REQUEST FOR LETTER OF AUTHORIZATION FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM NAVY TRAINING OPERATIONS CONDUCTED WITHIN THE NAVY CHERRY POINT RANGE COMPLEX

Submitted to:

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June 2008

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ACRONYMS AND ABBREVIATIONS

%	Percent
°	Degree(s)
§	Section
ALMDS	Airborne Laser Mine Detection System
AMCM	Airborne Mine Countermeasures
AMNS	Airborne Mine Neutralization System
AMW	Amphibious Marine Warfare
A-S	Air-to-Surface
AUTEC	Atlantic Undersea Test and Evaluation Center
BRS	Behavioral Response Study
C	Celsius
CASS	Comprehensive Acoustic System Simulation
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CH	Critical Habitat
chl *a*	Chlorophyll *a*
CNO	Chief of Naval Operations
CO	Commanding Officer
CREEM	Centre for Environmental and Ecological Modelling
CVN	Aircraft Carrier
dB re 1 μPa	Decibels Referenced to One Micropascal
dB re 1 μPa^2-s	Decibels Referenced to One Micropascal Squared Second
dB	Decibel(s)
DoN	Department of the Navy
DVD	Digital Versatile Disk
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
EL	Energy Flux Density Level
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act
EWS	Early Warning System
FAA	Federal Aviation Administration
FEIS	Final Environmental Impact Statement
FIREX	Firing Exercise
FR	Federal Register
ft	Foot(Feet)
GAM	Generalized Additive Model
GPS	Global Positioning System
GRAB	Gaussian Ray Bundle
HARPS	High Frequency Acoustic Recording Packages
HE	High Explosive
HPA	Hypothalamic-Pituitary-Adrenal
hr	Hour(s)
Hz	Hertz
IADS	Integrated Air Defense System
ICMP	Integrated Comprehensive Monitoring Program
IMPASS	Integrated Maritime Portable Acoustic Scoring and Simulator System

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in.	Inch(es)
in.-lb/in.^{2}	Inch Pounds per Square Inch
IWC	International Whaling Commission
JOOD	Junior Officer of the Deck
kg	Kilogram(s)
km	Kilometer(s)
km^2	Square Kilometer(s)
kt	Knot(s)
lb	Pound(s)
LIDAR	Light Detection and Ranging
LOA	Letter of Authorization
m	Meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MAEWR	Mid-Atlantic Electronic Warfare Range
MCAS	Marine Corp Air Station
MCB	Marine Corp Base
MCM	Mine Countermeasures
MCMEX	Mine Countermeasures Exercise
MFAS	Mid-frequency Active Sonar
MHC	Coastal Minehunter
min	Minute(s)
MINEX	Mine Exercise
MISSILEX	Missile Exercise
MIW	Mine Warfare
mm	Millimeter(s)
MMPA	Marine Mammal Protection Act
MRA	Marine Resource Assessment
ms	Millisecond(s)
MSAT	Marine Species Awareness Training
MU	Management Unit
N	North
NDE	National Defense Exemption
NEPM	Non-Explosive Practice Munitions
NEW	Net Explosive Weight
nm	Nautical Miles
nm^2	Square Nautical Miles
NMFS	National Marine Fisheries Service
NEFSC	Northeast Fisheries Science Center
NOAA	National Oceanic and Atmospheric Administration
NODE	Navy Operating Area Density Estimate
NRC	National Research Council of the National Academies
OAMCM	Organic Airborne Mine Countermeasures
OAML	Oceanographic Atmospheric Master Library
OASIS	Organic Airborne and Surface Influence Sweep
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
OOD	Officer of the Deck
OPAREA	Operating Area
PL	Public Law
psi	Pounds per Square Inch

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PTS	Permanent Threshold Shift
R&D	Research and Development
RAMICS	Rapid Airborne Mine Clearance System
RDT&E	Research, Development, Test, and Evaluation
RHIB	Rigid-Hulled Inflatable Boat
s	Second(s)
S	South
SAR	Stock Assessment Report
SCORE	Southern California Offshore Range
SEAD	Suppression of Enemy Air Defenses
SEFSC	Southeast Fisheries Science Center
SNS	Sympathetic Nervous System
SOSUS	Sound Surveillance System
spp.	Species (plural)
SSC	Space and Naval Warfare Systems Center
SSN	Submarine
SST	Sea Surface Temperature
STW	Strike Warfare
SUA	Special Use Airspace
SUBOA	Submarine Operating Area
SUW	Surface Warfare
SVP	Sound Velocity Profile
TM	Tympanic Membrane
TNT	Trinitrotoluene
TOW	Tube-launched, Optically-tracked, Wire-guided
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USMC	United States Marine Corps
USN	United States Navy
USWTR	Undersea Warfare Training Range
UUV	Unmanned Underwater Vehicle
UXO	Unexploded Ordnance
VAST	Virtual at Sea Training
W	Warning Area/West
wk	Week(s)
XO	Executive Officer
yd	Yard(s)
yr	Year
ZOI	Zone of Influence

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CHAPTER 1   DESCRIPTION OF ACTIVITIES

The Department of the Navy (DoN) has prepared this request for Letter of Authorization (LOA) to analyze the potential environmental effects associated with Atlantic Fleet training in the Navy Cherry Point Range Complex detailed below. Activities evaluated in this document can be part of single unit training exercises or integrated, multi-platform training events.

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 (yr). The issuance occurs when the Secretary of Commerce, after notice has been published in the Federal Register (FR) 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 [PL] 108 136). The bases of this LOA are (1) the analysis of spatial and temporal distributions of protected marine mammals in the Navy Cherry Point Range Complex (hereafter referred to as the Study Area), (2) the review of operational activities that have the potential to incidentally take marine mammals from the Environmental Impact Statement (EIS)/Overseas EIS (OEIS), and (3) a technical risk assessment to determine the likelihood of effects. This chapter describes those activities that are likely to result in Level B harassment (e.g., behavioral effects with temporary threshold shift [TTS] and behavioral effects without TTS) and possible Level A harassment (e.g., mortality or permanent threshold shift [PTS]), under the MMPA of 1972.

An EIS/OEIS is being prepared for the Navy Cherry Point Range Complex to evaluate all components of the proposed activities. A description of each of the training activities for which an incidental take authorization is being requested is provided in the following sections, and represent all training activities conducted in the Navy Cherry Point Range Complex that involve the use of explosive ordnance. This LOA request is based on the proposed activities of the Navy's preferred alternative (Alternative 2 in the EIS/OEIS).

1.1   Surface Warfare (SUW)

Surface Warfare (SUW) supports the defense of a geographical area (e.g., a zone or barrier) in cooperation with surface, subsurface, and air forces. SUW operations detect, localize, and track surface targets, primarily ships. Detected ships are monitored visually and with radar. Operations include identifying surface contacts, engaging with weapons, disengaging, evasion, and avoiding attack, including implementation of radio silence and deceptive measures. For this LOA request, SUW events involving the use of explosive ordnance include air-to-surface Missile Exercises (MISSILEX) that occur at sea.

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MISSILE EXERCISE (AIR-TO-SURFACE) (MISSILEX [A-S])

Air-to-surface missile exercises involve helicopter (AH-1W) crews launching missiles at at-sea surface targets with the goal of destroying or disabling the target. MISSILEX (A-S) training in the Navy Cherry Point Study Area can occur during the day or at night in the locations described in **Chapter 2** (**Figure 1**; **Table 1**):

Table 1   **Summary of MISSILEX (A-S) Typical Parameters**

Operation	Platform	System/Ordnance	Number of Events per year	Potential Time of Day	Typical Duration of Event
Missile Exercise (MISSILEX) (Air-to-Surface)	AH-1W (Helicopter)	AGM-114 (Hellfire; 8-pound [lb] Net Explosive Weight [NEW] High Explosive [HE] rounds[1] and Non-Explosive Practice Munitions [NEPM])	8 sorties (5 HE missiles; 3 NEPM)	Day or Night	
		Tube-launched, Optically tracked, Wire-guided (TOW) Missile (all 15.33 NEW HE rounds)[1]	8 sorties (8 missiles)		

AH-1W with Hellfire and TOW Missiles

One or two helicopters approach and acquire an at-sea surface target, which is then designated with a laser to guide the Hellfire or tube-launched, optically tracked, wire-guided (TOW) missile to the target. The laser designator may be onboard the helicopter firing the missile, another helicopter, or another source. The helicopter launches a missile from an altitude of about 300 feet (ft) at a specially prepared target. The target is a platform (a stationary barge, a remote controlled speed boat, or a jet ski towing a trimaran) that is fitted with a cardboard banner. The missile passes through the banner without damaging the platform, and explodes very near the surface of the water. The platform is recovered and reused, but the banner is destroyed during the explosion and is therefore not recovered. The Net Explosive Weight (NEW) (Trinitrotoluene [TNT] equivalent) of the Hellfire missile is 8 pounds (lb). The NEW of the TOW Missile is 15.33 lb.

1.2 Mine Warfare (MIW)

Mine Warfare (MIW) includes the strategic, operational, and tactical use of mines and mine countermeasures (MCM). MIW is divided into two basic subdivisions: a) the laying of mines to degrade the enemy's capabilities to wage land, air, and maritime warfare, and b) the countering of enemy-laid mines to permit friendly maneuver or use of selected land or sea areas (DoN, 2007d).

MIW consists of two unit level operations: airborne mine countermeasures (AMCM) and mine neutralization. AMCM or Mine Countermeasures Exercises (MCMEX) train forces to detect, identify, classify, mark, avoid, and disable (or verify destruction of) underwater mines (bottom or moored) using a variety of methods including air, surface, sub-surface, and ground assets. The AMCM systems include

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1 Uses stationary or towed surface targets; 1 missile/sortie.

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mine hunting sonar (AQS-24A), influence mine sweeping systems (MK-105 and MK-104), anti-mine ordnance (Airborne Mine Neutralization System [AMNS]), and moored mine sweep system (MK-103).

Mine Neutralization operations involve the detection, identification, evaluation, rendering safe, and disposal of underwater Unexploded Ordnance (UXO) that constitutes a threat to ships or personnel. Mine hunting techniques involve divers, specialized sonar, and unmanned underwater vehicles (UUVs) to locate and classify the mines and then destroy them using one of two methods: mechanical (explosive cutters) or influence (matching the acoustic, magnetic, or pressure signature of the mine).

In addition to the current mine exercises (AMCM), the Organic Airborne Mine Countermeasures (OAMCM) training exercises will begin in the Navy Cherry Point Operating Area (OPAREA) as these new systems are introduced into the fleet. The OAMCM systems include mine hunting sonar (AQS-20), influence mine sweeping towed arrays (Organic Airborne and Surface Influence Sweep [OASIS]) that emulates the magnetic and acoustic signatures of transit platforms, anti-mine ordnance systems (Rapid Airborne Mine Clearance System [RAMICS] and AMNS), and mine hunting laser (Airborne Laser Mine Detection System [ALMDS]) that uses a light imaging detecting and ranging (LIDAR) to detect, localize, and classify near-surface moored/floating mines. Four proposed areas will be designated for training each particular system which would include the following:

- Ordnance – RAMICS (anti-mine): 30-millimeter (mm) armor-piercing flat-nosed projectiles using LIDAR, AMNS (anti-mine): self-contained shape charges, MK-44

MIW training using Explosive Ordnance Disposal (EOD) underwater detonations in the Navy Cherry Point Study Area occur only during daylight hours in the locations described in **Chapter 2** (**Figure 1**; **Table 2**).

MINE NEUTRALIZATION

Table 2   Summary of Mine Neutralization Typical Parameters

Operation	Platform	System/Ordnance	Number of Events per year	Potential Time of Day	Typical Duration of Event
Mine Neutralization	EOD	20-lb NEW charges	20 events[2]	Day	8 hours (hr)

EOD Personnel with Mine Neutralization Charges

EOD personnel detect, identify, evaluate, and neutralize mines. The EOD mission during training is to locate and neutralize mine shapes after they are initially located by another source, such as an MCM or coastal minehunter (MHC) class ship or an MH-53 or MH-60 helicopter. For underwater detonations, EOD divers are deployed from a ship or small boat to practice neutralizing a mine shape underwater. The neutralization exercise in the water is normally done with an explosive charge of 20-lb NEW. The initiation of the charge is controlled remotely by EOD personnel. If the mine shape were an actual mine, it would explode due to the pressure and energy exerted in the water from the smaller EOD explosive charge. This training is conducted only during day light hours in the Navy Cherry Point Study Area.

1.3   Amphibious Warfare (AMW)

Amphibious Warfare (AMW) involves the utilization of naval firepower and logistics in combination with United States Marine Corps (USMC) landing forces to project military power ashore. AMW

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[2] One 20 lb NEW charge/event.

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encompasses a broad spectrum of operations involving maneuver from the sea to objectives ashore, ranging from shore assaults, boat raids, ship-to-shore maneuver, shore bombardment and other naval fire support, and air strike and close air support training. In the Navy Cherry Point Study Area, AMW training is limited to Firing Exercises (FIREX).

FIRING EXERCISE (FIREX) WITH INTEGRATED MARITIME PORTABLE ACOUSTIC SCORING AND SIMULALTION SYSTEM (IMPASS)

During a FIREX, surface ships use their main battery guns to fire from sea at land targets in support of military forces ashore. On the east coast, the land ranges where FIREX training can take place are limited. Therefore, land masses are simulated during east coast FIREX training using the Integrated Maritime Portable Acoustic Scoring and Simulation System (IMPASS), a system of buoys that simulate a land mass. FIREX training using IMPASS in the Navy Cherry Point Study Area occurs only during daylight hours in the locations described in **Chapter 2** (**Figure 1**; **Table 3**):

Table 3   Summary of FIREX with IMPASS Typical Parameters

Operation	Platform	System/Ordnance	Number of Events per year	Potential Time of Day	Typical Duration of Event
FIREX with IMPASS	CG, DDG	5-inch (in.) guns [3](IMPASS)	2 Events (78 HE rounds)	Day	12 hr

FIREX with IMPASS

The IMPASS system is a technology solution the has been developed to precisely determine the impact of rounds fired at a simulated or virtual land area containing virtual targets located in the ocean, which enables ships to complete FIREX training in the absence of a land target or impact area. The IMPASS system uses an onboard computer that provides a realistic presentation to ship personnel, such as a land mass with topography, to the ship's systems. The scoring system is deployed by the firing ship and consists of five sonobuoys set in a pentagon-shaped arrangement at 1.3-kilometer (km) intervals. Within the ship's combat system, the training system creates a virtual land mass that overlays the array and simulates land targets. The ship fires its ordnance into this target area; the sonobuoys detect the bearing to the acoustic noise resulting from the impact of a high explosive or non-explosive round landing in the water, then transmit their Global Positioning System (GPS) position and their bearing information to the ship. From the impact location data collected, the training system computer triangulates the exact point of impact of the round and, from that data, the exercise may be conducted as if the ship were firing at an actual land target. When the training is complete, the IMPASS buoy system is recovered by the ship.

During FIREX training using IMPASS, the ship positions itself about 4 to 6 nautical miles (nm) from the IMPASS buoy target area. One or more High Explosive (HE) rounds are fired at the target to calibrate the system. Then, approximately five explosive and non-explosive rounds are fired in rapid succession (about one round every 5 – 7 seconds [s]). Ten or more minutes will pass, and then similar missions will be conducted until the allocated number of rounds for the exercise has been expended. In total, about 70 rounds of ordnance are expended during a typical exercise, with and average of 39 explosive rounds (NEW 8 lb) and 31 non-explosive rounds being fired for each event. The exercise is

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3 IMPASS events include 39 explosive rounds and 31 non-explosive rounds per event.

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conducted during the day a minimum of 12 nm from shore. A ship will normally conduct three FIREXs at different levels of complexity over several months to become fully qualified.

1.4   Vessel Movement

Vessel movements are associated with most activities under the training operations in the Navy Cherry Point Study Area. Currently, the number of Navy vessels operating in the Navy Cherry Point Study Area varies based on training schedules and can range from 0 to about 10 vessels at any given time. Ship sizes range from 362 ft for a submarine (SSN) to 1,092 ft for an aircraft carrier (CVN) and speeds generally range from 10 to 14 knots (kt). Operations involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to 2 weeks (wk). These operations are widely dispersed throughout the OPAREA, which is a vast area encompassing 18,617 square nautical miles (nm^2) (an area approximately the size of West Virginia). The Navy logs about 950 total vessel days within the Study Area during a typical year. Consequently, the density of ships within the Study Area at any given time is extremely low (i.e., less than 0.005 ships/nm^2).

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CHAPTER 2   DURATION AND LOCATION OF ACTIVITIES

2.1   Description of the Navy Cherry Point Range Complex

The Navy Cherry Point Range Complex geographically encompasses offshore and near-shore OPAREAs, instrumented ranges, and special use airspace (SUA) located along the United States (U.S.) Atlantic coast (**Figure 1**). The geographic scope of this LOA, referred to as the the Study Area, includes the area from the shoreline out to the 3 nm boundary of the OPAREA, as well as the Cherry Point OPAREA. The Study Area does not include the separate and distinct Marine Corp Air Station (MCAS) Cherry Point Range Complex and Marine Corp Base (MCB) Camp Lejeune Range Complex. Together, components of the Navy Cherry Point Range Complex encompass:

- 18,966 nm^2 of special use airspace (warning area);
- 18,617 nm^2 of offshore surface and subsurface OPAREA; and
- 12,529 nm^2 of subsurface area greater than 100 fathoms (600 ft) in depth.

The specific OPAREAs and airspace included in the Navy Cherry Point Range Complex to be addressed in this LOA request are identified in **Table 1**.

2.1.1   Offshore Operating Areas

The Navy Cherry Point OPAREA is a set of operating and maneuver areas with defined ocean surface and subsurface operating areas described in detail in **Table 4** and displayed in **Figure 1**. Navy Cherry Point OPAREA within the Navy Cherry Point Range Complex has an area of 18,617 nm^2 extending from 3 nm to 130 nm from the shoreline at Point Lookout. The OPAREA is subdivided into 23 areas (called a surface grid). These are used by Navy operators to communicate locations in which they will be located or where training will occur. Training in these areas includes surface gunnery, missile firing, mine warfare, and amphibious operations.

The subsurface portion of the Navy Cherry Point OPAREA underlies and is coterminous with the surface portion of the OPAREA and includes 12,529 nm^2 of deep-sea offshore waters, defined as waters in excess of 100 fathoms (600 ft) in depth.

2.1.2   Special Use Airspace (SUA)

Restricted Airspace and Warning Areas are components of SUA and are defined by the Federal Aviation Administration (FAA) as follows (FAA Order 7400.8):

Special Use Airspace: Airspace of defined dimensions identified by an area on the surface of the earth wherein activities must be confined because of their nature and/or wherein limitations may be imposed upon aircraft operations that are not part of those activities.

Restricted Airspace: The flight of aircraft, while not wholly prohibited, is subject to restriction. Restricted Airspace denotes the existence of unusual, often invisible hazards to aircraft (e.g. release of ordnance). No Restricted Airspace in the Navy Cherry Point Range Complex is considered in this LOA.

Warning Areas: A warning area is airspace of defined dimensions, extending from 3 nm outward from the coast of the U.S. that contains activity that may be hazardous to nonparticipating aircraft. The purpose of such warning areas is to warn nonparticipating pilots of the potential danger. A warning area may be located over domestic or international waters or both. The only Warning Area in the Navy Cherry Point Range Complex considered in this LOA is W-122.

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Figure 1   High Explosive Ordnance Areas in the Navy Cherry Point Study Area, Navy Cherry Point Range Complex

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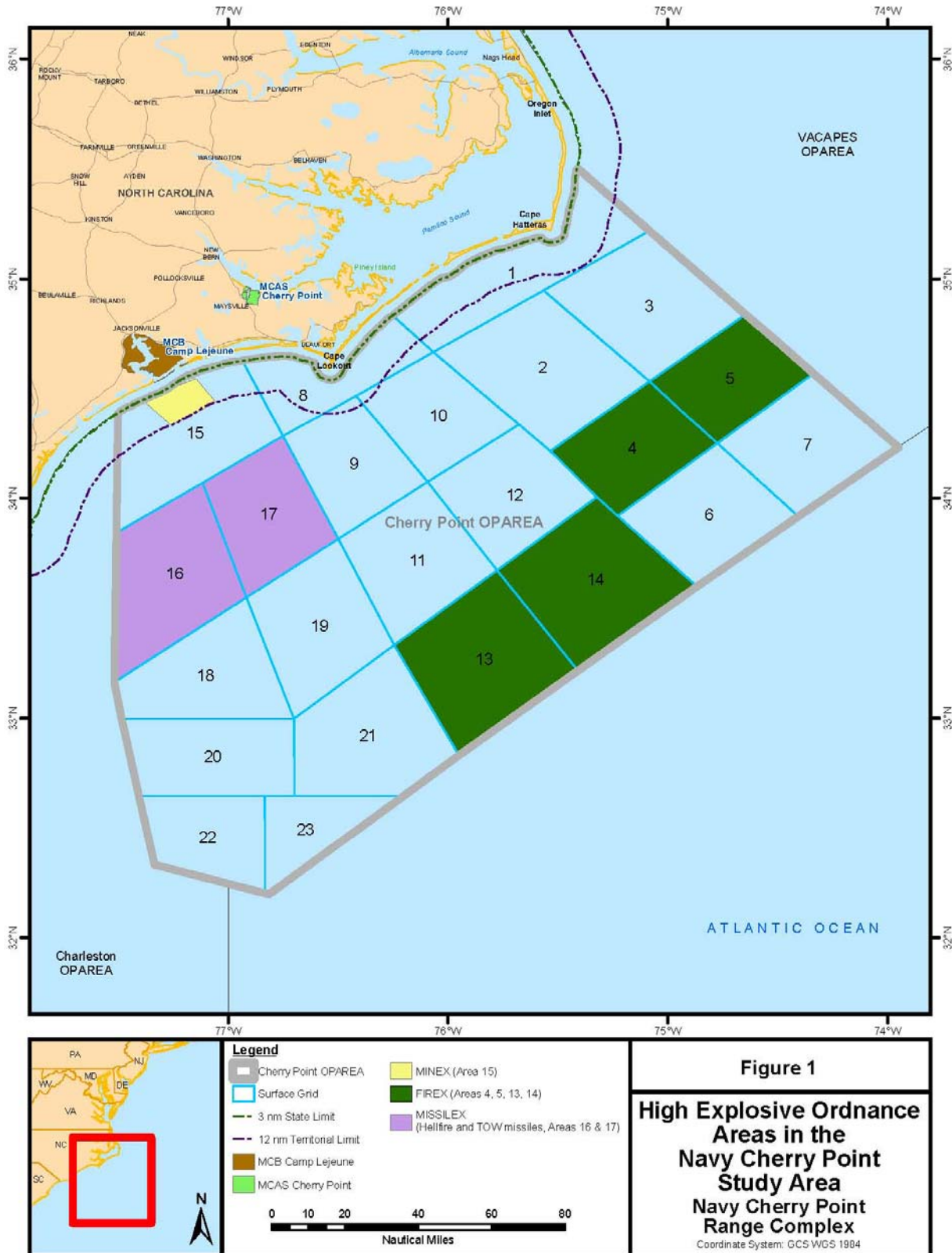
Table 4   Components of Navy Cherry Point Range Complex

Component Area	Description	Addressed in this LOA?
OPAREAs	<u>Navy Cherry Point OPAREA</u>: Offshore surface and subsurface operating area extending 127 nm seaward from the 3 nm state waters boundary and located along the coast of North and South Carolina. Water depth in the OPAREA ranges from approximately 10 to 4,000 meter (m). <u>Submarine Operating Area (SUBOA) Sierra</u>: Submarine operations are normally conducted in the subsurface areas of surface area 20 and 21, which include two submarine transit lanes (Charlie and Delta).	Yes
Special Use Airspace (SUA)	Warning Area (W)–122: Off-shore SUA generally overlying the Navy Cherry Point OPAREA, with dimensions of 185 nm (north-south) and 100 nm (east-west).	Yes
Nearshore Area	Area extending from shore to 3 nm offshore. Amphibious excercises are coducted in the nearshore area of Onslow Bay	Yes
MAEWR Instrumented Range	<u>Mid-Atlantic Electronic Warfare Range (MAEWR):</u> Electronic Warfare Range serving the western portion of Navy Cherry Point OPAREA and W-122, providing electronic threat emissions from 30 threat sites; simulates surface-to-air missiles, anti-aircraft artillery, and RF threats.	No

Warning Area (W)–122 is 18,966 nm^2 of SUA overlaying the Navy Cherry Point OPAREA from the surface to an unlimited altitude. Operations conducted in W-122 include all-weather flight training, refueling, rocket and missile firing, bombing, fleet training, independent unit training, and air warfare, and surface gunnery. Conventional ordnance is permitted.

2.1.3   Nearshore Area (Shoreline to 3 nm)

That portion of the Study Area extending from shore to 3 nm offshore is referred to as the nearshore area. Vessel movements and other activities associated with Marine Corps amphibious exercises will be conducted in the nearshore area within Onslow Bay (**Figure 1**). No exercises involving explosive ordnance will be conducted in the nearshore area.

2.2   Levels and Locations of Explosive Operations

The following tables (**Tables 5** through **8**) summarize operations involving the use of explosive ordnance in the Navy Cherry Point Range Complex. The operations are based on the level of activity proposed in the Navy's preferred alternative (Alternative 2 in the EIS/OEIS). For each warfare area, the type of operation, platform, type of explosive ordnance, number of events per year, and the location of ordnance delivery in the range is described (**Table 5**). The number of each type of explosive ordnance used per year in the study area is summarized in **Table 6**. Eight of the twenty-three surface grid areas within the Navy Cherry Point OPAREA are designated for explosive ordnance use (**Figure 1**).

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Table 5   Operations Involving Explosive Ordnance in the Study Area

Primary Warfare Area	Range Operation	Platform	System or Ordnance	Activity	Location
Mine Warfare[4] (MIW)	Mine Neutralization	EOD	20-lb NEW underwater charge	20 events per year	UNDET Area Onslow Bay
Surface Warfare (SUW)	Missile Exercise (MISSILEX) (Air-to-Surface)	AH-1W	AGM-114 (Hellfire; HE rounds)[5]	8 sorties per year (5 HE missiles; 3 NEPM)	W-122 (Area 16, 17)
			TOW Missile (all HE rounds)[8]	8 sorties per year (8 missiles)	
Amphibious Warfare (AMW)	Firing Exercise (FIREX) Surface-to-Surface with IMPASS	CG, DDG	5-in. guns [6](IMPASS)	2 events per year (140 rounds)	Navy Cherry Point OPAREA (Area 4/5, 13/14)

Table 6   Summary of Explosive Ordnance Use in the Navy Cherry Point Study Area

Potential Stressor and Operational Parameter	HE and Underwater Explosive Use (Number Per Year)
Underwater Explosions/HE Use	
Missiles (USMC)	
Hellfire (A-S)	5
TOW (A-S)	8
5-in. rounds (U.S. Navy [USN])	
Naval gun shells (IMPASS)	78
UNDET Area, Onslow Bay (USN)	
20 lb NEW charges	20
Total =	**119**

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[4] Mine Warfare training would be for ESG major exercises only. During 10 day exercise, four MH-53Es will fly two 3-hr missions/day and three MH-60S would fly three 2-hr missions/day. Temporary moored and bottom mine shapes (non-explosive, instrumented and non-instrumented expendable shapes)

5 Uses stationary or towed surface targets; 1 missile/sortie.

6 IMPASS events include 39 explosive rounds and 31 non-explosive rounds per event.

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Naval gun shells (5-inch [in.] HE and 76-mm rounds) are to be used in areas 4, 5, 13, and 14 (**Table 7**). Hellfire and TOW missile exercises are to be conduced in areas 16 and 17 (**Table 7**). All underwater charges will be detonated in the Underwater Detonation (UNDET) Area in Onslow Bay (**Figure 1**, **Table 7**). An estimated total of 119 explosive ordnance may be released in the Study Area each year, including 78 gun shells, 21 missiles, and 20 underwater explosive charges. The NEW of each type of explosive ordnance used in the Study Area is provided in **Table 8**.

Table 7 **Summary of Explosive Ordnance Use by Training Area in the Navy Cherry Point Study Area**

Training Area and Ordnance Type	Number of Rounds Per Year
Navy Cherry Point OPAREA (Area 4/5 and 13/14)	
Naval gun shells (HE, 5 in. and 76 mm)	78
Navy Cherry Point OPAREA (Area 16,17)	
Missiles, Hellfire (HE), Air to Surface	5
Missiles, TOW (HE), Air to Surface	8
Subtotal =	13
UNDET Area, Onslow Bay	
Underwater explosive charges (HE)	20
Total =	**119**

Table 8 **Summary of the Net Explosive Weight (NEW) of Explosive Ordnance Use in the Study area by Training Area**

Training Area and Ordnance Type	Net Explosive Weight (NEW) Per Single Ordnance (lb)
Navy Cherry Point OPAREA (Area 4/5 and 13/14)	
Naval gun shells (HE, 5 in.)	8.5
Navy Cherry Point OPAREA (Area 16,17)	
Missiles, Hellfire (HE), Air to Surface	8.0
Missiles, TOW (HE), Air to Surface	15.33
UNDET Area, Onslow Bay	
Underwater explosive charges, (HE)	20

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Chapter 3 – Marine Mammal
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CHAPTER 3   MARINE MAMMAL SPECIES AND NUMBERS OCCURRING IN THE NAVY CHERRY POINT STUDY AREA

Table 9 provides a list of marine mammal species that have confirmed or potential occurrence in the Navy Cherry Point Study Area. These include 33 cetacean species, 4 pinniped species, and 1 sirenian species (DoN, 2007b). Although it is possible that 38 species of marine mammals could occur in the Study Area, only 34 of those species are expected to occur regularly in the OPAREA. The remaining species are considered extralimital in the Study Area; indicating there are one or more records of an animal's presence in the Study Area, but it is considered beyond the normal range of the species. Extralimital species will not be analyzed further in this study. Some cetacean species are resident year-round [e.g., bottlenose dolphins (*Tursiops truncatus*) and beaked whales], while others [e.g., North Atlantic right whales (*Eubalaena glacialis*) and humpback whales (*Megaptera novaeangliae*)] occur seasonally as they migrate through the area.

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 OPAREAs. Specifically, the goal of the MRA program is to describe and document the marine resources present in each of the Navy's OPAREAs. The MRA for the Navy Cherry Point OPAREA was recently updated in 2007 (DoN, 2007b).

3.1   Marine Mammal Occurrence

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

The Navy has initiated consultation with NMFS under the Endangered Species Act (ESA) in support of this LOA request.

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Table 9   Marine Mammal Species Found in the Navy Cherry Point Study Area

Family and Scientific Name	Common Name	Federal Status
Order Cetacea		
Suborder Mysticeti (baleen whales)		
Family Balaenidae (right whales)		
Eubalaena glacialis	North Atlantic right whale	ENDANGERED
Family Balaenopteridae (rorquals)		
Megaptera novaeangliae	Humpback whale	ENDANGERED
Balaenoptera acutorostrata	Minke whale	
Balaenoptera brydei	Bryde's whale	
Balaenoptera boreali	Sei whale	ENDANGERED
Balaenoptera physalus	Fin whale	ENDANGERED
Balaenoptera musculus	Blue whale	ENDANGERED
Suborder Odontoceti (toothed whales)		
Family Physeteridae (sperm whale)		
Physeter macrocephalus	Sperm whale	ENDANGERED
Family Kogiidae (pygmy sperm whales)		
Kogia breviceps	Pygmy sperm whale	
Kogia sima	Dwarf sperm whale	
Family Ziphiidae (beaked whales)		
Ziphius cavirostris	Cuvier's beaked whale	
Mesoplodon mirus	True's beaked whale	
Mesoplodon europaeus	Gervais' beaked whale	
Mesoplodon bidens	Sowerby's beaked whale	
Mesoplodon densirostris	Blainville's beaked whale	
Family Delphinidae (dolphins)		
Steno bredanensis	Rough-toothed dolphin	
Tursiops truncatus	Bottlenose dolphin	
Stenella attenuata	Pantropical spotted dolphin	
Stenella frontalis	Atlantic spotted dolphin	
Stenella longirostris	Spinner dolphin	
Stenella clymene	Clymene dolphin	
Stenella coeruleoalba	Striped dolphin	
Delphinus delphus	Common dolphin	
Lagenodelphis hosei	Fraser's dolphin	
Grampus griseus	Risso's dolphin	
Peponocephala electra	Melon-headed whale	
Feresa attenuata	Pygmy killer whale	
Pseudorca crassidens	False killer whale	
Orcinus orca	Killer whale	
Globicephala melas	Long-finned pilot whale	
Globicephala macrorhynchus	Short-finned pilot whale	
Family Phocoenidae (porpoises)		
Phocoena phocoena	Harbor porpoise	
Order Carnivora		
Suborder Pinnipedia (seals, sea lions, walruses)		
Family Phocidae (true seals)		
Phoca vitulina	Harbor seal	
Order Sirenia		
Family Trichechidae (manatees)		
Trichechus manatus	West Indian manatee	ENDANGERED

Source: DoN, 2007b

3.2   Estimated Marine Mammal Densies

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

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

Model-Derived Density Estimates

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

SAR or Literature-Derived Density Estimates

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

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Species for Which Density Estimates Are Not Available[3]

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

[1] Abundance estimates were geographically and seasonally partitioned
[2] Abundance estimates were uniformly distributed geographically and seasonally
    Source: DoN (2007a)
[3] See DON, 2007a for additional discussion. For these species a qualitiative analysis was used for assessment purposes.

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

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

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CHAPTER 4   AFFECTED SPECIES STATUS AND DISTRIBUTION

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

Cetacean movements can also reflect the distribution and abundance of prey (Gaskin, 1982; Payne *et al.*, 1986; Kenney *et al.*, 1996). Cetacean movements have been linked to indirect indicators of prey, such as temperature variations, sea-surface chl *a* concentrations, and features such as bottom depth (Fiedler, 2002). Oceanographic features, such as eddies associated with the Gulf Stream, are important factors determining cetacean distribution since species that cetaceans prey on are attracted to the increased primary productivity associated with some of these features (Biggs *et al.*, 2000; Wormuth *et al.*, 2000; Davis *et al.*, 2002). The warm Gulf Stream moves rapidly through the Florida Straits and extends northeast along the continental shelf. This current is the single most-influential oceanographic feature of the region and influences water temperature, salinity, and nutrient availability. These factors, in turn, are important in regulating primary productivity associated with phytoplankton growth in the region and the subsequent secondary productivity of zooplankton and other animal life that provide prey for marine mammals.

There is also an association between cetaceans and cold-core and warm-core rings (Griffin, 1999; Biggs *et al.*, 2000; Waring *et al.*, 2001). Both ring types are eddies that detach from the Gulf Stream; it is possible to find either near the Navy Cherry Point OPAREA, increasing the likelihood of higher cetacean presence for the duration of these mesoscale hydrographic features. It is likely that the upwelling associated with cold-core rings permits greater feeding efficiency by cetaceans on mesopelagic squids and fishes.

Along the Virginia and North Carolina shoreline, upwelling and downwelling events are not limited to Gulf Stream or deep-sea canyon geography. Wind patterns and outflow from the Chesapeake Bay cause upwelling and downwelling features along the continental shelf on a regular basis (Cudaback and Largier, 2001), potentially increasing regional productivity and thereby enhancing local cetacean abundance.

Disturbances, such as hurricanes, atmospheric frontal systems, and shifts in current patterns can also increase the before-mentioned oceanographic conditions to enhance local productivity. For example, increased sediment and nutrient loads are present in freshwater systems following heavy and prolonged rainfall, similarly enhancing primary productivity along the continental shelf near the system's effluence.

Waters off North Carolina have the greatest cetacean diversity along the eastern seaboard (Webster *et al.*, 1995). Cape Hatteras is generally considered to be a boundary between temperate and tropical species in the western North Atlantic and an area of overlap for many marine species (Ekman, 1953; Briggs, 1974; Garrison *et al.*, 2003a). Many marine mammals along North Carolina waters are year-round residents, but others migrate into inshore waters during summer/fall and winter/spring months (Webster *et al.*, 1995).

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4.1   Threatened or Endangered Marine Mammal Species

As identified in **Table 9**, seven marine mammal species listed as endangered under the ESA may occur in the study Area. These mammals include five baleen whale species (blue, fin, humpback, North Atlantic right, and sei), one toothed whale species (sperm whale), and one sirenian species (West Indian manatee). Status, habitat, and distribution of each species are provided below.

4.1.1   Blue Whale

Blue whales are the largest living animals. Adult blue whales in the northern hemisphere reach 22.9 to 28 meters (m) in length (Jefferson *et al.*, 1993). Blue whales feed primarily on euphausiids (krill) (Kenney *et al.*, 1985; Nemoto and Kawamura, 1977). Like other rorquals, blue whales feed by "gulping" (Pivorunas, 1979).

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

Habitat—Blue whales inhabit both coastal and oceanic waters in temperate and tropical areas (Yochem and Leatherwood, 1985). Stranding and sighting data suggest the possibility of blue whale occurrence in the Atlantic extended south to Florida and the Gulf of Mexico, however the southern limit of this species' range is unknown (Yochem and Leatherwood, 1985). Blue whales in the Atlantic are primarily found in deeper, offshore waters and are rare in shallower, shelf waters (Wenzel *et al.*, 1988). However, in the Gulf of St. Lawrence, blue whales show strong preferences for the nearshore regions where strong tidal and current mixing leads to high productivity and rich prey resources (Sears *et al.*, 1990). Important foraging areas for this species include the edges of continental shelves and upwelling regions (Reilly and Thayer, 1990; Schoenherr, 1991). Based on acoustic and tagging data from the North Pacific, relatively cold, productive waters and fronts attract feeding blue whales (Moore *et al.*, 2002). Clark and Gagnon (2004) determined that vocalizing blue whales show strong preferences, even during summer months, for shelf breaks, seamounts, or other areas where food resources are known to occur.

Distribution—Blue whales are distributed from the ice edge to the tropics and subtropics in both hemispheres (Jefferson *et al.*, 1993). Stranding and sighting data suggest blue whale occurrence in the Atlantic extended south to Florida and the Gulf of Mexico, however the southern limit of this species' range is unknown (Yochem and Leatherwood, 1985). Blue whales now rarely occur in the U.S. Atlantic EEZ and the Gulf of Maine from August to October, which may represent the limits of their feeding range (CETAP, 1982; Wenzel *et al.*, 1988). 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 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).

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

Navy Cherry Point OPAREA blue whale occurrence—The majority of western North Atlantic blue whale observations during the spring, summer, and fall take place around Newfoundland, the Gulf of St.

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Lawrence, and Nova Scotia (CETAP, 1982; Wenzel *et al.*, 1988; Sears *et al.*, 1990). The southern extent of its feeding range may be somewhere near 40 degrees (°) North (N) latitude and records suggest occurrence of this species south to Florida and in the Gulf of Mexico. The information above suggests the blue whale is less likely to be present during summer months, but may occur any time of the year.

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 Study Area is unknown, but believed to be extremely low.

Navy Cherry Point OPAREA blue whale density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

4.1.2   Fin Whale

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

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

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

Distribution—Fin whales are broadly distributed throughout the world's oceans, including temperate, tropical, and polar regions (Jefferson *et al.*, 2008). The overall range of fin whales in the North Atlantic extends from the Gulf of Mexico/Caribbean and Mediterranean north to Greenland, Iceland, and Norway (Gambell, 1985; 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 U.S. to eastern Canada (CETAP, 1982; Hain *et al.*, 1992).

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

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fin whale habitat included the mid- to outer shelf from the northeast area of Georges Bank through the mid-Atlantic Bight.

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

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

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

Navy Cherry Point OPAREA fin whale occurrence—Fin whales are more commonly encountered north of Cape Hatteras (CETAP, 1982; Hain *et al.*, 1992; Waring *et al.*, 2008). Fin whales are the most commonly sighted large whale during the winter in the U.S. Atlantic continental shelf waters. As much as a quarter of the spring/summer peak population stay in continental shelf waters year-round (CETAP, 1982). During the spring, summer, and fall, fin whales occur along the Atlantic coasts of the U.S. and Canada, with smaller numbers of animals remaining through the winter. Sightings are almost exclusively limited to continental shelf waters inshore of the 1829 m (6000 ft) curve, from the Gulf of Maine south to Cape Hatteras (CETAP, 1982; Agler *et al.*, 1993). The greatest abundance and widest occupation of fin whales in the northeast U.S. has been shown to occur in the spring (Hain *et al.*, 1985). During the winter, the fin whale may occur in the entire OPAREA. During the spring and fall, they should occur north of the OPAREA; however individual whales may occur within the study area itself. During summer, it is expected that fin whales would be on their feeding grounds further north off the northeastern U.S. coast.

Navy Cherry Point OPAREA fin whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 10**. Methods and results are detailed in the NODE Report (DoN, 2007a). The Navy does not consider estimates of zero density to mean that this species does not occur in the area only that they generally occur in low numbers or infrequently based on the best available data. It may be reasonable to assume that a number of the sightings were recorded as unidentified rorquals might be of fin whales.

Table 10   Seasonal Density Estimates for the Fin Whale in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals per square kilometer [km^2])			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.00000	0.00000	0.00000	0.00000
13 & 14	0.00000	0.00000	0.00000	0.00000
16 & 17	0.00000	0.00000	0.00000	0.00000
UNDET	0.00000	0.00000	0.00000	0.00000

Source: DoN, 2007a

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4.1.3   Humpback Whale

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

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

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

Distribution—Humpback whales are globally distributed in all major oceans and most seas. They are generally found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep water during migration (Clapham and Mattila, 1990; Calambokidis *et al.*, 2001).

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

There has been an increasing occurrence of humpbacks, which appear to be primarily juveniles, during the winter along the U.S. Atlantic coast from Florida north to Virginia (Clapham *et al.*, 1993; Swingle *et al.*, 1993; Wiley *et al.*, 1995; Laerm *et al.*, 1997). It was recently 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).

Navy Cherry Point OPAREA humpback whale occurrence—Humpback whales may occur on the continental shelf and in deep waters of the Navy Cherry Point OPAREA in fall, winter, and spring during migrations between calving grounds in the Caribbean and feeding grounds off the northeastern U.S. The greater number of humpback whales observed in this region in the winter may represent whales that have chosen to stay in higher latitudes rather than migrating south to the breeding grounds (Barco *et al.*, 2002). The concentration of whales here also supports the notion of the mid-Atlantic

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region as a supplemental winter feeding ground for humpbacks (Barco *et al.*, 2002). During the summer, humpback whales are generally found farther north at the feeding grounds.

Navy Cherry Point OPAREA humpback whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 11**. Methods and results are detailed in the NODE Report (DoN, 2007a). Density estimates for the OPAREA reflect the migration patterns of the humpback whale with higher density predicted during spring and fall migration, lower densities during the winter when animals should be largely in calving grounds farther south, and zero density during the summer season when humpbacks should be on feeding grounds to the north.

Table 11   Seasonal Density Estimates for the Humpback Whale in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.00058	0.00116	0.00000	0.00116
13 & 14	0.00058	0.00116	0.00000	0.00116
16 & 17	0.00058	0.00116	0.00000	0.00116
UNDET	0.00058	0.00116	0.00000	0.00116

Source: DoN, 2007a

4.1.4   North Atlantic Right Whale

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

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

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

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

The North Atlantic right whale is under the jurisdiction of the NMFS. One calving and two feeding areas in U.S. waters are designated as critical habitat for the North Atlantic right whale (NMFS, 1994; NMFS, 2005a).

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

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

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

Habitat—North Atlantic right whales on the winter calving grounds are most often found in very shallow, nearshore waters in cooler sea surface temperatures inshore of a mid-shelf front (Kraus *et al.*, 1993; Ward, 1999). High whale densities can extend more northerly than the current defined boundary of the calving critical habitat in response to interannual variability in regional sea surface temperature distribution (Garrison *et al.*, 2005; Glass *et al.*, 2005). Warm Gulf Stream waters appear to represent a thermal limit (both southward and eastward) for right whales (Keller *et al.*, 2006).

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

Distribution—Right whales occur in sub-polar to temperate waters. The North Atlantic 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 (NMFS, 2006c; Reeves *et al.*, 2007). North Atlantic right whales are found primarily in continental shelf waters between Florida and Nova Scotia. Most sightings are concentrated within five high-use areas: coastal waters of the southeastern U.S. (Georgia and Florida), Cape Cod and Massachusetts bays, the Great South Channel, the Bay of Fundy, and the Nova Scotian Shelf (Winn *et al.*, 1986; NMFS, 2005a). Of these, one calving and two feeding areas in U.S. waters are designated as critical habitat for North Atlantic right whales under the ESA (NMFS, 1994; NMFS, 2005b; **Figure 2**). The critical habitat designated waters off Georgia and northern Florida are the only known calving ground for western North Atlantic right whales, with use concentrated in the winter (as early as November and through March) (Winn *et al.*, 1986). The feeding grounds of Cape Cod Bay, which have individuals in February through April (Winn *et al.*, 1986; Hamilton and Mayo, 1990), and the Great South Channel east of Cape Cod, with use in April through June (Winn *et al.*, 1986; Kenney *et al.*, 1995), have also been designated as critical habitat for the North Atlantic right whale (**Figure 2**).

Most North Atlantic right whale sightings follow a well-defined seasonal migratory pattern through several consistently utilized habitats (Winn *et al.*, 1986). It should be noted, however, that some individuals may be sighted in these habitats outside the typical time of year and that migration routes are poorly known (there may be a regular offshore component).

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

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Figure 2   Designated critical habitats, conservation areas, and mandatory ship reporting zones for North Atlantic right whales.
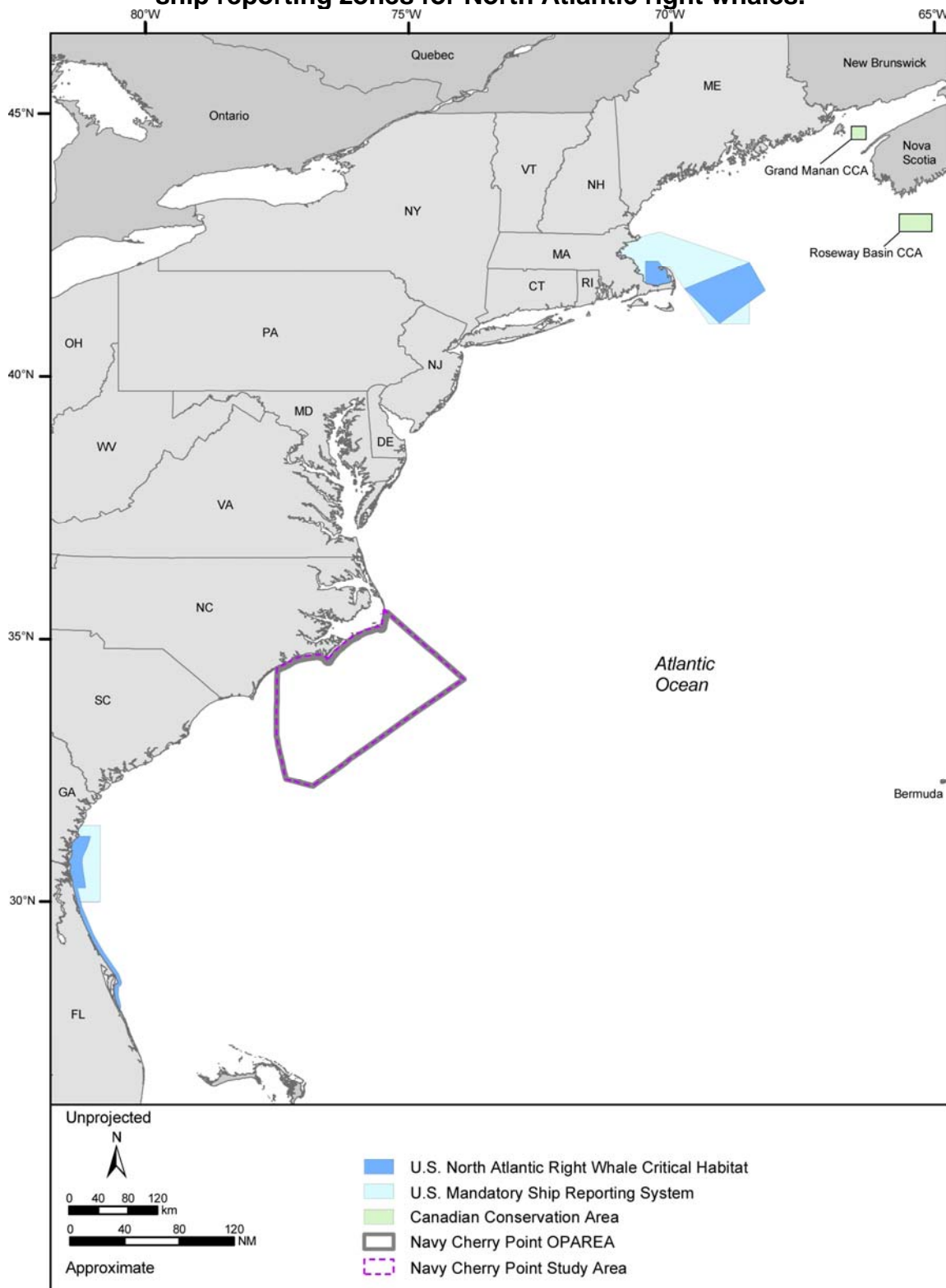
Source information: NMFS (1994), USCG (1999), and DFO (2003).

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Navy Cherry Point OPAREA North Atlantic right whale occurrence—North Atlantic right whales may occur inshore of the shelf break throughout this area. As noted by Gaskin (1982), North Atlantic right whales might be seen anywhere off the Atlantic U.S. throughout the year. The coastal waters of the Carolinas are part of a migratory corridor for the right whale (Winn *et al.*, 1986; Knowlton *et al.*, 2002). North Atlantic right whale sightings in very deep offshore waters of the western North Atlantic are infrequent (Knowlton *et al.*, 2002); however, there is limited evidence suggesting that a regular offshore component exists to their distributional and migratory cycle. This evidence includes a rare occurrence at Bermuda; off-shelf excursions by satellite-tracked individuals (Mate *et al.*, 1997); disappearance of right whales from most coastal habitats in winter; genetic and sighting data, indicating there are additional summer grounds; and right whale individuals sighted past the continental shelf break off Florida. There have also been opportunistic sightings of North Atlantic right whales in deep waters of the Navy Cherry Point OPAREA (DoN, 2007b). During the winter (as early as November and through March), North Atlantic right whales may be found in coastal waters off North Carolina, Georgia, and northern Florida (Winn *et al.*, 1986). Sightings observed during spring and fall months are likely of right whales transiting the area on their migrations to and from breeding grounds farther south or feeding grounds farther north. North Atlantic right whales should occur farther north on their feeding grounds during summer and are not likely to occur in the Navy Cherry Point OPAREA.

Navy Cherry Point OPAREA North Atlantic right whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 12**. Methods and results are detailed in the NODE Report (DoN, 2007a). The low density estimates, which likely reflect the low number of animals, do not signify there will be no animals in those areas. Although rare, North Atlantic right whales may occur in any warning area at any given time. Similarly, the summer estimates reflect right whale migration patterns since animals are likely to be on northern feeding grounds in this season; however, North Atlantic right whales may occur any where in the U.S. Atlantic throughout the year (Gaskin, 1982).

Table 12   Seasonal Density Estimates for the North Atlantic Right Whale in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.00000	0.00000	0.00000	0.00000
13 & 14	0.00000	0.00000	0.00000	0.00000
16 & 17	0.00027	0.00015	0.00000	0.00006
UNDET	0.00040	0.00023	0.00000	0.00011

Source: DoN, 2007a

4.1.5   Sei Whale

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

Status and Management—The International Whaling Commission (IWC) recognizes three sei whale stocks in the North Atlantic: Nova Scotia, Iceland-Denmark Strait, and Northeast Atlantic (Perry *et al.*, 1999). The Nova Scotia Stock occurs in U.S. Atlantic waters (Waring *et al.*, 2008). The best abundance estimate for sei whales in the western North Atlantic is 207; however this is considered conservative due to uncertainties in population movements and structure (Waring *et al.*, 2008). The sei whale is under the jurisdiction of the NMFS. A draft recovery plan for fin and sei whales was released in 1998 (NMFS,

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1998b). It has since been determined that the two species should have separate recovery plans. The independent recovery plan for the sei whale has not yet been issued; however, the species is listed as endangered under the ESA.

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

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

In the western North Atlantic Ocean, 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).

Navy Cherry Point OPAREA sei whale occurrence—Winter range of most rorquals (blue, fin, sei, and minke whales) is hypothesized to be in offshore waters (Kellogg, 1928; Gaskin, 1982). Based on their preference for deep, oceanic waters, rare occurrences of the sei whale may occur in deep waters of the Navy Cherry Point OPAREA during fall, winter, and spring. Sei whale occurrence is most likely during winter and spring (Janurary through April); however they may occur outside of this time frame due to individual whales migrating earlier or later in the year (and appearing in a different season). Sei whales are not likely to occur in the Navy Cherry Point OPAREA during summer, since they should be on feeding grounds around the eastern Scotian Shelf or Grand Banks.

Navy Cherry Point OPAREA sei whale density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a). Lack of sighting data for density estimates is not indicative of the absence of sei whales as they are difficult to distinguish from other rorquals at sea.

4.1.6   Sperm Whale

The sperm whale is the largest toothed whale species. Adult females can reach 12 m in length, while adult males measure as much as 18 m in length (Jefferson *et al.*, 1993). Sperm whales prey on large mesopelagic squids and other cephalopods, as well as demersal fishes and benthic invertebrates (Fiscus and Rice, 1974; Rice, 1989; Clarke, 1996).

Status and Management—Sperm whales are classified as endangered under the ESA (NMFS, 2006d), although they are globally not in any immediate danger of extinction. The current combined best

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estimate of sperm whale abundance from Florida to the Bay of Fundy in the western North Atlantic Ocean is 4,804 individuals (Waring *et al.*, 2008). Stock structure for sperm whales in the North Atlantic is unknown (Dufault *et al.*, 1999). The sperm whale is under the jurisdiction of the NMFS. The draft recovery plan for the sperm whale was released in June 2006 for public comment (NMFS, 2006d). In January 2007, NMFS initiated a 5-yr review for the sperm whale under the ESA (NMFS, 2007a).

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

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

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

Distribution—Sperm whales are found from tropical to polar waters in all oceans of the world between approximately 70ºN and 70º South (S) (Rice, 1998). Females are normally restricted to areas with SSTs 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).

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

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

Navy Cherry Point OPAREA sperm whale occurrence—Worldwide, sperm whales exhibit a strong affinity for deep waters beyond the continental shelf break (Rice, 1989). Sighting data from the Navy Cherry Point Study Area and vicinity are consistent with this known habitat preference (DoN, 2007b). Few sightings occur south of Cape Hatteras, but this is likely a result of the lack of survey effort. Strandings are scattered from North Carolina to Florida (Leatherwood *et al.*, 1976; Schmidly, 1981). Sperm whales may occur seaward of the shelf break throughout the Navy Cherry Point OPAREA in all seasons.

Navy Cherry Point OPAREA sperm whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 13**. Methods and results are detailed in the NODE Report (DoN, 2007a). Density is not expected to be uniform across the warning area. Sperm whales will likely be concentrated in waters near and seaward of the shelf break based on habitat preferences. The higher density estimated for summer likely reflects greater survey effort in offshore areas during the summer as compared to other seasons. Occurrence is anticipated to be the same across all seasons.

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Table 13   Seasonal Density Estimates for the Sperm Whale in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.00051	0.00051	0.00134	0.00051
13 & 14	0.00015	0.00015	0.00025	0.00015
16 & 17	<0.00001	<0.00001	<0.00001	<0.00001
UNDET	0.00000	0.00000	0.00000	0.00000

Source: DoN, 2007a

4.1.7   West Indian Manatee

The West Indian manatee (*Trichechus manatus*) is a rotund, slow-moving animal, which reaches a maximum length of 3.9 m (Jefferson *et al.,* 1993). They have an unusually low metabolic rate and a high thermal conductance that leads to energetic stress in winter (Bossart *et al.,* 2002). Manatees are herbivores that feed on a wide variety of submerged, floating, and emergent vegetation, but they also ingest invertebrates (USFWS, 2001; Courbis and Worthy, 2003; Reich and Worthy, 2006).

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

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

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

Distribution—Manatees occur in warm, subtropical, and tropical waters of the western North Atlantic Ocean, from the southeastern U.S. to Central America, northern South America, and the West Indies (Lefebvre *et al.,* 2001). Manatees occur along both the Atlantic and Gulf coasts of Florida. Manatees are sometimes reported in the Florida Keys; these sightings are typically in the upper Florida Keys, with

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some reports as far south as Key West (Moore, 1951a, 1951b; Beck, 2006a). During winter months, the 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) as far north as the Florida/Georgia border along the U.S. east coast. As water temperatures rise in spring, West Indian manatees disperse from winter aggregation areas. Manatees are frequently reported in coastal rivers of Georgia and South Carolina during warmer months (Lefebvre *et al.,* 2001).

Historically, 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, 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).

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 seen in 1996. In early September 2001, "Chessie" was once again sighted in Virginia. More recently, in August 2006, a West Indian manatee was sighted in waters off Rhode Island, Delaware, New Jersey, Massachusetts, and in the Hudson River (Beck, 2006b; Anonymous, 2006, Kenney, 2007)

Navy Cherry Point OPAREA manatee occurrence—West Indian manatees have been sighted in estuarine and coastal waters of North Carolina during all seasons, with summer and fall having the most reports (Schwartz, 1995). It is possible that West Indian manatees may be expanding their range into North Carolina waters (Schwartz, 1995). Based on their known habitat preferences, manatees may occur throughout the freshwater, estuarine, and nearshore coastal waters near the Navy Cherry Point OPAREA year-round.

Navy Cherry Point OPAREA manatee density—Sufficient data do not exist to calculate density estimates, nor was there an estimate in the published literature.

4.2   Non-Threatened or Endangered Marine Mammal Species

Twenty-six non-threatened/non-endangered marine mammal species may be affected by the proposed activities in the Navy Cherry Point Study Area. These include two baleen species and 24 toothed whale species.

4.2.1   Atlantic Spotted Dolphin

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

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

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boundary corresponding roughly to Cape Hatteras (Adams and Rosel, 2006). The Atlantic spotted dolphin is under the jurisdiction of NMFS.

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

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

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

Navy Cherry Point OPAREA Atlantic spotted dolphin occurrence—Atlantic spotted dolphins may occur in both continental shelf and offshore waters of the OPAREA year-round. Sightings are scattered throughout the Navy Cherry Point OPAREA and range from shallow, coastal waters to deep waters over the abyssal plain (DoN, 2007b). The Gulf Stream and its associated warm-core ring features likely influence occurrence of Atlantic spotted dolphins in this region.

Navy Cherry Point OPAREA Atlantic spotted dolphin density—The density estimates for training areas where explosive ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 14**. Methods and results are detailed in the NODE Report (DoN, 2007a).

Table 14   Seasonal Density for Atlantic Spotted Dolphin in the Navy Cherry Point Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** Sep, Oct, Nov)
4 & 5	0.00682	0.00682	0.00682	0.00682
13 & 14	0.00354	0.00354	0.00354	0.00354
16 & 17	0.14257	0.14257	0.14257	0.14257
UNDET	0.06628	0.06628	0.06628	0.06628

Source: DoN, 2007a

4.2.2   Beaked Whales

Based upon available data, the following five beaked whale species may be affected by the proposed activities in the Navy Cherry Point Study Area: Cuvier's beaked whales and four members of the genus *Mesoplodon* (True's, Gervais', Blainville's, and Sowerby's beaked whales). As noted earlier, northern bottlenose whales are extralimital to the Navy Cherry Point Study Area and are not likely to be affected by the proposed activities.

Cuvier's beaked whales are relatively robust compared to other beaked whale species. Male and female Cuvier's beaked whales may reach 7.5 and 7.0 m in length, respectively (Jefferson *et al.* 1993). *Mesoplodon* species have maximum reported adult lengths of 6.2 m (Mead 1989). Stomach content analyses of captured and stranded individuals suggest beaked whales are deep divers that feed by

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suction on mesopelagic fishes, squids, and deepwater benthic invertebrates (Heyning 1989; Heyning and Mead 1996; Santos *et al.* 2001; MacLeod *et al.* 2003). Stomach contents of Cuvier's beaked whales rarely contain fishes, while stomach contents of *Mesoplodon* species frequently do (MacLeod *et al.* 2003).

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

Habitat—World-wide, beaked whales normally inhabit continental slope and deep oceanic waters (>200 m) (Waring *et al.*, 2001; Cañadas *et al.*, 2002; Pitman, 2002; MacLeod *et al.*, 2004; Ferguson *et al.*, 2006; MacLeod and Mitchell, 2006). Beaked whales are only occasionally reported in waters over the continental shelf (Pitman, 2002). Distribution of *Mesoplodon* spp. in the North Atlantic may relate to water temperature (MacLeod, 2000a). The Blainville's and Gervais' beaked whales occur in warmer southern waters, in contrast to Sowerby's and True's beaked whales that are more northern (MacLeod, 2000b). Beaked whale abundance off the eastern U.S. may be highest in association with the Gulf Stream and the warm-core rings it develops (Waring *et al.*, 1992). In summer, the continental shelf break off the northeastern U.S. is primary habitat (Waring *et al.*, 2001).

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

The continental shelf margins from Cape Hatteras to southern Nova Scotia were recently identified as known "key areas" for beaked whales in a global review by MacLeod and Mitchell (2006).

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

Navy Cherry Point OPAREA beaked whale occurrence—Cuvier's, True's, Gervais', Sowerby's and Blainville's beaked whales may occur seaward of the continental shelf break throughout the Navy Cherry Point Study Area year-round. Beaked whale sightings in the western North Atlantic Ocean appear to be concentrated in waters between the 200 m isobath and those just beyond the 2,000-m isobath (DoN, 2007b; DoN, 2007c).

Navy Cherry Point OPAREA beaked whale density—**Table 15** below displays the densities for beaked whales in the Navy Cherry Point OPAREA. Occurrence of beaked whales is anticipated to be the same throughout all seasons. The increased density estimate for summer may reflect the higher survey effort during that season. Methods and results are detailed in the NODE Report (DoN, 2007a).

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Table 15   Seasonal Density Estimates for Beaked Whale in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** Sep, Oct, Nov)
4 & 5	0.00013	0.00013	0.00065	0.00013
13 & 14	0.00019	0.00019	0.00039	0.00019
16 & 17	< 0.00001	< 0.00001	< 0.00001	< 0.00001
UNDET	0.00000	0.00000	0.00000	0.00000

Source: DoN, 2007a

4.2.3   Bottlenose Dolphin

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

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

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

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

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

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

Distribution—In the western North Atlantic, bottlenose dolphins occur as far north as Nova Scotia but are most common in coastal waters from New England to Florida, the Gulf of Mexico, the Caribbean,

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and southward to Venezuela and Brazil (Würsig *et al.*, 2000). Bottlenose dolphins occur seasonally in estuaries and coastal embayments as far north as Delaware Bay (Kenney, 1990) and in waters over the outer continental shelf and inner slope, as far north as Georges Bank (CETAP, 1982; Kenney, 1990).

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

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

Coastal bottlenose dolphins along the western Atlantic coast may exhibit either resident or migratory patterns (Waring et.al. 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). Migratory dolphins may enter these areas seasonally as well, as evidenced by a bottlenose dolphin tagged in 2001 in Virginia Beach who overwintered in waters between Cape Hatteras and Cape Lookout (NMFS-SEFSC, 2001).

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

Navy Cherry Point OPAREA bottlenose dolphin occurrence—Bottlenose dolphins are abundant in continental shelf and inner slope waters throughout the western North Atlantic (CETAP, 1982; Kenney, 1990; Waring *et al.*, 2007). The greatest concentrations of offshore animals are along the continental shelf break and between the 200 and 2,000 m isobaths (Kenney, 1990; Waring *et al.*, 2007); however, tagging data suggest that the range of offshore bottlenose dolphins may actually extend into deeper waters (Wells *et al.*, 1999), possibly even over the Hatteras Abyssal Plain just southeast of the Navy Cherry Point OPAREA. Bottlenose dolphins also occur in nearshore waters of North Carolina year-round and in Virginia waters seasonally from late April to November (Blaylock, 1988; Barco *et al.*, 1999; NMFS-SEFSC, 2001). Therefore, bottlenose dolphins may occur throughout the Navy Cherry Point Study Area year-round.

Navy Cherry Point OPAREA bottlenose dolphin density—**Table 16** below provides the density estimates for bottlenose dolphins in the Navy Cherry Point Study Area. Methods and results are detailed in the NODE Report (DoN, 2007a).

Table 16   **Seasonal Density Estimates for Bottlenose Dolphin in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs**

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** Sep, Oct, Nov)
4 & 5	0.00013	0.00013	0.00003	0.00013
13 & 14	0.00494	0.00494	0.00678	0.00494
16 & 17	0.02342	0.02342	0.03410	0.02342
UNDET	0.02826	0.02826	0.07081	0.02826

Source: DoN, 2007a

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4.2.4   Bryde's Whale

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

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

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

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

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

Navy Cherry Point OPAREA Bryde's whale occurrence—There is a general lack of knowledge of this species, particularly in the North Atlantic, although records support a tropical occurrence for the species here (Mead, 1977). One Bryde's whale stranding is recorded from the winter of 1927 well within Chesapeake Bay (Mead, 1977). A few unidentified Bryde's/sei whale records are also documented near the shelf break off the coast of Virginia (DoN, 1995). This species has been known to strand further south on the coasts of Georgia and eastern Florida (Schmidly, 1981). Bryde's whales may occur seaward of the shoreline in the Study Area year-round based on occurrences both in coastal and offshore waters in other locales, but occurrence is not likely this far north.

Navy Cherry Point OPAREA Bryde's whale density—There were not sufficient data available to estimate a density for the Study Area nor is there an abundance estimate in the NOAA SAR (DoN, 2007a). Lack of sighting data for density estimates is not indicative of the absence of Bryde's whales as they are difficult to distinguish from other rorquals at sea.

4.2.5   Clymene Dolphin

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

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

Habitat—Clymene dolphins are a tropical to subtropical species, primarily sighted in deep waters well beyond the edge of the continental shelf (Fertl *et al.*, 2003). Biogeographically, the Clymene dolphin is found in the warmer waters of the North Atlantic and is often associated with the North Equatorial Current, the Gulf Stream, and the Canary Current (Fertl *et al.*, 2003). In the western North Atlantic, Clymene dolphins were identified primarily in offshore waters east of Cape Hatteras over the

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continental slope and are likely to be strongly influenced by oceanographic features of the Gulf Stream (Mullin and Fulling, 2003).

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

Seasonality and location of Clymene dolphin breeding is unknown.

Navy Cherry Point OPAREA Clymene dolphin occurrence—Sightings are recorded in offshore waters in or near the Navy Cherry Point OPAREA (DoN, 2007b). The oceanographic features of the Gulf Stream likely influence the distribution of Clymene dolphins in this area. Based on confirmed sightings and the preference of this species for deep waters, Clymene dolphins may occur in waters seaward of the shelf break throughout the Navy Cherry Point Study Area.

Navy Cherry Point OPAREA Clymene dolphin density—**Table 17** below provides density estimates for Clymene dolphins in the Navy Cherry Point Study Area. Methods and results are detailed in the NODE Report (DoN, 2007a). Density is not expected to be uniform across the warning areas. Clymene dolphins will likely be concentrated in deeper waters seaward of the shelf break and/or near the Gulf Stream based on habitat preferences.

Table 17 Seasonal Density Estimates for Clymene Dolphin in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
4 & 5	0.01063	0.01063	0.01063	0.01063
13 & 14	0.01063	0.01063	0.01063	0.01063
16 & 17	0.01063	0.01063	0.01063	0.01063
UNDET	0.01063	0.01063	0.01063	0.01063

Source: DoN, 2007a

4.2.6 Common Dolphin

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

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

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

Distribution—Common dolphins occur from southern Norway to West Africa in the eastern Atlantic and from Newfoundland to Florida in the western Atlantic (Perrin, 2002a), although this species more commonly occurs in temperate, cooler waters in the northwestern Atlantic (Waring and Palka, 2002).

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This species is abundant within a broad band paralleling the continental slope from 35ºN to the northeast peak of Georges Bank (Selzer and Payne, 1988). Short-beaked common dolphin sightings are known to occur along the continental shelf break south of 40ºN in spring and north of this latitude in fall. Throughout all seasons common dolphins occur along the shelf edge in a wide band, with occurrence extending onto the shelf (CETAP, 1982). During fall, this species is particularly abundant along the northern edge of Georges Bank (CETAP, 1982). The common dolphin is less abundant south of Cape Hatteras (Waring *et al.*, 2007).

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

Navy Cherry Point OPAREA common dolphin occurrence—Common dolphins primarily occur in a broad band along the shelf break from Cape Hatteras to Nova Scotia year-round (CETAP, 1982). This species is less common south of Cape Hatteras (Waring *et al.*, 2008). Common dolphins are only expected to occur in the extreme northern portion of the Navy Cherry Point Study Area to just south of Cape Hatteras and bounded to the east by the warmer waters of the Gulf Stream.

Navy Cherry Point OPAREA common dolphin density—**Table 18** below provides the density estimates for common dolphins in the Navy Cherry Point Study Area. Density is not anticipated to be uniform across the warning areas. This species is likely to be concentrated in the northern portion of the Study Area based on knowledge of occurrence patterns (DoN, 2007b; Waring *et al.*, 2007). Methods and results are detailed in the NODE Report (DoN, 2007a).

Table 18   Seasonal Density Estimates for Common Dolphin in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** Sep, Oct, Nov)
4 & 5	0.00000	0.00000	0.00000	0.00000
13 & 14	0.00000	0.00000	0.00000	0.00000
16 & 17	<0.00001	<0.00001	<0.00001	<0.00001
UNDET	0.00000	0.00000	0.00000	0.00000

Source: DoN, 2007a

4.2.7   False Killer Whale

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

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

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

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

Seasonality and location of false killer whale breeding are unknown.

Navy Cherry Point OPAREA false killer whale occurrence—False killer whales occur in offshore, warm waters worldwide (Baird, 2002). The warm waters of the Gulf Stream likely influence occurrence in the Navy Cherry Point Study Area. A small number of sightings and strandings are recorded near the Study Area; the sightings reflect the preference of this species for offshore waters (DoN, 2007b). False killer whales may occur seaward of the shelf break throughout the Study Area year-round.

Navy Cherry Point OPAREA false killer whale density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

4.2.8   Fraser's Dolphin

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

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

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

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

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

Navy Cherry Point OPAREA Fraser's dolphin occurrence—One confirmed sighting was recorded in deep waters (>3,000 m in depth) offshore of Cape Hatteras (NMFS-SEFSC, 1999). Fraser's dolphins may occur seaward of the shelf break throughout the OPAREA year-round. The most likely area of occurrence in the Study Area is in waters seaward of the continental shelf, and distribution is assumed to be similar year-round.

Navy Cherry Point OPAREA Fraser's dolphin density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (NMFS, 2007a).

4.2.9   Harbor Porpoise

Harbor porpoises are the smallest cetaceans in the North Atlantic with a maximum length of 2.0 m (Jefferson *et al.*, 1993). They feed on a variety of small, schooling clupeoid (herring-like) and gadid (cod-like) fishes usually less than 30 cm in length (Read, 1999).

Status and Management—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) with additional studies supporting this hypothesis (Wang et.al., 1996; Rosel et.al., 1999). Abundance estimates given in the SAR are based on the four population structure. The best estimate of abundance for the Gulf of Maine and Bay of Fundy stock is 89,054 individuals (Waring *et al.*, 2008). The harbor porpoise is under the jurisdiction of NMFS.

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Habitat—Harbor porpoises appear restricted to relatively cool waters where prey aggregations are concentrated (Watts and Gaskin, 1985). Harbor porpoises are seldom found in waters warmer than 17ºC (Read, 1999) and closely mirror the movements of their primary prey, Atlantic herring (Gaskin, 1992). Harbor porpoises are generally scarce in areas without significant coastal fronts or topographically-generated upwellings (Gaskin, 1992; Skov *et al.*, 2003). Harbor porpoises occur most frequently in shallow and shelf waters (Jefferson et. al., 2008; Read, 1999); however, pelagic drift net bycatches and movements of a satellite-tracked individual, which swam offshore into water over 1,800 m deep, indicate a potential offshore distribution (Read *et al.*, 1996; Westgate *et al.*, 1998).

Distribution—Harbor porpoises occur in subpolar to cool-temperate waters in the North Atlantic and Pacific (Read, 1999). Off the northeastern U.S., 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).

From January through March, harbor porpoises can be found in moderate densities in waters off New Jersey to North Carolina (Waring et. al. 2007). Densities of this species are lower in waters off New York to New Brunswick, Canada during this same time (Waring et. al., 2007). A satellite tagged harbor porpoise 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). 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).

In the Gulf of Maine, calves are born in late spring (Read, 1990; Read and Hohn, 1995). Generally, most calves are born April through August (Jefferson *et al.*, 2008). The location of breeding areas is unknown.

Navy Cherry Point OPAREA harbor porpoise occurrence—The harbor porpoise primarily occurs on the continental shelf in cool temperate to subpolar waters (Read, 1999) that are at higher latitudes than the Navy Cherry Point Study Area. Occurrences of harbor porpoises in the mid-Atlantic are scattered (CETAP, 1982; Northridge, 1996). Intermediate densities of harbor porpoises are found in waters off North Carolina during winter (January through March) (Waring *et al.*, 2008). Based on distribution records and known habitat preferences, harbor porpoises are expected to occur throughout the Study Area during most of the year (DoN, 2007b). During summer, harbor porpoises are concentrated in the northern Gulf of Maine and lower Bay of Fundy region and are not expected to occur as far south as the Study Area.

Navy Cherry Point OPAREA harbor porpoise density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

4.2.10   Killer Whale

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

Status and Management—There are no estimates of abundance for killer whales in the western North Atlantic (Waring *et al.*, 2008). Most cetacean taxonomists agree that multiple killer whale species or subspecies occur worldwide (Krahn *et al.*, 2004; Waples and Clapham, 2004); however, at this time,

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further information is not available, particularly for the western North Atlantic. The killer whale is under the jurisdiction of NMFS.

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

Distribution—Killer whales are found throughout all oceans and contiguous seas, from equatorial regions to polar pack ice zones of both hemispheres. In the western North Atlantic, killer whales are known from the polar pack ice, off of Baffin Island, and in Labrador Sound southward to Florida, the Bahamas, and the Gulf of Mexico (Dahlheim and Heyning, 1999), where they have been sighted year-round (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997; Würsig *et al.*, 2000). A year-round killer whale population in the western North Atlantic may exist south of around 35°N (Katona *et al.*, 1988).

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

Navy Cherry Point OPAREA killer whale occurrence—Several killer whale sightings are recorded in both shallow and deep waters of the Study Area and vicinity (DoN, 2007b). Strandings are also reported along the Outer Banks (DoN, 2007b). There is photo-identification evidence that a small population moves through parts of the Hatteras-Fundy region on a seasonal basis (Katona *et al.*, 1988). Killer whales may occur seaward of the shoreline year-round based on sighting data and the diverse habitat preferences of this species.

Navy Cherry Point OPAREA killer whale density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

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4.2.11   Melon-headed Whale

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). Melon-headed whales reach a maximum length of 2.75 m (Jefferson *et al.*, 1993). Melon-headed whales prey on squids, pelagic fishes, and occasionally crustaceans. Most fish and squid prey are mesopelagic in waters up to 1,500 m deep, suggesting that feeding takes place deep in the water column (Jefferson and Barros, 1997).

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

Habitat—Melon-headed whales are most often found in offshore waters. Sightings off Cape Hatteras, North Carolina are reported in waters greater than 2,500 m (Waring *et al.*, 2007) , and most in the Gulf of Mexico have been well beyond the edge of the continental shelf break (Mullin *et al.*, 1994; Davis and Fargion, 1996b; Davis *et al.*, 2000) and out over the abyssal plain (Waring *et al.*, 2004). Nearshore sightings are generally from areas where deep, oceanic waters approach the coast (Perryman, 2002).

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

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

Navy Cherry Point OPAREA melon-headed whale occurrence—The melon-headed whale is an oceanic species which may occur seaward of the shelf break year-round throughout the Study Area. One sighting of melon-headed whales is recorded in offshore waters north of the Navy Cherry Point OPAREA (DoN, 2007b). Based on warm water preferences, melon-headed whale occurrence in the Study Area during winter is likely influenced by the Gulf Stream.

Navy Cherry Point OPAREA melon-headed whale density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

4.2.12   Minke Whale

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

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

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

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

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England waters than in the mid-Atlantic (Hamazaki, 2002; Waring *et al.*, 2006). The southernmost sighting in recent NMFS shipboard surveys was of one individual offshore of the mouth of Chesapeake Bay, in waters with a bottom depth of 3,475 m (Mullin and Fulling, 2003). Minke whales off the U.S. Atlantic coast apparently migrate offshore and southward in winter (Mitchell, 1991). Minke whales are known to occur during the winter months (November through March) in the western North Atlantic from Bermuda to the West Indies (Winn and Perkins, 1976; Mitchell, 1991; Mellinger *et al.*, 2000).

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

Navy Cherry Point OPAREA minke whale occurrence—Minke whales are assumed to have a similar life history as the other rorquals, with seasonal offshore/inshore movements and a population shift north into summer feeding grounds. Minke whales generally occupy the continental shelf and are widely scattered in the mid-Atlantic region (CETAP, 1982). There is a more common occurrence further north of the Study Area. The dynamics of the Gulf Stream in the Cape Hatteras region probably play a role in the zoogeography of minke whales throughout much of the year.

There are no records of minke whales in the Navy Cherry Point Study Area; however, the presence of this species here is recognized based on sparse sighting and stranding records near the Navy Cherry Point Study Area (DoN, 2007b). Minke whales may occur in shelf and deep waters north of Cape Hatteras during winter. South of Cape Hatteras, occurrence is expected just inshore of the shelf break and seaward of the shelf break in the Study Area. The change in occurrence patterns just south of Cape Hatteras takes into consideration the steep bathymetric gradient. Minke whales may occur in shelf and offshore waters of the Study Area during spring and fall, but are most likely found north of the Study Area during these times of year. During summer, minke whales are expected to occur at higher latitudes on their feeding grounds.

Navy Cherry Point OPAREA minke whale density—**Table 19** below provides density estimates for minke whales in the Navy Cherry Point Study Area. Density numbers are too low to indicate any seasonal differences in minke whale numbers; however it is assumed that, as with other rorquals, minke whales engage in seasonal migrations and actual occurrences would reflect this. Methods and results are detailed in the NODE Report (DoN, 2007a).

Table 19   Seasonal Density Estimates for Minke Whale in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** Sep, Oct, Nov)
4 & 5	0.00004	0.00004	0.00004	0.00004
13 & 14	0.00004	0.00004	0.00004	0.00004
16 & 17	0.00004	0.00004	0.00004	0.00004
UNDET	0.00004	0.00004	0.00004	0.00004

Source: DoN, 2007a

4.2.13   Pantropical Spotted Dolphin

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

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dolphins prey on epipelagic fishes, squids, and crustaceans (Perrin and Hohn, 1994; Robertson and Chivers, 1997; Wang *et al.*, 2003).

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

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

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

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

Navy Cherry Point OPAREA pantropical spotted dolphin occurrence—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. Based on sighting data and known habitat preferences, pantropical spotted dolphins may occur seaward of the shelf break throughout the Study Area year-round.

Navy Cherry Point OPAREA pantropical spotted dolphin density—The density estimates for training areas where explosive ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 20**. Methods and results are detailed in the NODE Report (DoN, 2007a). Density will likely not be uniform across the Study Area. Based on habitat preferences, pantropical dolphins are anticipated to be found seaward of the shelf break. Given estimates may reflect lower survey efforts in offshore waters or the difficulty in distinguishing pantropical spotted dolphins from the offshore form of the Atlantic spotted dolphin.

Table 20   Seasonal Density Estimates for Pantropical Spotted Dolphin in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.02225	0.02225	0.02225	0.02225
13 & 14	0.02225	0.02225	0.02225	0.02225
16 & 17	0.02225	0.02225	0.02225	0.02225
UNDET	0.02225	0.02225	0.02225	0.02225

Source: DoN, 2007a

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4.2.14 Pilot Whales

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

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

Habitat—Pilot whales occur along the continental shelf break, in continental slope waters, and in areas of high-topographic relief (Olson and Reilly, 2002). While typically distributed along the continental shelf break, they are also commonly sighted on the continental shelf and inshore of the 100-m isobath (CETAP, 1982; Payne and Heinemann, 1993). Sightings of pilot whales also frequently occur seaward of the 2,000-m isobath north of Cape Hatteras (CETAP, 1982; Payne and Heinemann, 1993).

Waring *et al.* (1992) sighted pilot whales principally along the northern wall of the Gulf Stream and along the shelf break at thermal fronts. A few of these sightings were also made in the mid-portion of the Gulf Stream near Cape Hatteras (Abend and Smith, 1999).

Pilot whales occur close to shore at oceanic islands where the shelf is narrow and deeper waters are nearby (Mignucci-Giannoni, 1998; Gannier, 2000; Anderson, 2005). Long-finned pilot whale sightings extend south to near Cape Hatteras through the VACAPES OPAREA (Abend and Smith, 1999) along the continental slope.

Distribution—Long-finned pilot whales are distributed in subpolar to temperate North Atlantic waters offshore and in some coastal waters. The short-finned pilot whale usually does not range north of 50°N or south of 40°S (Jefferson *et al.*, 1993); 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). The apparent ranges of the two pilot whale species overlap in shelf/shelf-edge and slope waters of the northeastern U.S. between 35°N and 38° to 39°N (New Jersey to Cape Hatteras, North Carolina) (Payne and Heinemann, 1993); however, incidents of strandings of short-finned pilot whales as far north as Block Island, Rhode Island, and Nova Scotia indicate that area of overlap may be larger than previously thought (Waring et. al. 2007).

Pilot whales concentrate along the continental shelf break from during late winter and early spring north of Cape Hatteras (CETAP, 1982; Payne and Heinemann, 1993). This corresponds to a general movement northward and onto the continental shelf from continental slope waters (Payne and Heinemann, 1993). Short-finned pilot whales seem to move from offshore to continental shelf break waters and then northward to approximately 39ºN, 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 occurence in some continental shelf areas, such as the southern margin of Georges Bank (CETAP, 1982; Abend and Smith, 1999).

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

Navy Cherry Point OPAREA pilot whale occurrence—The Navy Cherry Point Study Area is located in a region of range overlap between both pilot whale species (Payne and Heinemann, 1993). As a deep-water species, pilot whales may occur seaward of the shelf break throughout the Study Area year-round. They may also occur between the shore and shelf break which is supported by opportunistic sightings and bycatch records inshore of the shelf break in the Navy Cherry Point Study Area (DoN, 2007b). Concentrated areas of occurrence are likely influenced by high levels of productivity generated by warm-core rings from the Gulf Stream as well as the steep sloping bottom topography of the area (DoN, 2007b).

Navy Cherry Point OPAREA pilot whale density—**Table 21** below provides density estimates for pilot whales in the Navy Cherry Point Study Area. Density is not anticipated to be uniform throughout the warning areas. Although pilot whales do occur over continental shelf waters in the OPAREA (DoN, 2007b), these species are more likely to be concentrated near and seaward of the shelf break. Methods and results are detailed in the NODE Report (DoN, 2007a).

Table 21   Seasonal Density Estimates for Pilot Whales in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.00044	0.00044	0.00070	0.00044
13 & 14	0.01302	0.01302	0.00615	0.01302
16 & 17	0.00019	0.00019	0.00015	0.00019
UNDET	0.00001	0.00001	0.00000	0.00001

Source: DoN, 2007a

4.2.15   Pygmy and Dwarf Sperm Whales

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

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

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

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Distribution—Both *Kogia* species apparently have a worldwide distribution in tropical and temperate waters (Jefferson *et al.*, 1993). In the western Atlantic Ocean, stranding records have documented the pygmy sperm whale as far north as the northern Gulf of St. Lawrence, New Brunswick and parts of eastern Canada (Piers, 1928, Measures *et al.*, 2004; McAlpine et. al. 1997; Baird, 1996) and as far south as Colombia and around to Brazil (in the southern Atlantic) (de Carvalho, 1967; Geise and Borobia 1987; Muñoz-Hincapié *et al.*, 1998). Pygmy sperm whales are also found in the Gulf of Mexico (Hysmith, 1976; Gunter et. al., 1955; Baumgartner *et al.*, 2001) and in the Caribbean (MacLeod and Hauser 2002).

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

Births have been recorded between December and March for dwarf sperm whales in South Africa (Plön, 2004); however, the breeding season and locations of specific are unknown.

Navy Cherry Point OPAREA Kogia occurrence—*Kogia* spp. generally occur along the continental shelf break and over the continental slope (Baumgartner *et al.*, 2001; McAlpine, 2002). Few sightings are recorded in the Study Area which is likely due to incomplete survey coverage throughout most of the deep waters of this region (especially during winter and fall) as well as their avoidance reactions towards ships (DoN, 2007b); however, strandings are recorded in the Navy Cherry Point Study Area during all seasons and support the likelihood of *Kogia* spp. occurrence in the region year-round (DoN, 2007b). During 15-16 January 2005, a noteworthy unusual mortality event took place involving two dwarf sperm whales stranding near Hatteras, North Carolina (Hohn *et al.*, 2006). A decomposed dwarf sperm whale was found south of the Outer Banks at around the same time as the other strandings and may have been involved in the same stranding event (MMC, 2006). *Kogia* spp. may occur seaward of the shelf break throughout the Study Area year-round.

Navy Cherry Point OPAREA Kogia density—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 22**. Methods and results are detailed in the NODE Report (DoN, 2007a). Density is not expected to be uniform across the warning areas. *Kogia* spp. will likely be concentrated in waters near and seaward of the shelf break based on habitat preferences. Density estimates may reflect the lower amount of survey effort in offshore waters as well as their documented avoidance reactions to ships.

Table 22　　**Seasonal Density Estimates for *Kogia* Spp. in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs**

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.00101	0.00101	0.00101	0.00101
13 & 14	0.00101	0.00101	0.00101	0.00101
16 & 17	0.00101	0.00101	0.00101	0.00101
UNDET	0.00101	0.00101	0.00101	0.00101

Source: DoN, 2007a

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4.2.16   Pygmy Killer Whale

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

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

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

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

Seasonality and location of pygmy killer whale breeding are unknown.

Navy Cherry Point OPAREA pygmy killer whale occurrence—Few strandings and an offshore sighting are recorded near the Navy Cherry Point Study Area (DoN, 2007b). The pygmy killer whale is an oceanic species which may occur seaward of the shelf break year-round throughout the Study Area. Based on warm water preferences, pygmy killer whale occurrence in the Study Area during winter is likely influenced by the Gulf Stream.

Navy Cherry Point OPAREA pygmy killer whale density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

4.2.17   Risso's Dolphin

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

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

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

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

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

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

Navy Cherry Point OPAREA Risso's dolphin occurrence—Risso's dolphins are most commonly found in areas with steep bottom topography and are often sighted along the northern wall of the Gulf Stream which is a region of enhanced productivity. Records of this species in the Study Area generally follow this pattern of distribution with patches of sightings recorded along the path of the Gulf Stream and over steep portions of the continental slope (DoN, 2007b). Risso's dolphins may occur just inshore of the shelf break and seaward of the shelf break throughout the Study Area year-round based on sighting data and the preference of this species for deep waters.

Navy Cherry Point OPAREA Risso's dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 23**. Methods and results are detailed in the NODE Report (DoN, 2007a). Density is not expected to be uniform across the warning area. Risso's dolphins will likely be concentrated in waters near and seaward of the shelf break based on habitat preferences.

Table 23   **Seasonal Density Estimates for Risso's Dolphin in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs**

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	<0.00001	<0.00001	<0.00001	<0.00001
13 & 14	0.00005	0.00005	0.00005	0.00005
16 & 17	0.02148	0.02148	0.02148	0.02148
UNDET	<0.00001	<0.00001	<0.00001	<0.00001

Source: DoN, 2007a

4.2.18   Rough-toothed Dolphin

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

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

Habitat—The rough-toothed dolphin is regarded as an offshore species that prefers deep waters; however, it can occur in shallower waters as well (e.g., Gannier and West, 2005). Tagging data for this species from the Gulf of Mexico and western North Atlantic provide important information on habitat preferences. Three dolphins with satellite-linked transmitters released in 1998 off the Gulf Coast of Florida were tracked off the Florida panhandle in average water depths of 195 m (Wells *et al.*, 1999b). Dolphins released in March of 2005 after a mass stranding were tagged with satellite-linked transmitters and released southeast of Fort Pierce moved within the Gulf Stream and parallel to the continental shelf

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off Florida, Georgia, and South Carolina, in waters with a depth of 400 to 800 m. (Manire and Wells, 2005). They later moved northeast into waters with a depth greater than 4,000 m (Manire and Wells, 2005). Another tagged dolphin from released after the 2005 mass stranding moved north as far as Charleston, South Carolina, before returning to the Miami area, remaining in relatively shallow waters (Wells, 2007). During May 2005, seven more rough-toothed dolphins (stranded in the Florida Keys in March 2005 and rehabilitated) were tagged and released by the Marine Mammal Conservancy in the Florida Keys (Wells, 2007). During an initial period of apparent disorientation in the shallow waters west of Andros Island, they continued to the east, then moved north through Crooked Island Passage, and paralleled the West Indies (Wells, 2007). The last signal placed them northeast of the Lesser Antilles (Wells, 2007). During September 2005, two more individuals (from the same mass stranding) were satellite-tagged and released east of the Florida Keys and proceeded south to a deep trench close to the north coast of Cuba (Wells, 2007).

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

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

Navy Cherry Point OPAREA rough-toothed dolphin occurrence—A few strandings and one sighting have been recorded in or near the Study Area (DoN, 2007b). Rough-toothed dolphins may occur seaward of the shelf break based on this species' preference for deep waters. During the winter, the rough-toothed dolphin's occurrence is expected in warmer waters so occurrence in the Study Area may follow the western edge of the standard deviation of the Gulf Stream. The rough-toothed dolphin may occur in the Study Area year-round.

Navy Cherry Point OPAREA rough-toothed dolphin occurrence—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 24**. Methods and results are detailed in the NODE Report (DoN, 2007a). Density is not expected to be uniform across the warning area. Risso's dolphins will likely be concentrated in waters near and seaward of the shelf break and/or along the Gulf Stream based on habitat preferences.

Table 24   Seasonal Density Estimates for Rough-Toothed Dolphin in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	0.00048	0.00048	0.00048	0.00048
13 & 14	0.00048	0.00048	0.00048	0.00048
16 & 17	0.00048	0.00048	0.00048	0.00048
UNDET	0.00048	0.00048	0.00048	0.00048

Source: DoN, 2007a

4.2.19   Spinner Dolphin

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

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

Habitat—Spinner dolphins occur in both oceanic and coastal environments. Most sightings of this species in tropical waters have been associated with inshore waters, islands, or banks (Perrin and Gilpatrick, 1994).

Spinner dolphin distribution in the Gulf of Mexico and off the northeastern U.S. coast is primarily in offshore waters. Along the northeastern U.S. and in the Gulf of Mexico, they are distributed in waters with a depth greater than 2,000 m (CETAP, 1982; Davis *et al.*, 1998). Off the eastern U.S. coast, spinner dolphins were sighted within the Gulf Stream, which is consistent with the oceanic distribution and warm-water preference of this genus (Waring *et al.*, 1992).

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°N latitude (Jefferson *et al.*, 1993). Distribution in the western North Atlantic is thought to extend from North Carolina south to Venezuela (Schmidly, 1981), including the Gulf of Mexico (Davis *et al.* 2002).

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

Navy Cherry Point Study Area spinner dolphin occurrence—There is only one sighting record for this species in the Navy Cherry Point Study Area; several sighting and bycatch records are north of this area (DoN, 2007b). Spinner dolphins prefer warm, offshore waters as evidenced by the sighting and bycatch records associated with the Gulf Stream in the winter and spring months (DoN, 2007b). Spinner dolphins may occur from the vicinity of the continental shelf break to eastward of the Study Area boundary in association with the Gulf Stream's northern boundary. No seasonal differences in occurrence are anticipated.

Navy Cherry Point OPAREA spinner dolphin density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

4.2.20   Striped Dolphin

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

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

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

Distribution—Striped dolphins are distributed worldwide in cool-temperate to tropical zones. In the western North Atlantic, this species occurs from Nova Scotia southward to the Caribbean Sea, Gulf of Mexico, and Brazil (Baird *et al.* 1993; Jefferson *et al.* 2008). Off the northeastern U.S., striped dolphins

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are distributed along the continental shelf break from Cape Hatteras to the southern margin of Georges Bank, as well as offshore over the continental slope and continental rise in the mid-Atlantic region (CETAP, 1982).

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

Navy Cherry Point OPAREA striped dolphin occurrence—As noted earlier, the striped dolphin is a deep water species that is generally distributed north of Cape Hatteras (CETAP, 1982). In the Study Area, there is one sighting near the northern perimeter of the OPAREA and several strandings along the coast (DoN, 2007b). Occurrence here is likely influenced by the path of the Gulf Stream since striped dolphins are often associated with the Gulf Stream's northern wall and warm-core rings (Waring *et al.*, 1992). Striped dolphins may occur near and seaward of the shelf break throughout the Study Area year-round.

Navy Cherry Point OPAREA striped dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the Navy Cherry Point OPAREA are provided in **Table 25**. Methods and results are detailed in the NODE Report (DoN, 2007a). Density is not expected to be uniform across the warning area. Striped dolphins will likely be concentrated in waters near and seaward of the shelf break and/or along the Gulf Stream based on habitat preferences.

Table 25   Seasonal Density Estimates for Striped Dolphin in the Navy Cherry Point Study Area where Explosive Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	**Spring** (Mar, Apr, May)	**Summer** (Jun, Jul, Aug)	**Fall** (Sep, Oct, Nov)
4 & 5	<0.00001	<0.00001	<0.00001	<0.00001
13 & 14	<0.00001	<0.00001	<0.00001	<0.00001
16 & 17	<0.00001	<0.00001	<0.00001	<0.00001
UNDET	<0.00001	<0.00001	<0.00001	<0.00001

Source: DoN, 2007a

4.2.21 Harbor Seal

The harbor seal (or common seal) is a small- to medium-sized seal. Adult males attain a maximum length of 1.9 m and weigh 70 to 150 kg; females reach 1.7 m in length and weigh between 60 and 110 kg (Jefferson *et al.*, 1993). Northeastern U.S. harbor seals eat sand lance, Atlantic herring, cod, and winter flounder (Payne and Selzer, 1989).

Status and Management—Five subspecies of *Phoca vitulina* 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 U.S. (Katona *et al.*, 1993). Currently, harbor seals along the coast of the eastern U.S. and Canadian coasts are considered a single population (Waring *et al.*, 2008).

The best estimate of abundance of harbor seals in the western North Atlantic stock is 99,340 individuals (Waring *et al.*, 2008). 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. The harbor seal is under NMFS jurisdiction.

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Habitat—This is a coastal species, usually found near shore, and frequently occupying bays, estuaries, and inlets (Baird, 2001). Individual harbor seals have been observed miles upstream in coastal rivers (Baird, 2001).

Although primarily aquatic, harbor seals also utilize terrestrial environments where they haul out periodically. Haulout substrates vary but include intertidal and subtidal rocky outcrops, sandbars, sandy beaches, and even peat banks in salt marshes (Wilson, 1978; Schneider and Payne, 1983; Gilbert and Guldager, 1998). Along the majority of the New England coast, harbor seals haul out on rocky outcroppings and intertidal ledges (Kenney, 1994; Gilbert and Guldager, 1998; Schroeder, 2000). In the mid-Atlantic Bight, harbor seals are commonly observed hauled out on dry parts of submerged structures (Steimle and Zetlin, 2000).

Distribution—Harbor seal distribution is associated with temperate waters (Jefferson *et al.*, 1993; 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 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. 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 U.S. is thought to occur during this period (Rosenfeld *et al.*, 1988). Tagging efforts by Gilbert and Wynne (1985) support this hypothesis. 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).

The timing of harbor seal pupping along the eastern North American coast varies geographically (Temte *et al.* 1991). Pupping takes place from mid May through mid June along the Maine coast (Richardson, 1976; Wilson, 1978; DeHart, 2002).

Navy Cherry Point OPAREA harbor seal occurrence—Several strandings near the Navy Cherry Point OPAREA have occured during the winter, spring, and fall. Winn *et al.* (1979) suggested that harbor seals found in this area are likely young individuals that disperse from the north during the winter months. Stranding data support a consistent seasonal occurrence of harbor seals in this region (Harry *et al.*, 2005). Between 2000 and 2005, at least 71 records of harbor seal strandings were reported for North Carolina and Virginia (Harry *et al.*, 2005). Most of these strandings occurred between November and April and were of young individuals. In February 2003, a harbor seal was rescued from Cape Lookout, North Carolina (WhaleNet, 2003). Sightings and strandings of harbor seals have been documented throughout the year in South Carolina (McFee, 2006). Therefore, harbor seals may occur in or near the OPAREA any time of the year.

Navy Cherry Point OPAREA harbor seal density—There were not sufficient data available to estimate a density for the Study Area, nor is there an abundance estimate in the NOAA SAR (DoN, 2007a).

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CHAPTER 5   TAKE AUTHORIZATION REQUESTED

A LOA for the incidental taking of marine mammals is requested pursuant to § 101 (a)(5)(A) [16 U.S.C. § 1371 (a)(5)(A)] of the MMPA. The request is for a 5-yr period commencing upon issuance of the permit. The term "take," as defined in § 3 (16 U.S.C. § 1362) of the Marine Mammal Protection Act [16 U.S.C.§ 1361 to 1423h], means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of "harassment," Level A (potential injury) and Level B (potential disturbance) [16 U.S.C. § 1362 (18)(A); MMPA § 3 (18)(A)].

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

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment") [16 U.S.C. § 1362 (18)(B)(i),(C); MMPA § 3 (18)(B)(i),(C)].
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 U.S.C. § 1362 (18)(B)(ii); MMPA § 3 (18)(B)(ii)]..

Modeling results from explosive ordnance use in MISSILEX and mine exercise (MINEX) predict MMPA - Level B TTS exposures for up to 2 Atlantic spotted dolphins and 1 bottlenose dolphin. There are no predicted MMPA-Level A injury or mortality exposures. There are no predicted harassment exposures for FIREX with IMPASS. These estimates do not take into account the mitigation measures discussed in **Chapter 11**. Given the implementation of the measures, the actual exposures would likely be lower than the anticipated amount.

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CHAPTER 6   NUMBERS AND SPECIES TAKEN

The Navy Cherry Point Range Complex EIS/OEIS Section 3.7 analyzed all stressors associated with proposed exercises in the Navy Cherry Point Study Area, assessing their potential impact on marine mammal species found in the study area. Based on modeling results and a qualitative analysis of stressors, the EIS/OEIS concluded that only explosions associated with MISSILEX, FIREX with IMPASS and MINEX were the activities with the potential to result in Level A or Level B harassment or mortality of marine mammals. Consequently, only the use of explosive ordnance under these exercises is addressed in this analysis.

6.1   Vessel Strikes

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

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

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

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

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

- Using lookouts trained to detect all objects on the surface of the water, including marine mammals.

- Implementing reasonable and prudent actions to avoid the close interaction of Navy assets and marine mammals.

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- Maneuvering to keep away from any observed marine mammal.

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

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

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

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

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

For the Action Area, the Southeast Protective measures covering the right whale consultation area and Southeast Critical Habitat apply. These include:

- Annual message sent to all ships prior to the 1 December through 30 March calving season.

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- Movement through the Critical Habitat (CH) will be in the most direct manner possible, avoiding north – south transits during the calving season.

- Vessels will use extreme caution and operate at a slow, safe speed; that is the slowest speed consistent with essential mission, training and operations at which the ship can take proper and effective action to avoid a collision and can be stopped within a distance appropriate to the prevailing circumstances and conditions.

- To the extent practicable and consistent with mission, training and operations, naval vessel operations in the critical habitat and associated area of concern will be limited to daylight and periods of good visibility.

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

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

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

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

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

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

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

For purposes of these measures, the mid-Atlantic is defined broadly to include ports south and east of Block Island Sound southward to South Carolina. These measures are similar to vessel transit

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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 Navy Cherry Point Study Area the likelihood that a vessel collision would occur is very low.

6.2 Analytical Framework for Assessing Marine Mammal Response to Anthropogenic Sound

Marine mammals respond to various types of anthropogenic 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. The Navy enlisted the expertise of the NMFS as the cooperating agency in the preparation of this LOA.

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 Navy training activities.

- Identified the location, season, and duration 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 OPAREAs during the Navy training activities.

- Applied the applicable acoustic threshold criteria to the predicted sound exposures from the proposed activity. The results of this effort were 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, and 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' populations.

- The following flow chart (**Figure 3**) is a representation of the general analytical framework utilized in applying the specific thresholds discussed in this section. 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 effects 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 designate those effects that "will" happen; dotted lines designate those that "might" happen but must be considered (including those hypothesized to occur but for which there is no direct evidence).

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Figure 3   Analytical Framework Flow Chart

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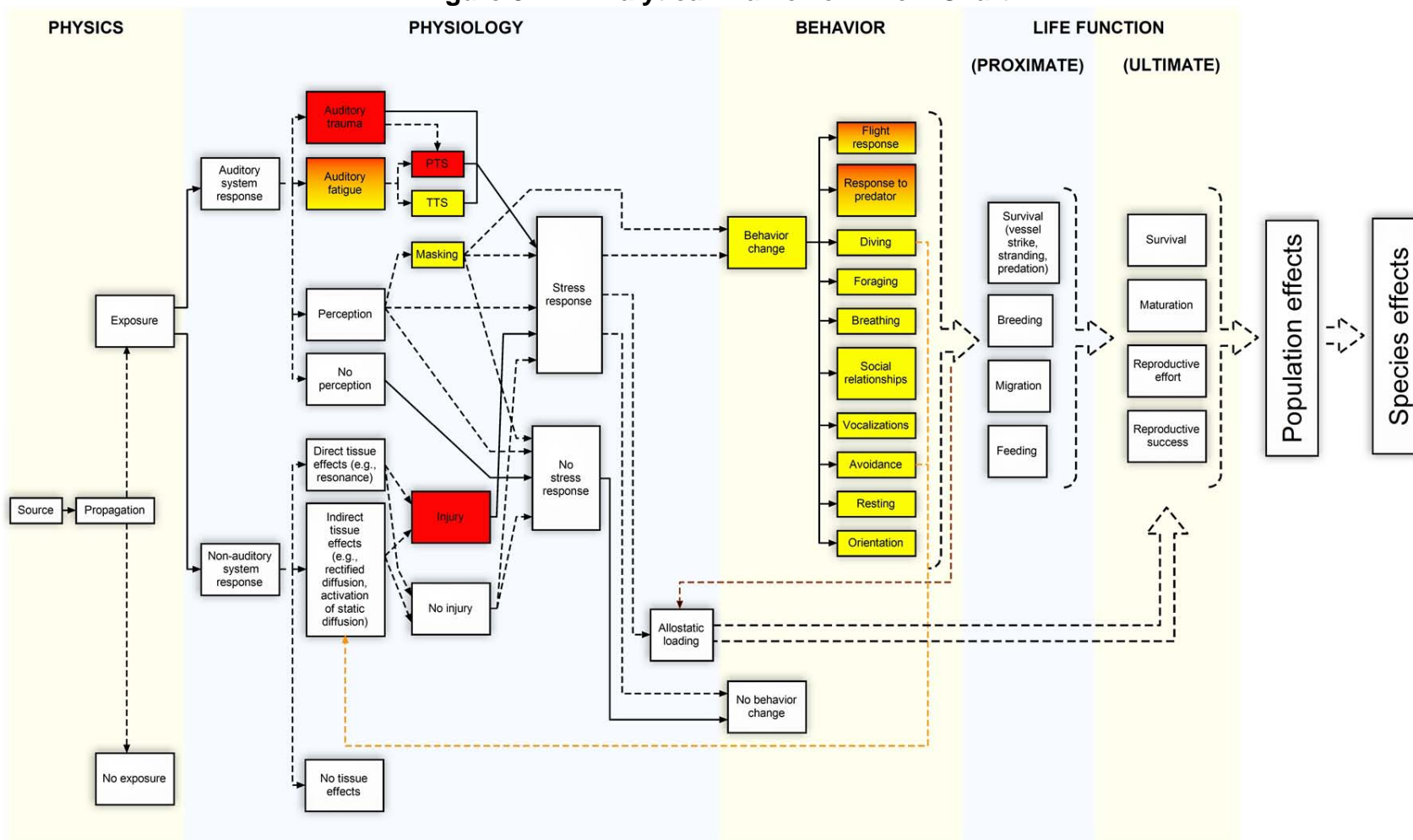
Some boxes contained within the flow chart are colored according to how they relate to the definitions of harassment under the MMPA. Red boxes correspond to events that are injurious. By prior ruling and usage, these events would be considered as Level A harassment under the MMPA. Yellow boxes correspond to events that have the potential to qualify as Level B harassment under the MMPA. Based on prior ruling, the specific instance of 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.

6.2.1   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.

6.2.2   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, 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 among 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

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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 (not perceived).

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 nonauditory 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 noninjurious stimulation may or may not.

2.   Indirect tissue effects – Based on 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 on 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.

THE STRESS RESPONSE

The acoustic source is considered a potential stressor if, by its action on the animal, via auditory or nonauditory 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 **Figure 3** and the later 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

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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 lipids 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 an indicator of the overall severity of a stress response (Hennessy *et al.*, 1979). Each component of the stress response is variable in time; e.g., adrenalines are released 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 as 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 that 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, **Figure 3** 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 in **Figure 3**) is assumed to also produce a stress response and contribute to the allostatic load.

6.2.3   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 auditory masking. The presence of a masking sound may not produce a stress

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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.

Impulsive sounds from explosions have very short durations as compared to other sounds like sonar or ship noise. Additionally the explosive sources analyzed in this LOA are used infrequently and the training events are typically of short duration. Therefore, the potential for auditory masking is unlikely and no impacts to marine mammals due to auditory masking are anticipated due to implementing the proposed action.

Numerous behavioral changes can occur as a result of stress response, and **Figure 3** 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 needs 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 Navy operations, specifically 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.

6.2.4   Life Function

6.2.4.1   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 effect 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.

6.2.4.2   Ultimate Life Functions

The ultimate life functions are those that 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.

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The proximate life functions are loosely ordered in decreasing severity of impact. Mortality (survival) has an immediate effect, 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.

6.2.5   Application of the Framework

For each species in the region of a proposed action, the density and occurrence of the species in the region relative to the timing of the proposed action should be determined. The probability of exposing an individual will be based on the density of the animals at the time of the action and the acoustic propagation loss. Based upon the calculated exposure levels for the individuals, or proportions of the population, an assessment for auditory and nonauditory responses should be made. Based on the available literature on the bioacoustics, physiology, dive behavior, and ecology of the species, **Figure 3** should be used to assess the potential impact of the exposure to the population and species.

6.3   Explosive Ordnance Exposure Analysis

The effects of an underwater explosion on a marine mammal depends on many factors, including the size, type, and depth of both the animal and the explosive charge; the depth of the water column; and the standoff distance between the charge and the animal, as well as the sound propagation properties of the environment. Potential impacts can range from brief effects (such as behavioral disturbance), tactile perception, physical discomfort, slight injury of the internal organs and the auditory system, to death of the animal (Yelverton *et al.*, 1973; O'Keeffe and Young, 1984; DoN, 2001). Non-lethal injury includes slight injury to internal organs and the auditory system; however, delayed lethality can be a result of individual or cumulative sublethal injuries (DoN, 2001). Immediate lethal injury would be a result of massive combined trauma to internal organs as a direct result of proximity to the point of detonation (DoN, 2001).

The exercises that use explosives include: FIREX with IMPASS, MISSILEX, and MINEX. **Table 26** summarizes the number of events (per year by season) and specific areas where each occurs for each type of explosive ordnance used. For most of the operations, there is no difference in how many events take place between the different seasons. Fractional values are a result of evenly distributing the annual totals over the 4 seasons. For example, there are 6 Hellfire events per year that can take place in 16 &17 during any season, so there are 1.5 events modeled for each season.

Table 26   Number of Explosive Events within the Navy Cherry Point OPAREA

Sub-Area	Ordnance	Winter	Spring	Summer	Fall	Annual Totals
	MISSILEX					**22**
16 & 17	Hellfire	1.5	1.5	1.5	1.5	
16 & 17	TOW	2	2	2	2	
	FIREX with IMPASS					**2**
13 & 14	5-in. rounds	.25	.25	.25	.25	
4 & 5	5-in. rounds	.25	.25	.25	.25	
	MINEX					**20**
UNDET	20 LB	5	5	5	5	

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THRESHOLDS AND CRITERIA FOR IMPULSIVE SOUND

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 2001a). NMFS adopted these criteria and thresholds in its final rule on unintentional taking of marine animals occurring incidental to the shock testing (NMFS, 2001a). Since the ship-shock events involve only one large explosive at a time, additional assumptions were made to extend the approach to cover multiple explosions for FIREX with IMPASS. In addition, this section reflects a revised acoustic criterion for small underwater explosions (i.e., 23 pounds per square inch [psi] for peak pressure instead of previous acoustic criteria of 12 psi for peak pressure), which is based on the final rule issued to the Air Force by NMFS (NMFS, 2005b). As was the case for Seawolf and Churchill, in the absence of specifically developed criteria, criteria and thresholds for impact on protected marine mammals are used for protected sea turtles. **Figure 4** depicts the acoustic impact framework used in this assessment.

Figure 4   **Physiological and Behavioral Acoustic Effects Framework for Explosives**
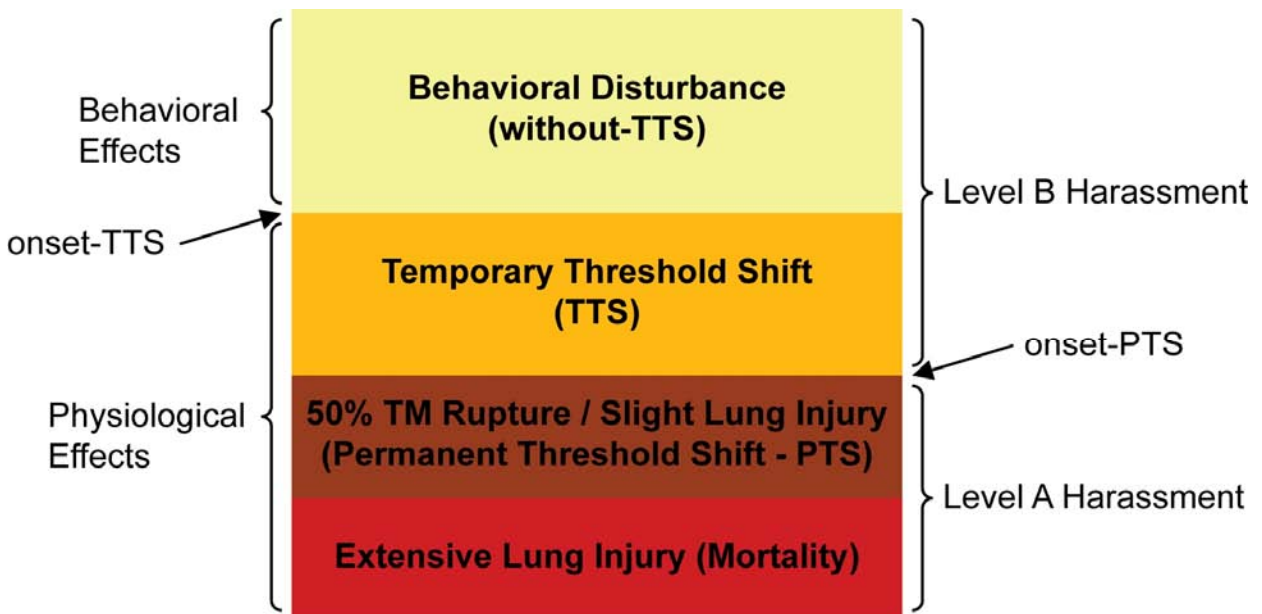
(Figure is not to scale and is for illustrative purposes only)

THRESHOLDS AND CRITERIA FOR INJURIOUS PHYSIOLOGICAL EFFECTS

Single Explosion

For injury, Churchill used dual criteria: eardrum rupture (i.e., tympanic membrane [TM] rupture) and onset of slight lung injury. These criteria are considered indicative of the onset of injury. The threshold for TM rupture corresponds to a 50% rate of rupture (i.e., 50% of animals exposed to the level are expected to suffer TM rupture); this is stated in terms of an Energy Flux Density Level (EL) value of 1.17 inch pounds per square inch (in.-lb/in.^{2}) (about 205 decibels referenced to 1 micropascal squared second [dB re 1 μPa^2-s]). This recognizes that TM rupture is not necessarily a serious or life-threatening

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injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing impairment. Ketten (1998) indicates a 30% incidence of PTS at the same threshold).

The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 26.9 lb), and is given in terms of the "Goertner modified positive impulse," indexed to 13 psi-millisecond (ms) (DoN, 2001). This threshold is conservative since the positive impulse needed to cause injury is proportional to animal mass, and therefore, larger animals require a higher impulse to cause the onset of injury. The criterion with the largest potential impact range (most conservative), either TM rupture (energy threshold) and onset of slight lung injury (peak pressure threshold), will be used in the analysis to determine injurious physiological (MMPA – Level A) exposures.

For mortality, the Navy uses the criterion corresponding to the onset of extensive lung injury. This is conservative in that it corresponds to a 1% chance of mortal injury, and yet any animal experiencing onset severe lung injury is counted as a lethal exposure. For small animals, the threshold is given in terms of the Goertner modified positive impulse, indexed to 30.5 psi-ms. Since the Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way, the actual impulse value corresponding to the 30.5 psi-ms index is a complicated calculation. Again, to be conservative, the analysis used the mass of a calf dolphin (at 26.9 lb), so that the threshold index is 30.5 psi-ms.

Multiple Explosions

For this analysis, the use of multiple explosions only applies to FIREX with IMPASS. Since FIREX with IMPASS requires multiple explosions, the Churchill approach had to be extended to cover multiple sound events at the same training site. For multiple exposures, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot (explosion); this is consistent with the treatment of multiple arrivals in Churchill. For positive impulse, it was presented in Churchill to use the maximum value over all impulses received.

THRESHOLDS AND CRITERIA FOR NON-INJURIOUS PHYSIOLOGICAL EFFECTS

The Churchill criterion for non-injurious harassment is TTS—a slight, recoverable loss of hearing sensitivity (DoN, 2001). For this assessment, there are dual criteria for TTS, an energy threshold and a peak pressure threshold. The criterion with the largest potential impact range (most conservative), either the energy threshold or peak pressure threshold will be used inh the analysis to determine non-injurious TTS (MMPA-Level B) exposures.

Single Explosion –TTS-Energy Threshold

The energy metric threshold is a 182 dB re 1 μPa^2-s maximum energy flux density level in any 1/3-octave band. For large explosives, as in the case of the Churchill FEIS, frequency range cutoffs at 10 and 100 Hertz (Hz) make a difference in the range estimates. For small explosives, as what was modeled for this analysis, the spectrum of the shot arrival is broad, and there is essentially no difference in impact ranges for toothed whales or baleen whales.

The TTS energy threshold for explosives is derived from the Space and Naval Warfare Systems Center (SSC) pure-tone tests for TTS. The pure-tone threshold (192 decibels [dB] as the lowest value) is modified for explosives by (a) interpreting it as an energy metric, (b) reducing it by 10 dB to account for the time constant of the mammal ear, and (c) measuring the energy in 1/3-octave bands, the natural filter band of the ear. The resulting threshold is 182 dB re 1 μPa^2-s in any 1/3-octave band. The energy threshold usually dominates and is used in the analysis to determine potential non-injurious physiological (MMPA – Level B) exposures for single explosion ordnance.

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Single Explosion –TTS-Peak Pressure Threshold

The pressure metric threshold is stated in terms of peak pressure at 23 psi (about 225 dB referenced to 1 micropascal [dB re 1 μPa]). This threshold is that which is presented in Churchill; 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. To more accurately estimate TTS for smaller shots while preserving the safety feature provided by the peak pressure threshold, the peak pressure threshold is appropriately scaled for small shot detonations. This scaling is based on the similitude formulas (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.

Multiple Explosions –TTS

For multiple explosions, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot/detonation. This is the energy argument as was presented in Churchill. For peak pressure, it was presented in Churchill to use the maximum value over all impulses received.

THRESHOLDS AND CRITERIA FOR BEHAVIORAL EFFECTS

Single Explosion

For a single explosion, as was presented in Churchill, TTS is the criterion for non-injurious physiological (MMPA – Level B) exposures. In other words, because behavioral disturbance for a single explosion is likely to be limited to a short-lived startle reaction, use of the TTS criterion is considered sufficient protection and therefore behavioral effects (without TTS) are not considered for single explosions.

Multiple Explosions-without TTS

For this analysis, the use of multiple explosions only applies to FIREX with IMPASS. Because multiple explosions would occur within a discrete time period, an acoustic criterion-behavioral disturbance (without TTS)-is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower noise levels than those that may cause TTS.

The threshold is based on test results published in Schlundt *et al.* (2000), with derivation as was presented in the Churchill FEIS for the energy-based TTS threshold. The original Schlundt *et al.* (2000) data and the report of Finneran and Schlundt (2004) are the basis for thresholds for behavioral disturbance (without TTS). As reported by Schlundt *et al.* (2000), instances of altered behavior generally began at lower exposures than those causing TTS; however, there were many instances when subjects exhibited no altered behavior at levels above the onset-TTS levels. Regardless of reactions at higher or lower levels, all instances of altered behavior were included in the statistical summary.

The behavioral disturbance (without TTS) threshold for tones is derived from the SSC tests, and is found to be 5 dB below the threshold for TTS, or 177 dB re 1 μPa^2-s maximum EL in any 1/3-octave band at frequencies above 100 Hz for toothed whales/sea turtles and in any 1/3-octave band above 10 Hz for baleen whales. As stated previously for TTS, for small explosives (<1500-lb NEW), as what was modeled for this analysis, the spectrum of the shot arrival is broad, and there is essentially no difference in impact ranges for toothed whales/sea turtles or baleen whales. The behavioral disturbance (without TTS) impact range for FIREX with IMPASS can, especially in shallower water, be about twice the impact range for TTS. However, the TTS pressure criteria (23 psi) impact range for FIREX with

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IMPASS can, especially in deeper water, result in a longer impact range than the behavioral disturbance (without TTS) criteria impact range.

6.3.1   Summary of Thresholds and Criteria for Impulsive Sounds

Table 27 summarizes the effects, criteria, and thresholds used in the assessment for impulsive sounds. The criteria for behavioral effects without physiological effects used in this analysis are based on use of multiple explosives that only take place during an FIREX with IMPASS event.

Table 27   Effects, Criteria, and Thresholds for Impulsive Sounds

Effect	Criteria	Metric	Threshold	Effect
Mortality	Onset of Extensive Lung Injury	Goertner modified positive impulse	indexed to 30.5 psi-msec (assumes 100% small animal at 26.9 lb)	Mortality
Injurious Physiological	50% Tympanic Membrane Rupture	Energy flux density	1.17 in.-lb/in.^{2} (about 205 dB re 1 μPa^2-s)	*MMPA* - Level A
Injurious Physiological	Onset Slight Lung Injury	Goertner modified positive impulse	indexed to 13 psi-msec (assumes 100% small animal at 26.9 lb)	*MMPA* - Level A
Non-injurious Physiological	TTS	Greatest energy flux density level in any 1/3-octave band (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures	182 dB re 1 μPa^2-s	*MMPA* - Level B
Non-injurious Physiological	TTS	Peak pressure over all exposures	23 psi	*MMPA* - Level B
Non-injurious Behavioral	Behavioral Disturbance Without TTS	Greatest energy flux density level in any 1/3-octave (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures (multiple explosions only)	177 dB re 1 μPa^2-s	*MMPA* - Level B
MMPA = Marine Mammal Protection Act TTS = Temporary Threshold Shift				

6.3.2   Acoustic Environment

Sound propagation (the spreading or attenuation of sound) in the oceans of the world is affected by several environmental factors: water depth, variations in sound speed within the water column, surface roughness, and the geo-acoustic properties of the ocean bottom. These parameters can vary widely with location.

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

- **Seasonal Sound Velocity Profiles (SVPs)** – Plots of propagation speed (velocity) as a function of depth, or SVPs, are a fundamental tool used for predicting how sound will travel. Seasonal SVP averages were obtained for each training area.

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- **Seabed Geo-acoustics** – The type of sea floor influences how much sound is absorbed and how much sound is reflected back into the water column.

- **Wind Speeds** – Several environmental inputs, such as wind speed and surface roughness, are necessary to model acoustic propagation in the prospective training areas.

- **Bathymetry data** - Bathymetry data are necessary to model acoustic propagation and were obtained for each of the training areas.

6.3.3   Acoustic Effects Analysis

The acoustic effects analysis presented in the following sections is briefly described for each major type of exercise. A more in-depth effects analysis is in **Appendix A**.

FIREX with IMPASS

Modeling was completed for a 5-in. round, 8-lb NEW charge exploding at a depth of 1 ft (0.3 m). The analysis approach begins using a high-fidelity acoustic model to estimate energy in each 5-in. explosive round. Effects areas are calculated by summing the energy from multiple explosions over a FIREX with IMPASS mission, and determining the effects area based on the thresholds and criteria. MMPA - Level B exposures were determined based on the 177 dB re 1 μPa^2-s (energy) criteria for behavioral disturbance (without TTS) due to the use of multiple explosions.

Effect areas for a full FIREX with IMPASS event must account for the time and space distribution of 39 explosions, as well as the movement of animals over the several hours of the exercise. The total effect area for the 39-shot event is calculated as the sum of small effect areas for seven FIREX with IMPASS missions (each with four to six rounds fired) and one pre-FIREX with IMPASS action (with six rounds fired). **Table 28** shows the Zone of Influence (ZOI) results of the model estimation.

Table 28   Estimated ZOI (km^2) for a single FIREX with IMPASS Event

Area	Estimated ZOI @ 177 dB re 1 μPa^2-s (multiple detonations only)	Estimated ZOI @ 23 psi	Estimated ZOI @ 205 dB re 1 μPa^2-s or 13 psi
Navy Cherry Point			
4 & 5	0*	3.7387	0.18522
13 & 14	0*	3.7387	0.18522

In these areas, which occur in deeper water, the 23psi criteria dominates over the 177 dB re 1 μPa2-sec behavioral disturbance criteria and therefore was used in the analysis.

The ZOI, when multiplied by the animal densities and the total number of events (**Table 26**), provides the exposure estimates for that animal species for the nominal exercise case of 39 5-in. explosive rounds. The potential effects would occur within a series of small effect areas associated with the pre-calibration rounds and missions spread out over a period of several hours. Additionally, target locations are changed from event to event and because of the time lag between events, it is highly unlikely, even if a marine mammal were present (not accounting for mitigation), that the marine mammal would be within the small exposure zone for more than one event.

FIREX with IMPASS is restricted to two locations (4 &5 and 13 &14) (**Figure 1**). In addition to other mitigation measures (see **Section 11.4**), a dedicated lookout monitors the target area for marine mammals and sea turtles before the exercise, during the deployment of the IMPASS array, and during the return to firing position. Ships will not fire on the target until the area is cleared and will suspend the exercise if any enter the buffer area. Implementation of mitigation measures like these reduce the likelihood of exposure and potential effects in the ZOI.

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MINEX

The Comprehensive Acoustic System Simulation/Gaussian Ray Bundle (CASS/GRAB) (OAML, 2002) model, modified to account for impulse response, shock-wave waveform, and nonlinear shock-wave effects, was run for acoustic-environmental conditions derived from the Oceanographic and Atmospheric Master Library (OAML) standard databases. The explosive source was modeled with standard similitude formulas, as in the Churchill FEIS. Because all the sites are shallow (less than 50 m), propagation model runs were made for bathymetry in the range from 10 m to 40 m.

Estimated ZOIs varied as much within a single area as from one area to another, which had been the case for the Virtual at Sea Training (VAST)/IMPASS (DoN, 2004). There was, however, little season dependence. As a result, the ZOIs are stated as mean values with a percentage variation. Generally, in the case of ranges determined from energy metrics, as the depth of water increases, the range shortens. The single explosion TTS-energy criterion (182 dB re 1 μPa^2-s) was dominant and therefore used to determine the ZOI for the non-injurious physiological (MMPA – Level B) exposure analysis. **Table 29** shows the ZOI results of the model estimation.

Table 29   Estimated ZOI (km^2) for MINEX

Threshold	ZOIs
	20-lb NEW
Estimated ZOI @ 13 psi	0.13 km^2 ± 10%
Estimated ZOI @ 182 dB re 1 μPa^2-sec	0.8 km^2 ± 25%

The total ZOI, when multiplied by the animal densities (See **Chapter 4**) and total number of events (**Table 26**), provides the exposure estimates for that animal species for each specified charge. Because of the time lag between detonations, it is highly unlikely, even if a marine mammal were present (not accounting for mitigation), that the marine mammal would be within the small exposure zone for more than one detonation.

Underwater detonations are restricted to one area (UNDET Area, Onslow Bay) (**Figure 1**). In addition to other mitigation measures (see **Section 11.4**), observers will survey the target area for marine mammals and sea turtles for 30 min prior through 30 min post detonation. Detonations will be suspended if a marine mammal enters the ZOI and will only restart after the area has been clear for a full 30 min. Implementation of mitigation measures like these reduce the likelihood of exposure and potential effects in the ZOI.

MISSILEX (Hellfire and TOW)

Modeling was completed for three explosive missiles involved in MISSILEX, each assumed detonation at 1-m depth. The NEW used in the modelling of the Hellfire and TOW missiles are 8 lb, 15.33 lb respectively. The single explosion TTS-energy criterion (182 dB re 1 μPa^2-s) was used to determine the ZOI for the MMPA - Level B exposure analysis. **Table 30** shows the ZOI results of the model estimation. MISSILEX is restricted to W-122 (Area 16, 17; **Figure 1**). In addition to other mitigation measures (see **Section 11.4**), aircraft will survey the target area for marine mammals before and during the exercise. Ships will not fire on the target until the area is cleared and will suspend the exercise if any enter the buffer area. Implementation of mitigation measures like these reduce the likelihood of exposure and potential effects in the ZOI.

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Table 31   Estimated ZOI (km^2) for MISSILEX

Area	Ordnance	Esitmated ZOI @ 182 dB re 1 µPa2-sec or 23 psi				Estimated ZOI @ 205 dB re 1 µPa2-sec or 13 psi				Estimated ZOI @ 30.5 psi			
		Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
Navy Cherry Point													
Area 16 17	Hellfire	0.31	0.31	0.31	0.31	0.04	0.04	0.04	0.04	<0.01	<0.01	<0.01	<0.01
Area 16 17	TOW	0.39	0.39	0.35	0.39	0.04	0.04	0.04	0.04	<0.01	<0.01	<0.01	<0.01

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The total ZOI, when multiplied by the animal densities (See **Chapter 4**) and total number of events (**Table 26**), provides the exposure estimates for that animal species for each specified missile. Because of the time lag between detonations, it is highly unlikely, even if a marine mammal were present (not accounting for mitigation), that the marine mammal would be within the small exposure zone for more than one detonation.

6.3.4　Summary of Potential Exposures from Explosive Ordnance Use

Explosions that occur in the OPAREA are associated with training exercises that use explosive ordnance, including missiles (MISSILEX), and 5-in. explosive naval gun shells with (FIREX, with IMPASS), as well as underwater detonations associated with Mine Neutralization training (MINEX). Explosive ordnance use and underwater detonation is limited to a few specific training areas.

An explosive analysis was conducted to estimate the number of marine mammals that could be exposed to impacts from explosions. **Table 31** provides a summary of the explosive analysis results. Fin, humpback whales, and sperm whales will have high detections rates at the surface because of their large body size and pronounced blows. Because of large group sizes, it is likely that lookouts would detect Atlantic spotted dolphins, bottlenose dolphins, Clymene, common, pantropical spotted dolphins, Risso's dolphins, rough-toothed dolphin, and striped dolphins.

Exposure estimates could not be calculated for several species (blue whale, sei whale, Bryde's whale, killer whale, pygmy killer whale, false killer whale, melon-headed whale, spinner dolphin, Fraser's dolphin, and harbor porpoise) because density data could not be calculated due to the limited available data for these species. Lack of density estimates reflect the paucity of sighting data for these species in the Study Area. It is assumed that fewer or no sightings result from low numbers of animals in the area. Therefore, the likelihood of exposure for species with no density estimates should be even lower than that estimated for other species with given densities since a lack of density indicates that they are less likely to occur in the Study Area.

In addition to the low likelihood of exposure, the mitigation measures presented in **Chapter 11** will be implemented. Lookouts will monitor the area before ordnance is used. Implementation of mitigation measures will reduce the likelihood of exposure and potential effects.

6.3.5　Potential Effects of Exposures to Explosives

Effects from exposure to explosive vary depending on the level of exposure.

Animals exposed to levels that constitute MMPA - Level B may experience a behavioral disruption from the use of explosive ordnance. Behavioral responses 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 (NRC, 2005); however, it is not known how these responses relate to significant effects (e.g., long-term effects or population consequences) (NRC, 2005). In addition, animals exposed to levels that constitute MMPA Level B may experience a TTS, which may result in a slight, recoverable loss of hearing sensitivity (DoN, 2001).

Exposures that reach MMPA - Level A may result in long-term injuries such as PTS. The resulting injuries may limit an animal's ability to find food, communicate with other animals, and/or interpret the environment around them. Impairment of these abilities can decrease an individual's chance of survival or impact their ability to successfully reproduce. MMPA - Level A harassment will have a long-term impact on an exposed individual.

Mortality of an animal will remove the animal entirely from the population as well as eliminate any future reproductive potential.

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Based on best available science the Navy concludes that exposures to explosive ordnance and underwater detonations would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival of the species. The mitigations presented in **Chapter 11** will further reduce the potential for exposures.

Table 31   **Summary of Potential Exposures from Explosive Ordnance (per year) for Marine Mammals in the Navy Cherry Point OPAREA**

Species/Training Operation	Potential Exposures @ 177 dB re 1 μPa^2-s (multiple detonations only)	Potential Exposures @ 182 dB re 1 μPa^2-s or 23 psi	Potential Exposures @ 205 dB re 1 μPa^2-s or 13 psi	Potential Exposures @ 30.5 psi
Fin whale				
MISSILEX training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Humpback whale				
MISSILEX training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
North Atlantic right whale				
MISSILEX training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Sperm whale				
MISSILEX training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Atlantic Spotted dolphin				
MISSILEX Training	NA	1	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	1	0	0
Total Exposures	**0**	**2**	**0**	**0**
Beaked whale				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Bottlenose dolphin				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	1	0	0
Total Exposures	**0**	**1**	**0**	**0**
Clymene dolphin				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**

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Table 31   **Summary of Potential Exposures from Explosive Ordnance (per year) for Marine Mammals in the Navy Cherry Point OPAREA (*continued*)**

Species/Training Operation	Potential Exposures @ 177 dB re 1 μPa^2-s (multiple detonations only)	Potential Exposures @ 182 dB re 1 μPa^2-s or 23 psi	Potential Exposures @ 205 dB re 1 μPa^2-s or 13 psi	Potential Exposures @ 30.5 psi
Common dolphin				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Kogia spp.				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Minke whale				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Pantropical spotted dolphin				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Pilot whales				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Risso's dolphin				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Rough-toothed dolphin				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**
Striped dolphin				
MISSILEX Training	NA	0	0	0
FIREX with IMPASS training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	**0**	**0**	**0**	**0**

Note: Events were either modeled for 177 dB re 1 μPa^2-s due to multiple detonations (FIREX with IMPASS) or modeled for 182 dB re 1 μPa^2-s or 23 psi due to single detonations (MISSILEX and MINEX). Therefore, for FIREX with IMPASS the NA refers to the criterion that is relevant for single detonations and therefore not modeled for these events. For MISSILEX and MINEX the NA refers the criterion that is relevant for multiple detonations and therefore not modeled for these events.

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CHAPTER 7   IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

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

- Most exposures are within the non-injurious TTS or behavioral effects zones (MMPA Level B harassment).

- Although the numbers presented in **Table 31** represent estimated harassment and mortality under the MMPA, the model calculates harassment without taking into consideration standard mitigation measures and likely over estimates the possibility of injury or harm.

- Additionally, the mitigation measures described in **Chapter 11** are designed to reduce exposure of marine mammals to potential impacts to achieve the least practicable adverse effect on marine mammal species or stocks.

The Navy concludes that Atlantic Fleet training in the Navy Cherry Point Range Complex would result in no exposures to the following marine mammal species:

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

The Navy concludes that exposures to the following marine mammal species due to Atlantic Fleet training in the Navy Cherry Point Range Complex would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival:

- Atlantic spotted dolphin
- Bottlenose dolphin

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CHAPTER 8   IMPACTS ON SUBSISTENCE USE

Potential impacts resulting from the proposed action would be limited to individuals of marine mammal species located off the East Coast of the U.S., and would not affect Arctic marine mammals that are harvested for subsistence use. Therefore, the proposed action would not have an unmitigable adverse impact on the availability of marine mammals for subsistence used identified in MMPA Section 101(a)(5)(A)(i): [16 U.S.C. § 1371 (a)(5)(A)].

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Chapter 9 – Impacts to Marine
Mammal Habitat and
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CHAPTER 9   IMPACTS TO MARINE MAMMAL HABITAT AND RESTORATION LIKELIHOOD

Sources from Atlantic Fleet training activities that may affect marine mammal habitat include changes in water quality, the introduction of sound into the water column, and temporary changes to prey distribution and abundance. There is no critical habitat designated in the Navy Cherry Point Study Area.

9.1   Water Quality

The Navy Cherry Point EIS/OEIS analyzed the potential effects to water quality from expendable and hazardous training items associated with the various exercises taking place. Training activities would introduce pollutants into the water column. Based on the analysis, these pollutants would be released in quantities and at rates that would not result in a violation of any water quality standard or criteria. The pollutants would immediately disperse and water quality would be expected to return to an original state.

Equipment used by military organizations within the Navy Cherry Point Range Complex, including ships and other marine vessels, aircraft, and other equipment, are also potential sources of pollutants. All equipment is properly maintained in accordance with applicable Navy or legal requirements. All such operating equipment meets federal water quality standards, where applicable.

Military training activities in the Navy Cherry Point OPAREA involving the use of high explosives are potential sources of water quality pollutants. Initial concentrations of explosion by-products are not expected to be hazardous to marine life (DoN, 2001) and would not accumulate in the training area because exercises are spread out over time and chemicals rapidly disperse in the ocean. Any potential impacts to water quality from combustion products are localized and temporary. The water quality in the area would not be substantially affected by these products and would be expected to immediately return to the original state.

9.2   Sound in the Water Column

Various activities and events, both natural and anthropogenic, above and below the water's surface, contribute to oceanic ambient or background noise. Anthropogenic noise attributable to military activities in the Navy Cherry Point Range Complex emanates from multiple sources including naval ship power plants, military aircraft, surface or airborne targets, bombs, missiles, small arms and underwater detonations. Sound produced from military sources in the Navy Cherry Point Range Complex is temporary and transitory. The sounds produced during training activities can be widely dispersed or concentrated in small areas for varying periods. Any anthropogenic noise attributed to activities in the Navy Cherry Point Range Complex would be temporary and the affected area would be expected to immediately return to the original state when these activities cease.

9.3   Prey Distribution and Abundance

Physical effects from pressure waves generated by underwater detonations of explosives might affect fish within proximity of the source. In particular, the rapid oscillation between high and low-pressure peaks has the potential to burst the swim bladders and other gas-containing organs of fish (Keevin and Hemen 1997). Sublethal effects, such as changes in behavior of fish, have been observed in several occasions as a result of noise produced by explosives (Wright 1982; NRC 2003). The abundances of various fish and invertebrates near the detonation point could be altered for a few hours before animals from surrounding areas repopulate the area; however these populations would be replenished as waters near the detonation point are mixed with adjacent waters.

Any training item (ex. bomb casings, mine simulators, etc.) left behind during exercises would result in minor, but long-term changes to benthic habitat. Similar to an artificial reef structure, the structure

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would be colonized overtime by benthic organisms that prefer hard substrate and would provide structure that could attract some species of fish.

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Chapter 10 – Impacts to Marine
Mammals from Loss or
Modification of Habitat

CHAPTER 10   IMPACTS TO MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

Based on discussions in **Chapter 9**, marine mammal habitat will not be lost; however, it may be modified. Modifications to the water column would be short-term in nature while modifications to the sea floor may be longer-term. Potential impacts to marine mammal habitat are not anticipated to alter the function of the habitat and, therefore, will have little to no impact of marine mammal species.

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CHAPTER 11   MITIGATION MEASURES

INTRODUCTION

Effective training in the Navy Cherry Point Range Complex dictates that ship, submarine, and aircraft participants utilize their sensors and exercise weapons to their optimum capabilities as required by the mission. Recognizing that in some cases this training has the potential to impact the environment, as part of its commitment to sustainable use of resources and environmental stewardship the Navy incorporates measures that are protective of the environment into all of its activities. Some of these measures are generally applicable and others are designed to apply to certain geographic areas, during certain times of year, and/or for specific types of Navy training.

Due to the nature of the proposed action analyzed in this document, mitigation measures for many elements of the action have been established through previous environmental analyses, consultation, and/or permitting processes.

APPROACH

Mitigation of impacts is defined in the Council on Environmental Quality (CEQ) regulations (40 CFR 1508.20) to include avoidance, minimization, rectification, reduction/elimination over time, and compensation. Given the nature of the proposed action and alternatives and potential impacts analyzed here, the Navy believes that a comprehensive approach to mitigation for the Navy Cherry Point Range Complex requires focus on: (1) mitigation by avoidance, in which adverse impacts are avoided altogether by altering the location, design, or other aspect of an activity, and (2) minimization of impacts when avoidance is not feasible. An important complement to the *avoidance* and *minimization* of impacts is *monitoring* to track compliance with take authorizations, impacts on protected resources, and effectiveness of mitigation measures. Taken together, these three elements – avoidance, minimization, and monitoring – comprise the Navy's integrated approach to addressing potential environmental impacts.

Avoidance. Avoidance of geographic areas of particular sensitivity has been integrated into the proposed action and alternatives where feasible. Mitigation measures discussed later in this chapter involve avoidance of sensitive areas. Planning for training activities takes into consideration the sitting of activities, the possible impacts to a resource, and whether/how training locations could be planned to avoid sensitive areas (e.g. those known to have a high density of protected species or the presence of a protected species of particular concern). Consideration is also given to avoiding smaller scale habitats (e.g. *Sargassum* rafts, a known sea turtle habitat) as they are encountered during an activity. Those avoidance measures that require an ongoing evaluation of conditions or awareness during an activity are listed later in this chapter.

Minimization. In some cases, avoiding environmentally sensitive locations altogether is not possible. In these instances, mitigation measures have been designed to minimize the potential for impact on the resources of concern. These minimization measures are also listed in this chapter.

Monitoring. A well-designed monitoring program can provide important feedback for validating assumptions made in analyses and allow for adaptive management. Since monitoring will be a requirement for compliance with the final rule issued for this proposed action under the MMPA, details of the monitoring program will be developed in coordination with NMFS through those regulatory processes. A description of the monitoring program framework is provided in **Chapter 13**.

It is important to note that discussions with resource agencies as part of consultation and permitting processes may result in changes to the mitigation as described in this document. Such changes will be

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reflected in the final EIS associated with this LOA Request as well as in documents that result from other regulatory processes (e.g. ESA Biological Opinion).

The DoN recognizes that such use has the potential to cause behavioral disruption of some marine mammal species in the vicinity of training, as discussed in **Chapter 6**. This chapter presents the Navy's mitigation measures that would be implemented to protect marine mammals and federally listed species during training activities. It should be noted that several of these mitigation measures align with mitigation measures for unit-level training that the Navy has had in place since 2004. In addition, the Navy coordinated with the NMFS to further develop measures for protection of marine mammals during the period of the National Defense Exemption[7].

Section 11.1 presents those measures that are taken by Navy personnel on a regular basis are known as "Standard Operating Procedures." Section 11.2 contains information for coordination with the local NMFS Stranding Coordinator. Section 11.3 presents special measures associated with the North Atlantic right whale and Section 11.4 presents those measures that would be taken *in addition to* standard naval operating procedures.

11.1   General Maritime Measures

11.1.1   Personnel Training – Watchstanders and Lookouts

The use of shipboard lookouts is a critical component of all Navy standard operating procedures. 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 OOD (e.g., trash, a periscope, marine mammals, sea turtles) and all disturbances (e.g., surface disturbance, discoloration) that may be indicative of a threat to the vessel and its crew. There are personnel serving as lookouts on station at all times (day and night) when a ship or surfaced submarine is moving through the water.

1. All COs, XOs, lookouts, OOD, junior OOD (JOOD), maritime patrol aircraft aircrews, and MIW helicopter crews will complete the NMFS-approved MSAT by viewing the U.S. Navy MSAT digital versatile disk (DVD). MSAT may also be viewed on-line at https://mmrc.tecquest.net. All bridge watchstanders/lookouts will complete both parts one and two of the MSAT; part two is optional for other personnel. 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.

2. Navy lookouts will undertake extensive training in order to qualify as a watchstanders in accordance with the Lookout Training Handbook (NAVEDTRA 12968-B).

3. Lookout training will include on-the-job instruction under the supervision of a qualified, experienced watchstander. Following successful completion of this supervised training period, lookouts will complete the Personal Qualification Standard Program, certifying that they have demonstrated the necessary skills (such as detection and reporting of partially submerged objects).

4. Lookouts will be trained by the most effective means to ensure quick and effective communication within the command structure in order to facilitate implementation of protective measures if marine species are spotted.

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[7] The National Defense Exemption (NDE) was primarily developed to address potential effects to marine mammals from the Navy's use of mid-frequency active sonar (MFAS). The first National Defense Exemption (NDE I) was in effect from July 2007 to December 2007. NDE II went into effect in January 2007 and will expire in January 2009.

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5. 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.

6. 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.

11.1.2   Operating Procedures & Collision Avoidance

1. Prior to major exercises, a Letter of Instruction, Mitigation Measures Message or Environmental Annex to the Operational Order will be issued to further disseminate the personnel training requirement and general marine species protective measures.

2. COs will make use of marine species detection cues and information to limit interaction with marine species to the maximum extent possible consistent with safety of the ship.

3. While underway, surface vessels will have at least two lookouts with binoculars; surfaced submarines will have at least one lookout with binoculars. Lookouts already posted for safety of navigation and man-overboard precautions may be used to fill this requirement. As part of their regular duties, lookouts will watch for and report to the OOD the presence of marine mammals and sea turtles.

4. On surface vessels equipped with a multi-function active sensor, pedestal mounted "Big Eye" (20x10) binoculars will be properly installed and in good working order to assist in the detection of marine mammals and sea turtles in the vicinity of the vessel.

5. Personnel on lookout will employ visual search procedures employing a scanning methodology in accordance with the Lookout Training Handbook (NAVEDTRA 12968-B).

6. After sunset and prior to sunrise, lookouts will employ Night Lookouts Techniques in accordance with the Lookout Training Handbook (NAVEDTRA 12968-B).

7. While in transit, naval vessels will be alert at all times, use extreme caution, and proceed at a "safe speed" so that the vessel can take proper and effective action to avoid a collision with any marine animal and can be stopped within a distance appropriate to the prevailing circumstances and conditions.

8. When whales have been sighted in the area, Navy vessels will increase vigilance and take reasonable and practicable actions to avoid collisions and activities that might result in close interaction of naval assets and marine mammals. Actions may include changing speed and/or direction and are dictated by environmental and other conditions (e.g., safety, weather).

9. Naval vessels will maneuver to keep at least 1,500 ft (460 m) away from any observed whale and avoid approaching whales head-on. This requirement does not apply if a vessel's safety is threatened, such as when change of course will create an imminent and serious threat to a person, vessel, or aircraft, and to the extent vessels are restricted in their ability to maneuver. Restricted maneuverability includes, but is not limited to, situations when vessels are

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engaged in dredging, submerged operations, launching and recovering aircraft or landing craft, minesweeping operations, replenishment while underway and towing operations that severely restrict a vessel's ability to deviate course. Vessels will take reasonable steps to alert other vessels in the vicinity of the whale.

10. Where feasible and consistent with mission and safety, vessels will avoid closing to within 200 yards (yd) (183 m) of sea turtles and marine mammals other than whales (whales addressed above).

11. Floating weeds, algal mats, *Sargassum* rafts, clusters of seabirds, and jellyfish are good indicators of sea turtles and marine mammals. Therefore, increased vigilance in watching for sea turtles and marine mammals will be taken where these are present.

12. Navy aircraft participating in exercises at sea will 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. Marine mammal detections will be immediately reported to assigned Aircraft Control Unit for further dissemination to ships in the vicinity of the marine species as appropriate where it is reasonable to conclude that the course of the ship will likely result in a closing of the distance to the detected marine mammal.

13. All vessels will maintain logs and records documenting training operations should they be required for event reconstruction purposes. Logs and records will be kept for a period of 30 days following completion of a major training exercise.

11.2   Coordination and Reporting Requirements

The Navy will coordinate with the local 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 (hr) after completion of training activities. Additionally, the Navy will follow internal chain of command reporting procedures as promulgated through Navy instructions and orders.

11.3   Mitigation Measures Applicable Vessel Transit in the Mid-Atlantic during North Atlantic 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. 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 U.S. 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 15 through April 30, 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. 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 32** below and within a 20 nm (37 km) arc (except as noted) of the specified reference points.

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 surfaced vessels transiting within 30 nm (56 km) 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

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approach any whale head on and would maneuver to keep at least 500 yd (457 m) away from any observed whale, consistent with vessel safety.

Table 32   North Atlantic Right Whale Migration Port References

Region	Months	Port Reference Points
South and East of Block Island, Rhode Island	Sep–Oct and Mar–Apr	37 km (20 NM) seaward of line between 41-4.49N 071-51.15W and 41-18.58N 070-50.23W
New York / New Jersey	Sep–Oct and Feb-Apr	40-30.64N 073-57.76W
Delaware Bay (Philadelphia)	Oct–Dec and Feb–Mar	38-52.13N 075-1.93W
Chesapeake Bay (Hampton Roads and Baltimore)	Nov-Dec and Feb–Apr	37-1.11N 075-57.56W
North Carolina	Dec–Apr	34-41.54N 076-40.20W
South Carolina	Oct–Apr	33-11.84N 079-8.99W 32-43.39N 079-48.72W

11.4   Measures for specific at-sea training events

The measures in the following sections are standard operating procedures currently in place and will be used in the future for all activities being analyzed in this LOA request.

11.4.1   Firing Exercise (FIREX) Using the Integrated Maritime Portable Acoustic Scoring System (IMPASS) (5-in. explosive and non-explosive rounds)

FIREX using IMPASS will occur in two areas in the Navy Cherry Point Study Area: Areas of 4/5 & 13/14. The locations were established to be far enough from shore to reduce civilian encounters (e.g., diving and recreational fishing). Surface ships conducting FIREX with IMPASS do not have strict distance from land restrictions like aircraft that embark from shore-based facilities.

1. FIREX using IMPASS will only be conducted in Areas 4/5 and 13/14.

2. Pre-exercise monitoring of the target area will be conducted with "Big Eyes"[8] prior to the event, during deployment of the IMPASS sonobuoy array, and during return to the firing position. Ships will maintain a lookout dedicated to visually searching for marine mammals and sea turtles 180° along the ship track line and 360° at each buoy drop-off location.

3. "Big Eyes" on the ship will be used to monitor a 640-yd (585-m) buffer zone for marine mammals/sea turtles during naval-gunfire events.

4. Ships will not fire on the target if any marine mammals or sea turtles are detected within or approaching the 640-yd (585-m) buffer zone until the area is cleared. If marine mammals or sea turtles are present, operations would be suspended. Visual observation will occur for approximately 45 min, or until the animal has been observed to have cleared the area and is heading away from the buffer zone.

5. Post-exercise monitoring of the entire effect range will take place with "Big Eyes" and the naked eye during the retrieval of the IMPASS sonobuoy array following each firing exercise.

6. The naval gunfire will only take place during daylight hours only.

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[8] "Big Eyes" are 20 x 110 binoculars.

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7. The naval gunfire utilizing 5-in. rounds will only be used in Beaufort Sea State three (3)[9] or less.

8. The visibility must be such that the fall of shot is visible from the firing ship during the exercise.

9. No firing will occur if marine mammals are detected within 70 yd (64 m) of the vessel.

11.4.2 Air-to-Surface Missile Exercises (explosive)

Marine Corps helicopters launch their Hellfire and TOW missiles in Air 16 and 17 of W-122 in the Navy Cherry Point Study Area. These sub-areas are far enough from shore to reduce civilian encounters (e.g., diving and recreational fishing), while remaining within 60nm of shore-based facilities, close enough so a helicopter can complete its training mission before needing to return for refueling.

1. This activity will only occur in Air 16 and 17 of W-122 for Hellfire and TOW missile launches.

2. The surface vessel that establishes the target area and deploys the target and unmanned remotely-controlled tow vehicle (if applicable) will use trained lookouts to survey the prospective target area for *Sargassum* rafts (which may be inhabited by immature sea turtles), sea turtles, and marine mammals. A target area shall not be established within 1,800 yards (1,646 m) of known or observed coral/live hardbottom, *Sargassum* rafts, sea turtles, or marine mammals.

3. Before launching a missile, participant aircraft will visually survey the target area for marine mammals and sea turtles at 1,500 ft altitude or lower, if safe to do so, and at slowest safe speed. The aircrew must be able to actually see ordnance impact areas. Explosive ordnance shall not be targeted to impact within 1,800 yd (1,646 m) of known or observed coral/live hardbottom, *Sargassum* rafts, marine mammals, or sea turtles.

11.4.3 Mine Neutralization Training Involving Underwater Detonations (up to 20-lb charges)

Mine neutralization involving underwater detonations occurs in shallow water (0-120 ft or 0-36 m) and is executed by divers using scuba.

These exercises utilize small boats that deploy from shore based facilities. Often times these small boats are rigid-hulled inflatable boats (RHIBs) which are designed for shallow water and have limited seaworthiness necessitating a nearshore location. The exercise is a 1-day event that occurs only during daylight hours therefore the distance from shore is limited.

1. This activity will only occur in the UNDET area of Onslow Bay.

2. Observers will survey the ZOI, a 656-yd (600-m) radius from detonation location, for marine mammals and sea turtles from all participating vessels during the entire operation. A survey of the ZOI (minimum of three parallel tracklines 219 yd [200 m] apart) using support craft will be conducted at the detonation location 30 minutes prior through 30 min post detonation. During late July through October, an additional surface observer will be added to more carefully look for hatchling turtles in the ZOI. Aerial survey support will be utilized whenever assets are available.

3. Detonation operations will be conducted during daylight hours.

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[9] The Beaufort Scale of Wind Force was developed as a means for sailors to gauge wind speeds through visual observations of the sea state. The scale runs from 0 for calm to force 12 for Hurricane.

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4. If a sea turtle or marine mammal is sighted within the ZOI, the animal will be allowed to leave of its own volition. The Navy will suspend detonation exercises and ensure the area is clear for a full 30 min prior to detonation.

5. Divers placing the charges on mines and dive support vessel personnel will survey the area for sea turtles and marine mammals and will report any sightings to the surface observers. These animals will be allowed to leave of their own volition and the ZOI will be clear for 30 min prior to detonation.

6. No detonations will take place within 3.2 nm (6 km) of an estuarine inlet (Bogue, Bear, Browns, New River, Inlets).

7. No detonations will take place within 1.6 nm (3 km) of shoreline.

8. No detonations will take place within 0.5 nm (1 km) of any artificial reef, shipwreck, or live hard-bottom community.

9. Personnel will record any protected species observations during the exercise as well as measures taken if species are detected within the ZOI.

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CHAPTER 12   MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Based on the discussion in **Chapter 8.0**, there are no impacts on the availability of species or stocks for subsistence use.

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CHAPTER 13   MONITORING AND REPORTING MEASURES

The Navy is committed to demonstrating environmental stewardship while executing its National Defense mission and is responsible for compliance with a suite of Federal environmental and natural resources laws and regulations that apply to the marine environment. A number of monitoring plans are currently being developed for protected marine species (primarily marine mammals and sea turtles) as part of the environmental planning and regulatory compliance process associated with a variety of training actions and range complexes. The purpose of these monitoring plans is to assess the effects of training activities on marine species. The primary focus of these monitoring plans will be on effects to individuals but data may also support investigation of potential population-level trends in marine species distribution, abundance, and habitat use in various range complexes and geographic locations where Navy training occurs.

The Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species in order to establish the overarching framework and oversight that will facilitate the collection and synthesis of information and data from the various monitoring efforts being implemented. The Program will compile data from range-specific monitoring efforts as well as research and development (R&D) studies that are fully or partially Navy-funded. While the ICMP is not a regulatory requirement, it will facilitate the synthesis of information across multiple monitoring efforts and help to coordinate the most efficient use of limited resources in order to address monitoring concerns navy-wide. Although the ICMP is intended to apply to all Navy training, use of MFA sonar in training, testing, and research, development, test, and evaluation (RDT&E) will comprise a major component of the overall program.

The primary objectives of the ICMP are:

- To monitor Navy training exercises, particularly those involving active sonar and underwater detonations, for compliance with the terms and conditions of ESA Section 7 consultations or MMPA authorizations;
- To minimize exposure of protected species to sound levels from active sonar or sound pressure levels from underwater detonations currently considered to result in harassment;
- To collect data to support estimating the number of individuals exposed to sound levels above current regulatory thresholds;
- To assess the efficacy of the Navy's current marine species mitigation;
- To assess the practicality and effectiveness of potential future mitigation tools and techniques;
- To document trends in species distribution and abundance in Navy training areas through focused longitudinal monitoring efforts;
- To add to the knowledge base on potential behavioral and physiological effects to marine species from active sonar and underwater detonations.

The ICMP will provide a comprehensive structure and serve as the basis for establishing monitoring plans for individual range complexes and specific training activities. Specific training exercise plans will be focused on short-term monitoring and mitigation for individual training activities. Each training event will be evaluated to determine if it represents an appropriate monitoring opportunity within the ICMP framework. Due to the scale (spatial, temporal, and operational) of various training activities, not every event will present optimum opportunity for concentrated monitoring and as a result various levels of effort and resources will be associated with individual exercises. The overall approach of the ICMP is to target the majority of available monitoring resources on a limited number of opportunities with best potential for high quality data collection rather than attempting to apply a thin blanket of monitoring over the entirety of Navy training.

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Data collection methods will be standardized across the program to the extent possible to provide the best opportunity for pooling data from multiple regions. Some methods may be universally applicable; however, some may be utilized only in specific locations where conditions are most appropriate. For example, in Hawaii, there is significant baseline data on odontocetes from tagging, which can be used to provide context for tagging data collected during training events. The navy's overall monitoring approach will seek to leverage and build upon existing research efforts whenever possible.

By using a combination of monitoring techniques or tools appropriate for the species of concern, the type of training activities conducted, sea state conditions, and the appropriate spatial extent, the detection, localization, and observation of marine species can be optimized and return on the monitoring investment can be maximized in terms of data collection and mitigation effectiveness evaluation. The ICMP will evaluate the range of potential monitoring techniques that can be tailored to any Navy range or exercise and the appropriate species of concern. The primary tools available for monitoring generally include the following:

- Visual Observations – Surface vessel and aerial survey platforms can provide data on both long term population trends (abundance and distribution) as well as occurrence immediately before, during, and after training events. In addition, visual observation has the potential to collect information related to behavioral response of marine species to Navy training activities. Both Navy personnel (watchstanders) and independent visual observers (Navy biologists and will be used from a variety of platforms (both navy and third-party) will be utilized for monitoring as appropriate and logistically feasible.

- Passive Acoustic Monitoring – Autonomous Acoustic Recorders (moored buoys), High Frequency Acoustic Recording Packages (HARPS), sonobuoys, passive acoustic towed arrays, shipboard passive sonar, and Navy Instrumented Acoustic Ranges can provide data on presence/absence as well as localization, identification and tracking in some cases. Passive acoustic observations are particularly important for species that are difficult to detect visually or when conditions limit the effectiveness of visual monitoring. Instrumented navy ranges present a unique opportunity to take advantage of infrastructure that would otherwise not be available for monitoring such a large area. The Marine Mammal Monitoring on Navy Ranges (M3R) program takes advantage of this opportunity and may support long-term data collection at specific fixed sites.

- Tagging is an important tool for examining the movement patterns and diving behavior of cetaceans. Sensors can be used that measure location, swim velocity, orientation, vocalizations, as well as record received sound levels. Tagging with sophisticated digital acoustic recording tags (D-tags) may also allow direct monitoring of behaviors not readily apparent to surface observers. D-tags have recently been deployed as part of a behavioral response study (BRS-07) initiated at the Atlantic Undersea Test and Evaluation Center (AUTEC) range in the Bahamas to begin identifying behavioral mechanisms related to anthropogenic sound exposure.

- Photo identification and tagging of animals – Photo identification contributes to understanding of movement patterns and stock structure which is important to determine how potential effects may relate to individual stocks or populations.

- Oceanographic and environmental data collection – Physical and environmental data related to habitat parameters is necessary for analyzing distribution patterns, developing predictive habitat and density models, and better understanding habitat use.

Because data concerning physiological and behavioral effects, as well as long-term modifications of habitat use are extremely limited at this time, geographically-fixed longitudinal monitoring sites may be incorporated to assess potential effects to marine mammals both at the individual and population level.

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One example of this geographically fixed monitoring approach is the program recently initiated for the proposed Undersea Warfare Training Range (USWTR) in the Atlantic. The Navy contracted with a consortium of researchers from Duke University, the University of North Carolina at Wilmington, the University of St. Andrews, and the NMFS NEFSC to conduct a pilot study analysis and subsequently develop a survey and monitoring plan that prescribes the recommended approach for data collection including surveys (aerial/shipboard, frequency, spatial extent, etc.), passive acoustic monitoring, photo identification and data analysis (standard line-transect, spatial modeling, etc.) necessary to establish a fine-scale seasonal baseline of protected species distribution and abundance. This baseline study will provide the foundation for establishing a monitoring program designed to provide meaningful data on potential long term effects to marine species that may be chronically exposed to training activities on the USWTR. The baseline data collection portion of the program began in June 2007 at the Onslow Bay alternative site and includes coordinated aerial, shipboard, and passive acoustic surveys as well as deployment of HARPs to supplement the traditional visual surveys. A similar program is currently being initiated at the Jacksonville preferred site.

In addition to the specific monitoring initiative outlined above, the ICMP framework proposes that the Navy will continue to collaborate with and incorporate data from studies of behavioral response, abundance, distribution, habitat utilization, etc. for species of concern using a variety of methods which may include visual surveys, passive and acoustic monitoring, radar and data logging tags (to record data on acoustics, diving and foraging behavior, and movements). This work will help to build the collective knowledgebase on the geographic and temporal extent of key habitats and provide baseline information to account for natural perturbations such as El Niño or La Niña events as well as establish baseline information to determine the spatial and temporal extent of reactions to Navy operations, or indirect effects from changes in prey availability and distribution. Both the Office of Naval Research (ONR) and Chief of Naval Operations (CNO) are heavily involved in supporting a variety of ongoing research efforts (summarized in the following section) including the recent Behavioral Response Study (BRS-07) conducted at AUTEC during the summer of 2007.

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CHAPTER 14   RESEARCH EFFORTS

The Navy provides a significant amount of funding and support to marine research. In 2008 the agency provided over $26 million to universities, research institutions, Federal laboratories, private companies, and independent researchers around the world to study marine mammals. Over the past 5 r the Navy has provided over $100 million for marine mammal research. The Navy sponsors approximately 70% of all U.S. research concerning the effects of human-generated sound on marine mammals and 50% of such research conducted worldwide. Major topics of Navy-supported research include the following:

- Better understanding of marine species distribution and important habitat areas,
- Developing methods to detect and monitor marine species before and during training,
- Understanding the effects of sound on marine mammals, sea turtles, fish, and birds, and
- Developing tools to model and estimate potential effects of sound.

This research is directly applicable to Navy training activities, particularly with respect to the investigations of the potential effects of underwater noise sources on marine mammals and other protected species. Proposed training activities employ sonar and underwater explosives, which introduce sound into the marine environment.

The Marine Life Sciences Division of the ONR currently coordinates six programs that examine the marine environment and are devoted solely to studying the effects of noise and/or the implementation of technology tools that will assist the Navy in studying and tracking marine mammals. The six programs are as follows:

1. Environmental Consequences of Underwater Sound,
2. Non-Auditory Biological Effects of Sound on Marine Mammals,
3. Effects of Sound on the Marine Environment,
4. Sensors and Models for Marine Environmental Monitoring,
5. Effects of Sound on Hearing of Marine Animals, and
6. Passive Acoustic Detection, Classification, and Tracking of Marine Mammals.

The Navy has also developed a suite of technical reports synthesizing data and information on marine resources throughout Navy OPAREA including the MRA and the NODE reports. Furthermore, population assessment cruises by the NMFS and by academic institutions have regularly received funding support from the Navy. For instance, the Navy funded a marine mammal survey in the Marinas Islands to gather information to support an environmental study in that region given there had been no effort undertaken by NMFS.

The Navy has sponsored several workshops to evaluate the current state of knowledge and potential for future acoustic monitoring of marine mammals. The workshops brought together acoustic experts and marine biologists from the Navy and other research organizations to present data and information on current acoustic monitoring research efforts and to evaluate the potential for incorporating similar technology and methods on instrumented ranges. However, acoustic detection, identification, localization, and tracking of individual animals still requires a significant amount of research effort to be considered a reliable method for marine mammal monitoring. The Navy supports research efforts on acoustic monitoring and will continue to investigate the feasibility of passive acoustics as a potential mitigation and monitoring tool.

At present the Navy-sponsored M3R program represents the most promising effort investigating the utility of passive acoustic monitoring specifically associated with Navy instrumented training ranges. The main objective of the M3R project is to develop a toolset for passive detection, localization, and

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tracking of marine mammals using existing Navy undersea range infrastructure. The project is funded by the ONR and CNO (N45) as an effort to provide an effective means of studying marine mammals in natural, open ocean environments.

M3R has successfully developed and tested a suite of signal processing tools that can automatically detect and track marine mammals in real-time using Navy range facilities at both AUTEC and Southern California Offshore Range (SCORE). The M3R toolset allows automated collection of data previously unavailable for the long-term monitoring of the acoustic behavior of marine mammals within their natural environment. Ongoing research applications of the M3R system include the ability to remotely estimate marine mammal abundance, assessment of acoustic behavioral baselines, and evaluation of effects of anthropogenic noise by comparison to those baselines. As these capabilities continue to be developed and mature they may become integrated components of the overall ICMP framework.

Overall, the Navy will continue to support and fund ongoing marine mammal research, and is planning to coordinate long-term monitoring/studies of marine mammals on various established ranges and operating areas. The Navy will continue to research and contribute to university/external research to improve the state of the science regarding marine species biology and acoustic effects. These efforts include mitigation and monitoring programs; data sharing with NMFS and via the literature for research and development efforts; and future research as described previously.

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Appendix A

Draft Technical Risk Assessment
for the
Use of Underwater Explosives in the Cherry Point Range Complex

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CHAPTER 1   INTRODUCTION

This appendix provides the background information, assumptions, and the details of the impact assessment for use of underwater explosives in conjunction with the training outlined in Chapter 2 of this LOA. It specifically addresses the potential impact to marine mammals and sea turtles from underwater explosives used in the Firing Exercises (FIREX) with the Integrated Maritime Portable Acoustic Scoring & Simulator (IMPASS) system, Mine Neutralization Exercises (MINEX), and Missile Exercises (MISSILEX) in the Cherry Point Range Complex.

Assumptions that were made for the analysis include:

- Exposures were rounded to the nearest whole number using conventional rounding methods (<0.5 was rounded down and ≥0.5 was rounded up).

- Unless otherwise indicated, annual event totals were divided evenly across the four seasons as we assume these events can occur at anytime during the year.

- For events that could occur in any one of multiple sub-areas (ex. FIREX), the number of events were evenly distributed over each of the sub-areas.

Figure 1-1 shows the areas where explosive ordnance is used in the Cherry Point Range Complex.

Table 1-1 summarizes the number of events (per year by season) and specific areas where each occurs for each type of explosive ordnance used for Alternative 2. For most of the operations, there is no difference in how many events take place between the different seasons. Therefore, fractional values are a result of evenly distributing the annual totals over the 4 seasons and multiple locations. For example, there are 6 Hellfire events per year for Alternatives 2 that can take place in Areas 16 and 17 during any season, so there are 1.5 events modeled for each season.

1.1   Thresholds and Criteria for Impulsive Sound

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 2001). NMFS adopted these criteria and thresholds in its final rule on unintentional taking of marine animals occurring incidental to the shock testing (NMFS, 2001). Since the ship-shock events involve only one large explosive at a time, additional assumptions were made to extend the approach to cover multiple explosions for FIREX w/IMPASS. In addition, this section reflects a revised acoustic criterion for small underwater explosions (<1500 NEW) (i.e., 23 pounds per square inch [psi] for peak pressure instead of previous acoustic criteria of 12 psi for peak pressure), which is based on an incidental harassment authorization (IHA) issued to the Air Force (NOAA, 2006). As was the case for Seawolf and Churchill, in the absence of specifically developed criteria, criteria and thresholds for impact on protected marine mammals are used for protected sea turtles. **Figure 1-2** depicts the acoustic impact framework used in this assessment.

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**Figure 1-1   Explosive Ordnance Areas in the Cherry Point
OPAREA**

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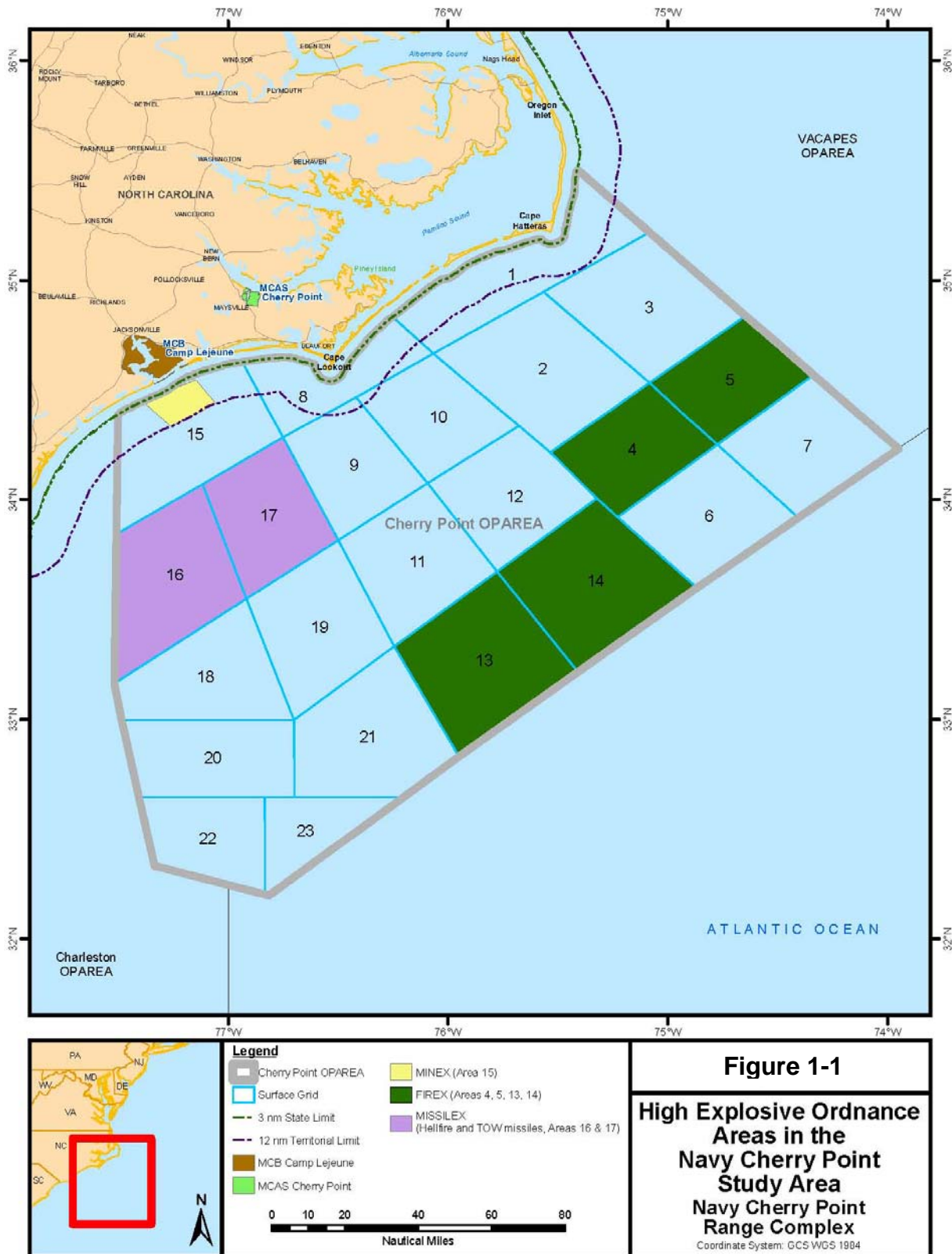
Table 1-1   Number of Explosive Events within the Cherry Point Range Complex – Alternative 2

OPAREA	Sub-Area	Ordnance	Winter	Spring	Summer	Fall	Annual Totals
NCP		FIREX					2
	13,14	5-in. rounds	0.25	0.25	0.25	0.25	
	4,5	5-in. rounds	0.25	0.25	0.25	0.25	
		MINEX					20
	UNDET	20 LB	5.00	5.00	5.00	5.00	
		MISSILEX					14
	16,17	Hellfire	1.5	1.5	1.5	1.5	
	16,17	TOW	2	2	2	2	

1.1.1 Metrics

Several standard acoustic metrics are used for underwater pressure waves in this document; textbooks on underwater sound (e.g., Urick, 1983) should be consulted for details. Four metrics are especially important for this analysis:
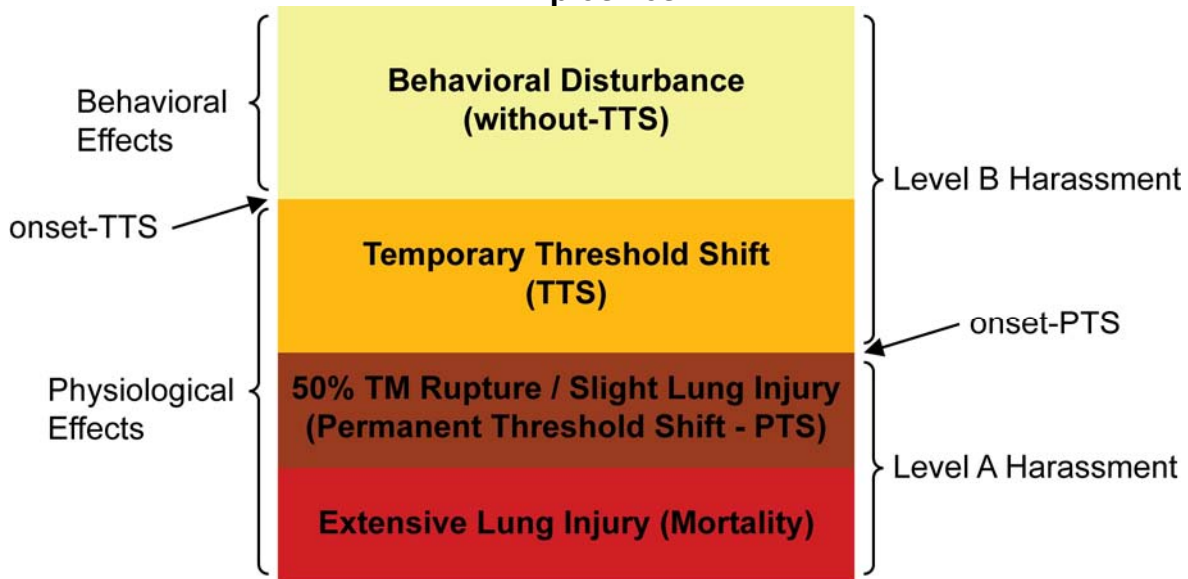
- *Energy flux density (EFD).* For plane waves, as assumed here, energy flux density (EFD) is the time integral of the squared pressure divided by the impedance. It has SI units of J/m^2 (but in-lb/in^2 is also used in CHURCHILL). EFD levels have units of dB re 1 μPa^2-s (using the usual convention that the reference impedance is the same as the impedance at the field point).

- *1/3-Octave EFD.* This is the energy flux density in a 1/3-octave frequency band. A 1/3-octave band has upper and lower frequency limits with a ratio of $2^{1/3}$. Hence, the bandwidth is about 25% of center frequency.

- *Positive impulse.* This is the time integral of the pressure over the initial positive phase of an arrival. SI units are Pa-s, but psi-ms are also used. There is no decibel analog for impulse.

- *Peak pressure.* This is the maximum positive pressure for an arrival. Units used here are psi and decibel levels with the usual underwater reference of 1 μPa.

1.1.2 Thresholds and Criteria for Injurious Physiological Effects

Single Explosion

For injury, the Navy uses dual criteria: eardrum rupture (i.e., tympanic-membrane [TM] rupture) and onset of slight lung injury. These criteria are considered indicative of the onset of injury. The threshold for TM rupture corresponds to a 50 percent rate of rupture (i.e., 50% of animals exposed to the level are expected to suffer TM rupture); this is stated in terms of an Energy Flux Density Level (EL) value of 1.17 inch pounds per square inch (in-lb/in^2) (about 205 dB referenced to 1 micro Pascal squared second (dB re 1 μPa^2-s). This recognizes that TM rupture is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing impairment (Ketten [1998] indicates a 30% incidence of permanent threshold shift [PTS] at the same threshold).

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Figure 1-2   Physiological and Behavioral Acoustic Effects Framework for Explosives

(Figure is not to scale and is for illustrative purposes only)

The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 26.9 lb), and is given in terms of the "Goertner modified positive impulse," indexed to 13 psi-millisecond (ms) (DoN, 2001). This threshold is conservative since the positive impulse needed to cause injury is proportional to animal mass, and therefore, larger animals require a higher impulse to cause the onset of injury. This analysis assumed the populations were 100% small animals. The criterion with the largest potential impact range (most conservative), either TM rupture (energy threshold) or onset of slight lung injury (peak pressure threshold), will be used in the analysis to determine injurious physiological (MMPA-Level A) exposures.

For mortality, the Navy uses the criterion corresponding to the onset of extensive lung injury. This is conservative in that it corresponds to a 1% chance of mortal injury, and yet any animal experiencing onset severe lung injury is counted as a lethal exposure. For small animals, the threshold is given in terms of the Goertner modified positive impulse, indexed to 30.5 psi-ms. Since the Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way, the actual impulse value corresponding to the 30.5 psi-ms index is a complicated calculation. To be conservative, the analysis used the mass of a calf dolphin (at 26.9 lb) for 100% of the population.

Multiple Explosions

For this analysis, the use of multiple explosions only applies to FIREX w/IMPASS. Since FIREX w/IMPASS require multiple explosions, the Churchill approach had to be extended to cover multiple sound events at the same training site and for exercise time frames up to 6 hours. For multiple exposures, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot (explosion); this is consistent with the treatment of multiple arrivals in Churchill. For positive impulse, it is consistent with Churchill to use the maximum value over all impulses received.

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1.1.3 Thresholds and Criteria for Non-Injurious Physiological Effects

The Navy criterion for non-injurious harassment is temporary threshold shift (TTS) — a slight, recoverable loss of hearing sensitivity (DoN, 2001). For this assessment, there are dual criteria for TTS, an energy threshold and a peak pressure threshold. The criterion with the largest potential impact range (most conservative), either the energy threshold or peak pressure threshold, will be used in the analysis to determine non-injurious TTS (MMPA-Level B) exposures.

Single Explosion –TTS-Energy Threshold

The first threshold is a 182 dB re 1 μPa^2-s maximum energy flux density level in any 1/3-octave band at frequencies above 100 Hz for toothed whales/sea turtles and in any 1/3-octave band above 10 Hz for baleen whales. For large explosives, as in the case of the Churchill FEIS, frequency range cutoffs at 10 and 100 Hz make a difference in the range estimates. For small explosives (<1500-lb NEW), as what was modeled for this analysis, the spectrum of the shot arrival is broad, and there is essentially no difference in impact ranges for toothed whales/sea turtles or baleen whales.

The TTS energy threshold for explosives is derived from the Space and Naval Warfare Systems Center (SSC) pure-tone tests for TTS (Schlundt et al. 2000, Finneran and Schlundt 2004). The pure-tone threshold (192 dB as the lowest value) is modified for explosives by (a) interpreting it as an energy metric, (b) reducing it by 10 dB to account for the time constant of the mammal ear, and (c) measuring the energy in 1/3-octave bands, the natural filter band of the ear. The resulting threshold is 182 dB re 1 μPa^2-s in any 1/3-octave band. The energy threshold usually dominates and is used in the analysis to determine potential MMPA-Level B exposures for single explosion ordnance.

Single Explosion –TTS-Peak Pressure Threshold

The second threshold applies to all species and is stated in terms of peak pressure at 23 psi (about 225 dB re 1 μPa). This criterion was adopted for Precision Strike Weapon (PSW) Testing and Training by Eglin Air Force Base in the Gulf of Mexico (NMFS, 2006). It is important to note that for small shots near the surface (such as in this analysis), the 23-psi peak pressure threshold generally will produce longer impact ranges than the 182-dB energy metric. Furthermore, it is not unusual for the TTS impact range for the 23-psi pressure metric to actually exceed the behavioral impact range (without TTS) for the 177-dB energy metric.

Multiple Explosions –TTS

For multiple explosions, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot/detonation. This is consistent with the energy argument in Churchill. For peak pressure, it is consistent with Churchill to use the maximum value over all impulses received.

1.1.4 Thresholds and Criteria for Behavioral Effects

Single Explosion

For a single explosion, to be consistent with Churchill, TTS is the criterion for MMPA-Level B. In other words, because behavioral disturbance for a single explosion is likely to be limited to a short-lived startle reaction, use of the TTS criterion is considered sufficient protection and therefore behavioral effects (without TTS) are not considered for single explosions.

Multiple Explosions

For this analysis, the use of multiple explosions only applies to FIREX w/. Because multiple explosions would occur within a discrete time period, a new acoustic criterion-behavioral disturbance (without

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TTS)-is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower noise levels than those that may cause TTS.

The threshold is based on test results published in Schlundt et al. (2000), with derivation following the approach of the Churchill FEIS for the energy-based TTS threshold. The original Schlundt et al. (2000) data and the report of Finneran and Schlundt (2004) are the basis for thresholds for behavioral disturbance (without TTS). As reported by Schlundt et al. (2000), instances of altered behavior generally began at lower exposures than those causing TTS; however, there were many instances when subjects exhibited no altered behavior at levels above the onset-TTS levels. Regardless of reactions at higher or lower levels, all instances of altered behavior were included in the statistical summary.

The behavioral disturbance (without TTS) threshold for tones is derived from the Spawar Systems Center (SSC) tests, and is found to be five dB below the threshold for TTS, or 177 dB re 1 μPa^2-s maximum energy flux density level in any 1/3-octave band at frequencies above 100 Hz for toothed whales/sea turtles and in any 1/3-octave band above 10 Hz for baleen whales. As stated previously for TTS, for small explosives (<1500-lb NEW), as what was modeled for this analysis, the spectrum of the shot arrival is broad, and there is essentially no difference in impact ranges for toothed whales/sea turtles or baleen whales. The behavioral disturbance (without TTS) impact range for FIREX with IMPASS can, especially in shallower water, be about twice the impact range for TTS. However, the TTS pressure criteria (23 psi) impact range for FIREX with IMPASS can, especially in deeper water, result in a longer impact range than the behavioral disturbance (without TTS) criteria impact range.

1.2   Summary of Thresholds and Criteria for Impulsive Sounds

Table 1-2 summarizes the effects, criteria, and thresholds used in the assessment for impulsive sounds. The criteria for behavioral effects without physiological effects used in this analysis are based on use of multiple explosives that only take place during a FIREX w/IMPASS event.

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Table 1-2   Effects, Criteria, and Thresholds for Impulsive Sounds

Effect	Criteria	Metric	Threshold	Effect
Mortality	Onset of Extensive Lung Injury	Goertner modified positive impulse	indexed to 30.5 psi-ms (assumes 100% small animal at 26.9 lbs)	Mortality
Injourious Physiological	50% Tympanic Membrane Rupture	Energy flux density	1.17 in-lb/in2 (about 205 dB re 1 μPa2-s)	MMPA - Level A
Injurious Physiological	Onset Slight Lung Injury	Goertner modified positive impulse	indexed to 13 psi-ms (assumes 100% small animal at 26.9 lbs)	MMPA - Level A
Non-injurious Physiological	TTS	Greatest energy flux density level in any 1/3-octave band (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures	182 dB re 1 μPa2-s	MMPA - Level B
Non-injurious Physiological	TTS	Peak pressure over all exposures	23 psi	MMPA - Level B
Non-injurious Behavioral	Behavioral Disturbance without TTS	Greatest energy flux density level in any 1/3-octave (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures (multiple explosions only)	177 dB re 1 μPa2-s	MMPA - Level B
MMPA TTS	Marine Mammal Protection Act Temporary Threshold Shift			

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CHAPTER 2   ACOUSTIC ANALYSIS FOR UNDERWATER EXPLOSIONS ASSOCIATED WITH FIREX W/IMPASS

2.1   Summary Description of the Action

A typical FIREX w/IMPASS evolution is summarized below.

- The plan is for up to 2 events per year in the CHPT OPAREA. The duration of an event is several hours.

- Each event is comprised of a "Pre-FIREX" test followed by a FIREX consisting of at least 6 "missions."

- "Pre-FIREX" consists of 4 live rounds to support Trend Analysis in order to remove mechanical error from the Fall of Shot (FOS). These rounds are fired at a one-minute cycle rate. This is followed by 2 live rounds fired for Trend Analysis Verification at a 10-s cycle time. Error distance between where the shell impacts and the target point is assumed to be less than 100 yards (yd) (~ 91 meters [m]).

- The first "mission" begins within 45 minutes of the last pre-FIREX round.

- For each event there are a minimum of 6 "missions," with approximately 5-10 minutes between each mission. These missions include:

  - *AREA Target* (6 live rounds, 10-s cycle time)

  - *Danger Close* (5 live rounds, 10- s cycle time)

  - *Coordinated Illumination* (4 live rounds, 20- s cycle time)

  - *Counter Mech* ((4 live rounds, 10- s cycle time)

  - *SEAD* (4 live rounds, 10- s cycle time)

  - *Re-fire* (4 live rounds, 10- s cycle time)

If a mission fails, a *Do Over* mission of up to 6 live rounds is executed.

- All rounds for a given mission are expected to impact within 50 yards (45 m) of the target point.

- The modeled typical event involves firing a total of 39 rounds (6 rounds for pre-FIREX, and 4-6 rounds for each of 6 mission types and one 6-round *Do Over*).

2.2   Characterization of Source Properties

For the acoustic analysis, the exploding shell is characterized here as a point source, with an 8 pound net weight of high-energy explosive.

2.2.1   Depths of Animals and Explosions

Although the 5-in. shells are set to detonate on contact with the ocean surface, actual detonation depth is not known. For this analysis, an assumption of a 1 ft (0.3 m) depth is made. Animal depths are selected to ensure the greatest direct path for the harassment ranges, and to give the greatest impact range for the injury thresholds; they are thus conservative. The latter is consistent with the approach of CHURCHILL.

2.2.2   Similitude Formulas for Source Properties

Standard similitude formulas are used to model the free-field source properties close to the source, starting at a nominal source-level range of 1 m (3.3 ft). Weak shock theory is used to estimate the

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waveform and levels to ranges beyond a few meters. Rather than revert to linear propagation theory when the amplitudes are small, the weak shock is used to all ranges. This is consistent with the SEAWOLF and CHURCHILL FEISs (although not explicitly stated in the documents). References for similitude and explosive sound propagation include Cole (1948), Arons et al. (1949), Weston (1960), Urick (1983), Goertner (1982), Gaspin (1983), Chapman (1988), Gaspin and Shuler (1971), and Bluy and Payne (1974). The formulas are provided below.

Waveform for Shock Wave, Positive Phase (Similitude, Arons et al., 1949):

The pressure as a function of time at a fixed location is given by:

$P(t) = P_o \exp(-t/t_o)$, for $t > 0$, and

$P(t) = 0$, $t < 0$,

where P_o is peak pressure, t is time (with $t = 0$ as arrival time of the shock front), and t_o is time constant. This is an idealized waveform, and does not include negative phase or bubble pulses. The latter is not at issue for shots at the surface. Negative pressure disturbances are treated here for the case of the surface reflected path.

Peak Pressure of Shock Wave (Similitude, Arons et al., 1949):

Peak pressure in psi is given by:

$P_o = 2.16 \times 10^4 \, (W^{1/3}/R)^{1.13}$

where W is net explosive weight (NEW) in pounds, and R is range in feet.

Time Constant for Shock Wave (Similitude, Arons et al., 1949):

The 1/e time in ms is given by:

$t_0 = 0.052 W^{1/3} \, (W^{1/3}/R)^{-0.26}$

where W is NEW in pounds and R is range in feet.

Positive Impulse for Shock Wave (Similitude, Arons et al., 1949):

Positive impulse is calculated directly from the time integral of the pressure over the positive phase.

Goertner (1982) Modified Positive Impulse

As in the CHURCHILL FEIS, this document utilizes the Goertner (1982) approach to determine the positive impulse. In this approach, either: (1) a surface reflected impulse, or (2) a lung/bubble resonance period is used to modify the positive impulse at various ranges and depths. For a pressure-release surface, the reflected pulse is the negative of the incident, with perhaps a reduction in amplitude and distortion of the waveform. The result of combining the surface reflected and direct paths is a reduction in positive impulse. Similarly, the lung/bubble resonance period cuts off the decaying peak pressure. The Goertner modified positive impulse is the integral of the pressure from the start of the arrival of the direct-path impulse until the start of the arrival of the surface-reflected pulse (or the period of the resonance). The minimum of the two integrals is calculated as a function of animal depth, and compared to the Goertner depth-dependent threshold. Since the maximum range over the possible animal depths is used in the analysis, the estimated impact ranges are conservative.

Energy Flux Density (Similitude, Arons et al., 1949):

EFD is calculated directly from the time integral of the squared pressure, normalized by impedance.

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Energy Flux Density Spectrum (Similitude, Weston, 1960):

The EFD spectrum is the squared modulus of the Fourier transform of the exponential waveform. It can be written as:

$$E = \{2P_o^2\} / \{\rho c \ (1/t_o^2 + 4\pi^2 f^2)\}$$

where E is in ergs/cm^{2}Hz, P_o is the peak pressure in μPa, $\rho c = 1.539 * 10^5$ g/cm^2-s, t_o is time constant in seconds, and f is frequency in Hz.

Dependence of Formulas on the Type of Explosive

All of the formulas above assume TNT as the high-explosive material. For other explosives, the formulas remain the same, but an adjustment is made for the density of the explosive relative to TNT. For example, RDX has a density about 15% greater than TNT. For an 8-lb RDX charge, a 9.2-lb NEW would be used in the formulas.

2.3   Environmental Provinces and Sound Propagation

2.3.1   Overview

For an ideal, deep-water environment (flat pressure-release surface, constant sound speed, no absorption, no bottom interaction, source and receiver away from the surface) and a single explosion, impact ranges associated with the acoustic thresholds defined in Section 1.3 can be estimated using standard formulas for shock waves. For a single 8-lb NEW charge at a depth of 1 ft (0.3 m), the MMPA-Level B harassment range is determined from the 23-psi TTS threshold to be approximately 295 m (320 yards). Injury ranges are approximately 45 m (50 yards) for small animals.

Because training would occur year-round, the assumption of an ideal, deep-water environment would not always be appropriate. In fact, FIREX w/IMPASS may be deployed in waters as shallow as 50 m (55 yd). To estimate impact areas for the variety of FIREX w/IMPASS deployment sites, Navy standard acoustic models and databases were applied to environmental 'provinces' within which the ocean acoustic environments are expected to be similar. The environmental provincing follows naturally from the Navy databases, and yields from 45 to 80 provinces in each OPAREA for each season.

Based on the Navy standard CASS/GRAB model (OAML, 2002), modified to account for impulse response, shock-wave waveform, and nonlinear shock-wave effects, and on the Navy (OAML, 2002) standard environmental databases (sound speed, wind speed, bottom interaction, and bathymetry), impact ranges were estimated for each season and province. Note that the model is validated for use of the highly specialized bottom sediment databases and for range-varying environments. In addition, test calculations were made to account for bubble pulses.

Impact ranges and impact areas were estimated for many cases (1 OPAREA, 40 to 80 provinces per OPAREA, 4 seasons, and eight impact thresholds) -- too many to list here (approximately 1,000 cases for 1 shot alone). The results are thus summarized in Table 2-2 according to intervals of water depth (e.g., locations for which water depths are between 100 m (110 yd) and 1,000 m [1,100 yd]).

2.3.2   Propagation Modeling

The approach begins with a high-fidelity acoustic model that has all of the required properties for the 'linear' problem. Since the OPAREAs of interest include shallow-water regions, the selected model must treat range-dependent environments and be able to exploit Navy standard bottom-sediment interaction approaches (e.g., the Navy Standard: OAML, 2002). It must cover a wide frequency band (up to about 10 kHz), and correctly account for caustics, surface cutoff, ducting, low-frequency cutoff, and important diffraction effects. Because of the wide bandwidth for small shots, wave-theory models (such as modal theory or parabolic equation method or finite-element approaches) are usually not practical, so that

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modified ray theory models are favored. Examples include Navy standard models (CASS/GRAB or ASTRAL) and the model used for long-range, flat bottom estimates in CHURCHILL and SEAWOLF - the REFMS model (Britt et al., 1991). The CASS/GRAB model is well suited for small shots and is used in this assessment.

Consider first the linear case. The approach is to first calculate the impulse response of the channel. This is one of the standard applications for the CASS/GRAB model. Let $\delta(t)$ be the delta function, $s_o(t)$ be the pressure waveform at the source (at 1 m from the source), and $S(s_o(t), x; t)$ be the pressure time series of the field at location x. Then:

$S(\delta(t), x; t)$ is the impulse response at location x.

Now, $S(s, x; t)$ is linear in s, and it is trivially the case that $s_o(t) = s_o(t) \otimes \delta(t)$, where $\otimes$ denotes convolution. Hence,

$S(s(t), x; t) = S(s(t) \otimes \delta(t), x; t) = s(t) \otimes S(\delta(t), x; t).$

Thus, given the impulse response, the field for any source waveform is available through simple convolution. This is a standard approach in sound wave modeling (e.g., Clay and Medwin, 1977).

The starting field (e.g., at 1 m), s(t), is prescribed as an idealized, exponentially decaying shock wave, followed by double-exponential bubble pulses, with negative pressures in between to ensure the impulse is zero (e.g., Weston, 1960).

The peak pressures of the bubble pulses are smaller than the peak pressure of the main pulse. The same is true for the positive impulse and the total energy. However, the bubble pulse contributions can change the shape of the energy spectrum. In the FIREX W/IMPASS case, with small shot and shallow depth, the bubble pulse frequency is below 1 Hz, and the spectral modification does not affect which 1/3 octave band has greatest level. Thus, bubble pulse contributions are not included in these calculations. Note that for the approach used here, it is no more difficult to include the bubble pulses, but there is no reason to add this complication to the problem.

In regions of high pressure, non-linearities can be important -- particularly in the rate of decay of the peak pressure and in the increasing time constant for the pressure wave. Although total energy is minimally affected, the energy spectrum is sensitive to nonlinear effects. The usual approach to incorporating these effects in a ray model is to propagate the waveform for each ray path according to the similitude formulas. This is what is done, for example, in REFMS (Britt et al., 1991).

The non-linear correction is made as follows. Let $S_n(x; t)$ be the idealized similitude waveform at location x, over time t. Then, for ranges at which the peak pressure is greater than 100 psi, the field is estimated as:

$S(s(t), x; t) = [\,|x|^2 \, S_n(x; t)] \otimes S(\delta(t), x; t)$

Since the model yields the full time series at each location, it can directly calculate the peak pressure, positive impulse, Goertner modified positive impulse, energy spectrum, and frequency-band values (e.g., 1/3 octave band) of the EFD. This model uses the same (similitude) approach to account for non-linearities in water-borne shock wave propagation as does the REFMS model.

Note on Propagation by Weak Shock Theory

Weak shock theory dates to the 19th century and is used in all types of shock wave propagation (in air, in water, etc.). Gaspin (1983) recommends that it be used beyond a range of:

$R_o = 12.0 * W^{1/3}$

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where W = explosive weight in pounds, and R_o = 'limiting range' in feet. For an 8-lb NEW charge, the range is only 24 ft (7.3 m). The recommendation is to use the similitude formulas to range R_o, and the weak shock formula, thereafter.

The weak shock formulas are:

$$P = Po * \{ [\ 1 + 2 * (R_o/L_o) * Ln\ (R/\ R_o)]^{\frac{1}{2}} - 1 \} / \{ [R/\ L_o] * Ln\ (R/\ R_o) \}$$

$$T = To * [\ 1 + 2 * (R/\ L_o) * Ln\ (R/\ R_o)]^{\frac{1}{2}}$$

where: $L_o = (\rho c^3 T_o) / (P_o \beta)$, P_o = peak pressure at R_o, T_o= time constant at R_o , ρc = acoustic impedance for seawater, β= coefficient of non-linearity for water (3.5).

These formulas have been published many times, with a recent, relevant example in Richardson et al. (1995). What is sometimes not noted is the comparison of the weak shock formulas with the similitude formulas, although Rogers (1977) does address this quite well. In particular, note that the weak shock theory and the Arons et al. (1949) similitude formulas are within 20% of each other for most parameters of interest in this assessment.

2.3.3 Underwater Explosive Measurements for Validation

Because of the special geometry of FIREX w/IMPASS (especially the shallow and uncertain depth of the explosions), there are very few measurements that can be used directly to estimate the sound field. Measurements for small shots and deeper depths are available for some of the FIREX w/IMPASS sites, and they are useful for determining bottom interaction properties. Results for these data sets have in most cases been analyzed and incorporated into the Navy databases (OAML, 2002) (which are used for this assessment). In that sense, the risk estimates have exploited the available propagation data.

2.4 Estimated Impact Ranges and Areas for a Single Exploding Shell

For a single 8-lb NEW charge, impact ranges are relatively short, and there is little dependence on season, water depth, or bottom properties for the OPAREAs covered. Model estimates are summarized in **Table 2-1**.

The impact ranges for TTS based on energy levels are the same for both frequency limits (10 Hz and 100 Hz) in all cases for small explosives because of the broadness of the frequency spectrum. The same is true for behavioral disturbance (without TTS).

There is little variability due to environmental conditions for any of the impact ranges in **Table 2-1**. In fact, the only case for which there is some variability (the TTS range for energy threshold), shows that most of this variability occurs in shallow water (less than 100 m [328 ft]). This result is as expected. However, greater variability is found in the estimation of TTS impact areas for multiple explosives -- primarily because of energy accumulation and hence, greater ranges for multiple shots.

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Table 2-1   Estimated Impact Ranges1 for Cetaceans and Sea Turtles for Explosion of a Single 5-Inch Shell

Criterion and Threshold	Estimated Impact Range
MMPA-Level A Harassment: 50% tympanic membrane (TM) rupture. Threshold: Energy above 1.17 in-lb/in^2 [205 dB re 1 μPa^2-s]	15-25 m (16 -28 yd)
MMPA-Level A Harassment: Onset of slight lung injury. Threshold: Goertner modified positive impulse exceeds threshold indexed to 13 psi-ms	40-45 m (44-50 yd)
MMPA-Level B Harassment: TTS for baleen whales. Threshold: 1/3 octave-band energy flux density level above 10 Hz exceeds 182 dB re 1 μPa^2-s	71-80 m (78-88 yd)
MMPA-Level B Harassment: TTS for toothed whales and sea turtles. Threshold: 1/3 octave-band energy flux density level above 100 Hz exceeds 182 dB re 1 μPa^2-s	71-80 m (78-88 yd)
MMPA-Level B Harassment: TTS. Threshold: 23 psi peak pressure [225 dB re 1 μPa]	255-275 m (280-300 yd)
MMPA-Level B Harassment: Behavioral disturbance (without TTS) for baleen whales. Threshold: 1/3 octave-band energy flux density level above 10 Hz exceeds 177 dB re 1 μPa^2-s (multiple explosions only)	140-150 m (155-165 yd)
MMPA-Level B Harassment: Behavioral disturbance (without TTS) for toothed whales Threshold: 1/3 octave-band energy flux density level above 100 Hz exceeds 177 dB re 1 μPa^2-s (multiple explosions only)	140-150 m (155-165 yd)

[1] *These impact ranges assume detonation occurs at 1 ft (0.3 m) below the water's surface.*

2.5   Impact Areas for Marine Mammals for a Full FIREX w/IMPASS Event (39 Explosions)

Impact areas for a full FIREX W/IMPASS event must account for the time and space distribution of 39 explosions, as well as the movement of animals over the several hours of the exercise. The reason is that impact areas depend on whether an animal is exposed to a single pressure wave or multiple waves over time.

As is discussed in detail below, the total impact area for the 39-shot event is calculated as the sum of small impact areas for 7 FIREX missions (each with 4-6 shells fired) and 1 pre-FIREX action (with 6 shells fired). For a single 5-shell mission, the total impact area is typically small (<0.2 nm^2) and impact ranges also small (<500 m [550 yd]). Because target locations are changed from mission to mission and because of the time lag between missions, it is highly unlikely that a cetacean would be within the small impact zone for more than one mission.

Section 2.5.1 outlines the approach to estimating the impact ranges and areas, and Section 2.5.2 gives an example in detail of the take estimate calculations for a typical case. Section 2.5.3 summarizes the resulting total impact areas for the FIREX W/IMPASS OPAREAs and representative depth strata.

2.5.1 Example of How the Calculations of Estimated Impact Areas Are Made

The nominal FIREX W/IMPASS event can be broken down into two components: 1) a 6-round Pre-FIREX, and 2) seven FIREX missions, each with 4-6 rounds. The time between pre-FIREX and the first FIREX mission, as well as the time between the individual FIREX missions is sufficiently large as to allow these components to be examined independently (i.e., their small impact areas calculated). The

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total impact area for an event can be calculated by adding together the component areas for the Pre-FIREX and the 7 FIREX missions.

In order to determine the size of the area potentially impacted for each component of the mission, an estimate must be made of the time that a typical animal could be present in the impact area. This is necessary to correctly gauge the total energy exposure that an animal would receive if exposed to the sound of more than one explosion.

Additionally, inaccuracies in the location of the shell impact points need to be included in this analysis. The reason is that, for the peak pressure threshold for harassment, the harassment area depends on the relative location of the shell impact locations. The nominal targeting error (i.e., the radius within which all shells should nominally land) based on previous training exercises is 100 yd (91m) for the Pre-FIREX rounds and 50 yd (46 m) for an entire mission's fire. Therefore, the six Pre-FIREX rounds should land within 100 yd (91 m) of the targeting point, and all 4-6 mission rounds should land within 50 yd (46 m) of the targeting point for that mission.

For small explosives detonated near the sea surface, the impact range for MMPA-Level B harassment for a single explosive is often determined by the 23-psi peak-pressure threshold for TTS, even for the typical multiple shots encountered in a single mission.

TTS Harassment Calculation – Pre-FIREX Fire

For Pre-FIREX, four rounds (for Trend Analysis) are fired with a one-minute cycle time, followed by two rounds (for Verification) with a ten-second cycle rate. The target error is less than 100 yd (91 m).

For the peak pressure threshold for TTS, the impact area is no greater than the impact area of five widely-spaced shots (this assumes that the two verification rounds are nearly coincident in time and space) or:

$$\text{Area} = \pi * (300/2025)^2 * 5 = 0.345 \text{ nm}^2$$

where 300 yd is the impact range for 23-psi peak pressure threshold.

For the TTS energy threshold, the expected area is estimated to be no greater than:

$$\text{Area} = \pi * (215/2025)^2 = 0.035 \text{ nm}^2,$$

where 215 yd is the impact range for six shots.

TTS Harassment Calculation – Typical Mission

For the typical mission consisting of five rounds, the expected impact area is no greater than:

$$\text{Area} = \pi * ((300 + 50 + 68)/2025)^2 = 0.134 \text{ nm}^2$$

for the peak pressure threshold, and no greater than:

$$\text{Area} = \pi * (197/2025)^2 = 0.030 \text{ nm}^2,$$

for the energy threshold where 197 yd is the impact range for five shots. The peak pressure estimate assumes that the five rounds fall within 50 yd of the target, that the five rounds fall within 40 s, and that the average animal-swim distance for 40 s is about 68 yd (for a 3 knot or 1.7 yd/s swim speed).

Following the same approach, expected impact areas are derived below.

Behavioral Disturbance (without TTS) – Pre-FIREX Fire

Estimated area based on energy threshold is:

$$\text{Area} = \pi * ((405)/2025)^2 = 0.126 \text{ nm}^2$$

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where 405 yd is the impact range for six shots.

Behavioral Disturbance (without TTS) – Typical Mission

Estimated area based on energy threshold is:

$$\text{Area} = \pi * ((370)/2025)^2 = 0.105 \text{ nm}^2$$

where 370 yd is the impact range for five shots.

Injury Calculation – Pre-FIREX Fire

Estimated area based on positive impulse threshold is:

$$\text{Area} = \pi * (35/2025)^2 * 5 = 0.005 \text{ nm}^2$$

where 35 yd is the impact range for a single shot.

Estimated area based on energy threshold is:

$$\text{Area} = \pi * (69/2025)^2 = 0.004 \text{ nm}^2$$

where 69 yd is the impact range for six shots.

Injury Calculation – Typical Mission

Estimated area based on the positive impulse threshold is:

$$\text{Area} = \pi * (35/2025)^2 * 5 = 0.005 \text{ nm}^2$$

Estimated area based on the energy threshold is:

$$\text{Area} = \pi * ((63)/2025)^2 = 0.003 \text{ nm}^2$$

where 63 yd is the impact range for five shots.

Total Areas per Event

For **injury**, the total expected area per event is:

Total Area = Area (of one Pre-FIREX fire) + 2 * Area (one six-round mission) +

Area (one five-round mission) + 4 * Area (one four-round mission)

$$= 0.005 + 2 * (0.006) + 1 * (0.005) + 4 * (0.004) = 0.038 \text{ nm}^2$$

For **TTS,** the total expected area is:

Total Area = Area (of one pre-calibration fire) + 2 * Area (one six-round mission) + Area (one five-round mission) + 4 * Area (one four-round mission) – Total Injury Area

$$= 0.345 + 2 * (0.145) + 1 * (0.134) + 4 * (0.123) – 0.038 = 1.223 \text{ nm}^2.$$

For **behavioral disturbance (without TTS)**, the total expected area is:

Total Area = Area (of one pre-calibration fire) + 2 * Area (one six-round mission) + Area (one five-round mission) + 4 * Area (one four-round mission) – Total Injury Area – Total TTS Harassment Area

$$= 0.126 + 2*(0.126) + 1*(0.105) + 4*(0.083) – 0.038 – 1.223 = – 0.446 \text{ nm}^2.$$

The negative total area derived for behavioral disturbance without TTS is the result of the factors in the analysis: (1) a peak pressure metric used to determine TTS (and injury) but not for behavioral disturbance, and (2) the peak pressure threshold being used (23 psi) is not entirely scaled for the eight-point source.

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These total areas, when multiplied by the animal densities, provide the take estimates for that animal species for the nominal exercise case of 39 five-inch shells, as previously described.

Note that although these are presented as "total areas" of harassment in order to calculate takes, this "total area" would not be impacted at any one time. The potential impacts would occur within a series of small impact areas associated with the pre-calibration rounds and missions, spread out over a period of several hours.

2.5.2 Summary of Estimated Impact Areas for Marine Mammals for a Full FIREX W/IMPASS Event (39 Explosions)

Impact areas were estimated for each of the 50-80 environmental provinces in each OPAREA. Because sound propagation and animal densities are sensitive to water depth, a useful summary of the estimates is by depth strata. Note that the depth strata for the acoustic modeling were based on approximate 'octaves.' That is, the strata had depth intervals of 35-70 m, 70-150 m, 150-300 m, etc. Each was assigned a 'mean' water depth, with resulting values of 50, 100, 200, 500, 1000, 2000, and 4000 m.

A summary of the resulting impact areas is given in **Table 2-2** for the Cherry Point Range Complex and for selected depth strata.

Estimates for a given depth stratum are weighted averages of impact areas for those provinces which are within the depth limits. The weighting is according to the areas of the provinces. This weighted averaging is consistent with the assumption that a training site is equally likely to occur anywhere within the depth limits.

Table 2-2   Estimated Impact Areas for a Single 39-Shell Event (nm^2)

OPAREA	Depth Stratum	Impact Area for Injury @ 205 dB re 1 μPa^2-sec or 13 psi	Impact Area for TTS @ 182 dB re 1 μPa^2-sec or 23 psi	Impact Area for Behavioral Disturbance @ 177 dB re 1 μPa^2-sec (multiple detonations only)
CHPT	50 m – 100 m	0.038-0.054	1.11-1.17	0.46-2.02
CHPT	100 m – 1000 m	0.038-0.054	1.10-1.11	0.00-0.15
CHPT	>1000 m	0.054-0.054	1.09-1.11	0.00-0.00

It is important to note here that there was a general lack of seasonal dependence for the impact area calculations. There was also little dependence on animal depth (assuming the conservative case that the animal is not close to the surface and do not benefit from the effects of surface 'cutoff'). In deep water, because the impact ranges are relatively short, the bottom and sound speed properties have little effect on sound propagation and the impact areas are typically about the same throughout.

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CHAPTER 3 ACOUSTIC ANALYSIS FOR UNDERWATER EXPLOSIONS ASSOCIATED WITH MISSILEX

The following material provides an explanation of the marine mammal acoustic effects model used to estimate the acoustic impact of explosive ordnance associated with MISSILEX training on marine mammals and sea turtles. The best available data were used in combination with an underwater explosion model and exercise simulation to predict impacts. The method by which predicted effects were quantified is described.

3.1 MODEL DESCRIPTION

The modeling consists of five process components:

1. An exercise description including the type of weapons and acoustic sources used and their associated timelines and characteristics.

2. A physical oceanographic and geo-acoustic dataset for input to the acoustic propagation model for the planned exercise location and time of year.

3. An acoustic propagation model suitable for the source type to predict energy levels at ranges and depths from the source.

4. Marine animal density data for the test area.

5. A final calculation to multiply together the acoustic propagation results, the animal densities, and the number of operations.

3.1.1 Exercise Description

A timeline and sequence of weapon delivery was constructed from these records to form the basis of the test simulation. From this information, the order of weapon use, number of weapons fired, and time over which the weapons were fired is constructed.

3.1.2 Environmental Information for the Acoustic Propagation Model

Oceanographic data representative of the exercise locations were used to estimate propagation of the blast and acoustic energy using an analytical time-domain model for underwater explosions.

Environmental data parameters include bathymetry, sound speed profiles (SSP), and bottom type parameters including sediment characteristics, compressional and shear wave speed, density, and layer depth.

3.1.2.1 Bathymetry

The center latitude/longitude of the exercise boxes were used to determine the representative depth for each exercise location. The four sites are identified as CHPT CPOA Area 16 and 17 with given latitude and longitude locations as 33.80N, 77.04W.

3.1.2.2 Ocean Water Characteristics

Acoustic propagation at the exercise locations are mostly determined by the SSP due to deep water depths. For modeling, the SSP was partitioned into isovelocity water layers in order to calculate and predict propagation of blast and acoustic energy. Environmental databases used for this analysis are limited to those that were unclassified. The Naval Oceanographic Office online

Generalized Digital Environment Model, version 2.5 was used to obtain monthly SSPs, which were accessed at https://128.160.23.42/gdemv/gdemv.html. Twelve SSPs, the average for each month, were examined for the most conservative, which is defined as the profile that results in the best propagation

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conditions and largest zone of influence (ZOI) for the test. The SSP was then partitioned into isovelocity layers so that no layer had a change in sound speed greater than 3.28 ft/s (1 m/s) for the model input file.

3.1.2.3 Ocean Sediment Characteristics

Given a description of the bottom sediment, the sound speed ratio and density were acquired from the database of Hamilton (1980). Parameters used in the selected acoustic model to define ocean sediments are the sediment velocity ratio and wet density. Specifically, the sediment shear wave velocity is calculated from the sediment velocity ratio as a function of the compressional wave velocity, also called sediment sound speed. **Table 3-1** summarizes the data used for the MISSILEX site.

Table 3-1   Water Depth and Sediment Properties for the MISSILEX Site

Site	Water Depth (m)	Bottom Sediment	Sound Speed Ratio	Density (gm/cm^3)
CHPT Area 16/17	34	Sand	1.145	1.941

3.1.3 Acoustic Propagation Model

Only explosive sources were utilized and the Reflection and Refraction Multi-Layered Ocean/Ocean Bottoms with Shear Wave Effects (REFMS) model (version 5.06) (Britt et al. 1991) was used for the acoustic predictions. REFMS is used to calculate peak maximum and minimum pressures, positive impulse, EFD total and 1/3 octave band spectra, and maximum EFD above 10Hz and above 100 Hz from underwater detonations. The REFMS model calculates the combined reflected and refracted shock wave environment for underwater explosions using a single, generalized model that is based upon Cagniard's linear wave propagation theory (Cagniard 1962; Britt et al. 1991), convolved with a nonlinear similitude source term for each individual source type. In order to predict propagation of the underwater explosions, some of the various explosive types are converted to TNT equivalents.

For the present determination of ZOIs for each mammal threshold, improvements were made to the REFMS tool to allow multiple depths and range points concurrently. Two separate case runs of REFMS were selected that concentrated points near the sea surface and detonation for impulse thresholds and a second distribution set that extended down to the sea floor and further away from the explosive for the peak pressure and EFD. The acoustic results of each were combined to yield a larger more comprehensive database for the mammal ZOI determinations. Thus, the discrete points of depth and range were:

Impulse Threshold

   Depth (m): 0.5, 1.0, 2.0, 5.0, 15.0, 25.0, and 50.0

   Range (nmi): 0.0026, 0.0087, 0.0148, 0.0207, 0.0415, 0.688, 0.1, 0.2, 0.3, 0.4, and 0.5

Peak Pressure and EFD Thresholds

   Depth (m): 0.5, 1.0, 2.0, 5.0, 15.0, 50.0, 100.0, 150.0, and 200.0

   Range (nmi): 0.0375, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, and 3.0

These two-dimensional (range and depth) distributions give 77 discrete points of REFMS results for evaluating the ZOIs of mammal thresholds based on peak positive impulse (psi-ms) and 90 points for ZOIs of thresholds in terms of the and peak pressure (psi) and EFD in 1/3-octave bands (dB) and total energy (dB).

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3.1.4 Marine Animal Data

All density estimates that were used in the analysis are presented in the species descriptions located in Ch. 4 of this LOA. Once the acoustic propagation model determines the impact areas or ZOIs, then they are multiplied by the animal density estimates and the number of events to determine exposure estimates.

3.2 Estimated Impact Areas

Table 3-2 presents the MISSILEX modeling results of the impact ranges for the Cherry Point Range Complex.

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Table 3-2   Estimated ZOIs (km^2) for MISSILEX

Area	Ordnance	MMPA-Level B ZOI @ 182 dB re 1 μPa^2-s or 23 psi				MMPA-Level A ZOI @ 205 dB re 1 μPa^2-s or 13 psi				Mortality ZOI @ 30.5 psi			
		Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
NCP													
16,17	Hellfire	0.31	0.31	0.31	0.31	0.04	0.04	0.04	0.04	<0.01	<0.01	<0.01	<0.01
16,17	TOW	0.39	0.39	0.35	0.39	0.04	0.04	0.04	0.04	<0.01	<0.01	<0.01	<0.01

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CHAPTER 4   ACOUSTIC ANALYSIS FOR UNDERWATER EXPLOSIONS ASSOCIATED WITH MINEX

4.1   Introduction

This appendix provides explanatory text for a risk assessment of the Cherry Point Range Complex MINEX site. The driving sources of shock energy and noise in the water are from small (20 pounds explosive weight) charges of C-4. The analysis is done in a per shot/season format, so that exposure estimates are easy to determine for any combination of sites and seasons.

Since the MINEX explosive events are isolated in time, and hence in the same category as the ship shock trials, temporary threshold shift (TTS) is the sole criterion for MMPA-Level B harassment.

4.2   Characterization of Source Properties

For the acoustic analysis, the exploding shell is characterized here as a point source, with a 20 lb charge of high-energy explosive.

4.2.1   Depths of Animals and Explosions

For this analysis an assumption of a 1 ft (0.3 m) depth is made, and is more conservative than an assumption of a shallower detonation depth. Animal depths are selected to ensure the greatest direct path for the harassment ranges, and to give the greatest impact range for the injury thresholds; they are thus conservative. The latter is consistent with the approach of CHURCHILL.

4.2.2   Similitude Formulas for Source Properties

See **Section 2.2.2**, all background information is the same as for the FIREX W/IMPASS modeling.

4.3   Environmental Provinces and Sound Propagation

4.3.1   Overview

To determine impact areas for the MINEX deployment site, Navy standard acoustic models and databases were applied to environmental 'provinces' within which the ocean acoustic environments are expected to be similar. The environmental provincing follows naturally from the Navy databases.

4.3.2   Propagation Modeling

See Section 2.3.2, all background information is the same as for the FIREX W/IMPASS modeling.

4.3.3   Underwater Explosive Measurements for Validation

Because of the special geometry of MINEX (especially the shallow and uncertain depth of the explosions), there are very few measurements that can be used directly to estimate the sound field. Measurements for small shots and deeper depths are available for some of the MINEX sites, and they are useful for determining bottom interaction properties. Results for these data sets have in most cases been analyzed and incorporated into the Navy databases (OAML 2002) (which are used for this assessment). In that sense, the risk estimates have exploited the available propagation data.

4.4   Estimated Impact Areas

As was the case, for FIREX w/IMPASS, the modified CASS-GRAB shot-propagation model was used, together with existing environmental provinces for the MINEX sites. Because all the sites are shallow (less than 50 m), propagation model runs were made for bathymetry in the range from 10 m to 40 m.

Also, as had been the case for FIREX w/IMPASS, variations in estimated impact ranges varied as much within a single area as from one area to another. There was, however, little seasonal dependence. As a

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result, the impact ranges are stated as mean value with a percentage variation. As a rule, in the case of ranges determined from energy metrics, the deeper the water the shorter the range.

Table 4-1 shows the results of the model estimation. These apply to all of the MINEX sites.

Table 4-1   Estimated ZOI (km^2) for MINEX

Dominant Criterion	ZOIs 20-lb NEW
Estimated ZOI @ 13 psi-msec	0.13 sq km ± 10%
Estimated ZOI @ 182 dB re 1 μPa^2-sec	0.8 sq km ± 25%

MMPA-Level A impact areas are dominated by the onset slight lung injury criterion (pressure threshold). MMPA-Level B impact areas (for TTS) are dominated by the energy threshold.

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