine mammals are visually detected within 914 m (3,000 ft) of the SSQ-110A sonobuoy intended for use, then that payload shall not be detonated. Aircrews may utilize this post once the marine mammals have not been re-sighted for 10 minutes or are observed to have moved outside the 914 m (3,000 ft) safety buffer.
    - Aircrews may shift their multi-static active search to another post, where marine mammals are outside the 914 m (3,000 ft) safety buffer.
- Aircrews shall make every attempt to manually detonate the unexploded charges at each post in the pattern prior to departing the operations area by using the "Payload 1 Release" command followed by the "Payload 2 Release" command. Aircrews shall refrain from using the "Scuttle" command when two payloads remain at a given post. Aircrews will ensure a 914 m (3,000 ft) safety buffer, visually clear of marine mammals, is maintained around each post as is done during active search operations.
- Aircrews shall only leave posts with unexploded charges in the event of a sonobuoy malfunction, an aircraft system malfunction, or when an aircraft must immediately depart the area due to issues such as fuel constraints, inclement weather, and in-flight emergencies. In these cases, the sonobuoy will self-scuttle using the secondary method or tertiary method.
- Ensure all payloads are accounted for. Sonobuoys that can not be scuttled shall be reported as unexploded ordnance via voice communications while airborne, then upon landing via naval message.
- Mammal monitoring shall continue until out of own-aircraft sensor range.

11.3 MITIGATION MEASURES RELATED TO VESSEL TRANSIT AND NORTH ATLANTIC RIGHT WHALES

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 mitigation measures for Navy vessel transits during Atlantic right whale migratory seasons near ports located off the western North Atlantic, offshore of the eastern United States. The mitigation measures would apply to all Navy vessel transits, including those vessels that would transit to and from East Coast ports and OPAREAs. Seasonal migration of right whales is generally described by NMFS as occuring from October 15th through April 30th, when right 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 identifed ports located in the western Atlantic Ocean, offshore of the southeastern United States, where vessel transit during 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 11-2 and within a 37 km (20 NM) arc (except as noted) of the specified reference points.

Table 11-3. 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	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

During the indicated months, 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 above. All surface 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. Furthermore, Navy vessels would not knowingly approach any whale head on and would maneuver to keep at least 457 m (1,500 ft) away from any observed whale, consistent with vessel safety.

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 it calving season (Typically from December 1st through March 31st). During this period, North Atlantic right whales give birth and nurse their calves in and around a federally designated critical habitat off the coast of Georgia and Florida. This critical habitat is the area from 31-15N to 30-15N extending from the coast out to 28 km (15 NM), and the area from 28-00N to 30-15N 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 boundaries.

Prior to transiting or training in the critical habitat or associated area of concern, ships will contact Fleet Area Control and Surveillance Facility, Jacksonville, to obtain latest whale sighting and other information needed to make informed decisions regarding safe speed and path of intended movement. Subs shall 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 will exercise extreme caution and proceed at a slow safe speed. The speed will 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 new sighting less then 12 hours 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 will avoid head-on approached to North Atlantic right whale(s) and will maneuver to maintain at least 457 m (500 yd) of separation from any observed whale if deemed safe to do so. These requirements do 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 shall not transit through the critical habitat or associated area of concern in a North-South direction.
- Ship, surfaced subs, and aircraft will report any whale sightings to Fleet Area Control and Surveillance Facility, Jacksonville, by most convenient and fast means. Sighting report will include the time, latitude/longitude, direction of movement and number and description of whale (i.e., adult/calf).

11.4 ALTERNATIVE MITIGATION MEASURES CONSIDERED BUT ELIMINATED

As described in Chapter 6, the vast majority of estimated sound exposures of marine mammals during proposed active sonar activities would not cause injury. Potential acoustic effects on marine mammals would be further reduced by the mitigation measures described above. Therefore, the Navy concludes the proposed action and mitigation measures would achieve the least practical adverse impact on species or stocks of marine mammals.

A determination of "least practicable adverse impacts" includes consideration, in consultation with the Department of Defense (DoD), of personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity. 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 they may be called upon to react to. These training requirements are designed provide the experience needed to ensure sailors are properly prepared for operational success. There is not 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 participants' presence. 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.

    - 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 impact training flexibility, thus adversely affecting training effectiveness. The presence of other aircraft in the vicinity of naval exercises would present 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 protective measures if marine species are spotted. A critical skill set of effective Navy training is communication. Navy lookouts are trained to act swiftly and decisively to ensure that appropriate actions are taken.

- Use of third-party observers is not necessary because 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.

- 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-hour period 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. 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 areas where training events will mainly occur in the AFAST Study Area cover approximately 412,115 km^2 (120,000 NM^2). Contiguous ASW events may cover many hundreds of square miles. The number of civilian ships and/or aircraft required to monitor the area of these events would be considerable. It is, thus, not feasible to survey or monitor the large exercise areas in the time required ensuring these areas are devoid of marine mammals. In addition, marine mammals may move into or out of an area, if surveyed before an event, or an animal could move into an area after an exercise took place. Given that there are no adequate controls to account for these or other possibilities and there are no identified research objectives, there is no utility to performing either a before or an after the event survey of an exercise area.

- 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.

  - Multiple events may occur simultaneously in areas at opposite ends of the AFAST Study Area and then continue for up to 96 hours. There are not enough qualified third-party personnel to accomplish the monitoring task.

- Reducing or securing power during the following conditions.

  - Low-visibility / night training: The Navy must train in the same manner as it will fight. ASW can require a significant amount of time to develop the “tactical picture”, or an understanding of the battle space such as area searched or unsearched, identifying false contacts, understanding the water conditions, etc. 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. By 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 in the various proposed OPAREAs may change rapidly, resulting in continually changing mitigation requirements, resulting in a focus on mitigation vice training.

- Vessel speed: Establish and implement a set vessel speed.

  - As discussed in Section 11.3, are already 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. By 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 (1,500 and 3,000 ft), as well as the 183 m (600 ft) shut down 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 Navy has developed is also within a range sailors can realistically maintain situational awareness and achieve visually during most conditions at sea.

  - Although the three action alternatives were developed using marine mammal density data and areas believed to provide habitat features conducive to marine mammals, not all such areas could be avoided. ASW requires large areas of ocean space to provide realistic and meaningful training to the sailors. These areas were considered to the maximum extent practicable while ensuring Navy's ability to properly train its forces in accordance with federal law. Avoiding any area that has the potential for marine mammal populations is impractical thus adversely impacting the effectiveness of the military readiness activity.

- 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. MONITORING AND REPORTING

The U.S. 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. As part of those responsibilities, an assessment of the long-term and/or population-level effects of Navy training activities as well as the efficacy of mitigation measures is necessary. The Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species in order to assess the effects of training activities on marine species and investigate population trends in marine species distribution and abundance in various range complexes and geographic locations where Navy training occurs. This program will emphasize active sonar training, with Atlantic Fleet Active Sonar Training (AFAST) being a major component of the overall monitoring program.

The primary goals of the ICMP are:

- To monitor Navy training exercises, especially those involving mid-frequency sonar and underwater detonations, for compliance with the terms and conditions of Biological Opinions or Marine Mammal Protection Act (MMPA) authorizations.
- Estimate the number individuals (primarily marine mammals) exposed to sound levels above current regulatory thresholds
- Assess the effectiveness of the Navy's marine species mitigation
- To minimize exposure of protected species (primarily marine mammals) to sound levels from active sonar or sound pressure levels from underwater detonations currently considered to result in harassment.
- To document trends in species distribution and abundance in Navy training areas
- To add to the knowledge base on potential behavioral and physiological effects to marine species from mid-frequency active sonar and underwater detonations.
- To assess the practicality and usefulness of a number of mitigation tools and techniques.

The ICMP will serve as the basis for establishing Implementation Plans (IPs) for training activities as well as geographically based long-term monitoring sites. Training exercise IPs will be focused on short-term monitoring and mitigation for individual training activities. These exercise-specific Implementation Plans will be tailored to the specific logistical constraints for each exercise and include specifics concerning dates, location, spatial extent, appropriate monitoring methods, and reporting protocols. The IP will utilize information specific to the exercise to determine the most effective, logistically and financially feasible means to monitor each training event. Each IP will be developed to ensure compliance with all ESA Section 7 and MMPA authorization requirements.

By using a combination of monitoring techniques or tools appropriate for the species of concern, type of Navy activities conducted in the area, sea state conditions, and the size of the OPAREA, the detection, localization, and observation of marine species can be maximized. This 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 limitations and benefits to each type of monitoring technique and the type of environment or species of concern that would best be served by the technique will be addressed and a matrix of feasibility, temporal and spatial use, limitations, costs and availability of resources to accommodate the technique will be developed. The primary tools available for monitoring include the following:

- Visual Observations – Surface vessel, aerial and shore-based surveys, providing data on long term population trends (abundance and distribution) and response of marine species to Navy training activities. Both Navy personnel and independent visual observers will be considered.
- 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 presence/absence and movement data which are particularly important for species that are difficult to detect visually or when conditions limit the effectiveness of visual monitoring.
- Photo identification and tagging – Contributes to understanding of movement patterns and stock structure which is important to determine how potential effects may relate to individual stocks or populations. Tagging with sophisticated D-tags may also allow direct monitoring of behaviors not readily apparent to surface observers.
- Oceanographic and environmental data collection – Data to be used for analyzing distribution patterns and developing predictive habitat and density models.

In addition, the ICMP will propose to continue or initiate 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.

In 2005, the Navy contracted with a consortium of researchers from Duke University, University of North Carolina at Wilmington, University of St. Andrews, and NMFS Northeast Fisheries Science Center to conduct a pilot study analysis and subsequently develop a survey and monitoring plan in support of the planned Undersea Warfare Training Range (USWTR) activities. This survey and monitoring plan prescribes the recommended approach for data collection, including surveys (such as aerial/shipboard, frequency, and spatial extent) and data analysis (standard line-transect, spatial modeling) necessary to establish a fine-scale seasonal baseline of the distribution and abundance of protected species.

The baseline data collection portion of the program began in June 2007 and includes coordinated aerial, shipboard, and passive acoustic surveys, as well as deployment of high-frequency acoustic recording packages to supplement the traditional visual surveys. This intensive data collection effort is planned to continue in support of AFAST.

The Navy will coordinate with the local National Marine Fisheries Service (NMFS) Stranding 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 hours after completion of mid-frequency active sonar use associated with ASW training activities. The Navy will submit a report to the Office of Protected Resources, NMFS, within 120 days of the completion of a Major Exercise. This report must 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 AFAST 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.

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13. RESEARCH

The Navy provides a significant amount of funding and support to marine research. The agency provides $10 to $14 million annually to universities, research institutions, federal laboratories, private companies, and independent researchers around the world to study marine mammals. The U.S. Navy sponsors 70 percent of all U.S. research concerning the effects of human-generated sound on marine mammals and 50 percent 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 Atlantic Fleet 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 Office of Naval Research 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:

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 the technical reports referenced within this document, which include the Marine Resource Assessments and the Navy OPAREA Density Estimates reports. Furthermore, research cruises by the National Marine Fisheries Service (NMFS) and by academic institutions have received funding from the U.S. Navy. For instance, the ONR contributed financially to the Sperm Whale Seismic Survey in the Gulf of Mexico, coordinated by Texas A&M. The goals of the SWSS are to examine effects of the oil and gas industry on sperm whales and what mitigations would be employed to minimize adverse effects to the species. All of this research helps in understanding the marine environment and the effects that may arise from the use of underwater noise in the Gulf of Mexico and western North Atlantic Ocean.

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 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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