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

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TABLE OF CONTENTS

APPENDIX

LIST OF FIGURES

LIST OF TABLES

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ACRONYMS AND ABBREVIATIONS

°	Degree(s)
’	Minute(s)
%	Percent
AFAST	Atlantic Fleet Active Sonar Training
AMCM	Airborne Mine Countermeasures
AMNS	Airborne Mine Neutralization System
ASW	Anti-Submarine Warfare
BOMBEX	Bombing Exercise
C	Celsius
cal.	Caliber
CG	Guided Missile Cruiser
CHASN	Charleston
dB	Decibel(s)
dB re: 1 µPa	Decibel(s) Referenced to One Micropascal
dB re: 1 μPa^2-sec	Decibel(s) Referenced to One Square Micropascal-Second
DDG	Guided Missile Destroyer
DNR	Department of Natural Resources
DoN	Department of the Navy
EEZ	Exclusive Economic Zone
EFD	Energy Flux Density
EIS	Environmental Impact Statement
EOD	Explosive Ordnance Disposal
ESA	Endangered Species Act
ESME	Effects of Sound on the Marine Environment
EWS	Early Warning System
FACSFAC	Fleet Area Coordination and Surveillance Facility
FEIS	Final Environmental Impact Statement
FIREX	Firing Exercise
ft	foot (feet)
GRAB	Gaussian Ray Bundle
HARPS	High Frequency Acoustic Recording Package
HE	High Explosive
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
IMPASS	Integrated Maritime Portable Acoustic Scoring and Simulator System
in.	Inch(es)
in.-lb/in^2	Inch Pounds per Square Inch
IP	Implementation Plan
IWC	International Whaling Commission
JAX	Jacksonville
kg	Kilogram(s)
km	Kilometer(s)

km^2	Square Kilometer(s)
lb	Pound(s)
LOA	Letter of Authorization
m	Meter(s)
MISSILEX	Missile Exercise
MIW	Mine Warfare
mm	Millimeter(s)
MMPA	Marine Mammal Protection Act
MRA	Marine Resource Assessment
MSAT	Marine Species Awareness Training
msec	Millisecond(s)
MU	Management Unit
N	North
NEW	Net Explosive Weight
nm	Nautical Miles
nm^2	Square Nautical Miles
NMFS	National Marine Fisheries Service
NMFS-SEFSC	National Marine Fisheries Service-Southeast Fisheries Science Center
NOAA	National Oceanic and Atmospheric Administration
NODE	Navy Operating Area Density Estimate
NSFS	Naval Surface Fire Support
OAML	Oceanographic and Atmospheric Master Library
OBIS-SEAMAP	Ocean Biological Information System-Spatial Ecological Analysis of Megavertebrate Populations
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
PTS	Permanent Threshold Shift
RDT&E	Research, Development, Test, and Evaluation
S	South
SAB	South Atlantic Bight
SAR	Stock Assessment Report
SSC	Space and Naval Warfare Systems Center
SST	Sea Surface Temperature
STW	Strike Warfare
SUA	Special Use Airspace
SUW	Surface Warfare
SVP	Sound Velocity Profile
TAP	Tactical Training Theater Assessment and Planning
TM	Tympanic Membrane
TTS	Temporary Threshold Shift
U.S.	United States

U.S.C.	United States Code
USACE	United States Army Corp of Engineers
USCG	United States Coast Guard
UXO	Unexploded Ordnance
VACAPES	Virginia Capes
W	Warning Area
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 Virginia Capes (VACAPES) Range Complex. 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. The issuance occurs when the Secretary of Commerce, after notice has been published in the Federal Register and opportunity for comment has been provided, finds that such takes will have a negligible impact on the species and stocks of marine mammals and will not have an unmitigable adverse impact on their availability for subsistence uses. The National Marine Fisheries Service (NMFS) has promulgated implementing regulations under 50 Code of Federal Regulations (CFR) § 216.101-106 that provide a mechanism for allowing the incidental, but not intentional, taking of marine mammals while engaged in a specified activity.

This document has been prepared in accordance with the applicable regulations and the MMPA, as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law 108 136). The bases of this LOA are (1) the analysis of spatial and temporal distributions of protected marine mammals in the Virginia Capes 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 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., temporary threshold shift [TTS] and behavioral effects) and possible Level A harassment (e.g., mortality or permanent threshold shift [PTS]), under the MMPA of 1972.

An Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) is being prepared for the VACAPES 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 VACAPES Range Complex Study Area 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

Surface Warfare (SUW) supports 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 and surface-to-surface Bombing Exercises that occur at sea.

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

Fixed winged aircraft crews (P-3Cs and P-8As) and helicopter crews (MH-60Ss) launch missiles at at-sea surface targets with the goal of destroying or disabling the target. MISSILEX (A-S) training in the VACAPES Study Area can occur during the day or at night in the locations described in Chapter 2 (**Figure 1**) as depicted in the table below:

Operation	Platform	System/ Ordnance	Number of Events
Missile Exercise (MISSILEX) (Air to Surface)	MH-60S, HH-60H	AGM-114 (Hellfire missile)	60 sorties (60 missiles)
	F/A-18, P-3C, and P-8A	AGM-65 E/F (Maverick missile)	20 sorties (20 missiles)

HH-60H, & MH-60S Helicopters with Hellfire Missiles

One or two helicopters approach and acquire an at-sea surface target, which is then designated with a laser to guide the Hellfire to the target. The laser designator may be onboard the helicopter firing the Hellfire, another helicopter, or another source. The helicopter launches a missile from an altitude of about 300 feet 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) (TNT equivalent) of the Hellfire missile is 8-pounds (lbs).

F/A-18C/E/F Aircraft with Maverick Missiles

Two aircraft approach an at-sea surface target from an altitude between 25,000 feet and 5,000 feet, complete the internal targeting process, and launch a Maverick missile at the target. The targets used for the Maverick missile are the same as those described above for the Hellfire missile. The Maverick missile has a NEW of 100-lbs.

P-3C and P-8 Aircraft with Maverick Missiles

This training event is exactly the same as the Maverick missiles fired from the F/A-18C/E/F aircraft, except that only one aircraft is involved in the training.

BOMBING EXERCISE (AIR-TO-SURFACE) [BOMBEX (AIR-TO-SURFACE)] AT-SEA

Strike fighter aircraft (F/A-18s) deliver explosive bombs against at-sea surface targets with the goal of destroying the target. BOMBEX (A-S) training in the VACAPES Study Area occurs only during daylight hours in the locations described in Chapter 2 (**Figure 1**) as depicted in the table below:

Operation	Platform	System / Ordnance	Number of Events
Bombing Exercise (BOMBEX) (Air-to-Surface, At-Sea)	F/A-18	MK-83/GBU-32 [1,000 lb High Explosive (HE) bomb]	5 events (20 bombs 4 bombs/event)

F/A-18C/E/F with Unguided or Precision-guided Munitions

Two aircraft will approach an at-sea target from an altitude of between 15,000 feet to less than 3,000 feet and release a high-explosive (HE) 1,000-lb bomb on the target. Both unguided MK-83 bombs and GBU-32 laser-guided bombs are used. MK-83 and GBU-32 bombs have a NEW of 385-lbs. The typical bomb release altitude is below 3,000 feet and the target is usually a flare. Laser designators from participating aircraft, support aircraft, or ground support personnel are used to illuminate the target when laser guided bombs (GBU-32) are used. The time in between bomb drops is approximately 3 minutes.

1.2 Mine Warfare/Mine Exercises

Mine Warfare (MIW) includes the strategic, operational, and tactical use of mines and mine countermine measures (MCM). MIW training events are also collectively referred to as Mine Exercises (MINEX). MIW training/MINEX utilizes shapes to simulate mines. These shapes are either concrete-filled shapes or metal shapes. No actual explosive mines are used during MIW training in the VACAPES Study Area. MIW training or MINEX is divided into the following:

- Mine laying: Crews practice the laying of mine shapes in simulated enemy areas;
- Mine countermeasures: Crews practice "countering" simulated enemy mines to permit the maneuver of friendly vessels and troops. "Countering" refers to both the detection and identification of enemy mines, the marking and maneuver of vessels and troops around identified enemy mines and mine fields, and the disabling of enemy mines.
    - Mine neutralization: A subset of mine countermeasures is mine neutralization. Mine neutralization refers to the disabling of enemy mines by causing them to self-detonate either by setting a small explosive charge in the vicinity of the enemy mine, or by using various types of equipment that emit a sound, pressure, or a magnetic field that causes the mine to trip and self-detonate. In all cases, actual explosive (live) mines are not used during training events. Rather, mine shapes are used to simulate real enemy mines.

In the VACAPES Study Area, MIW training/MINEX events include the use of explosive charges for two types of mine countermeasures and neutralization training. These are: training using the Airborne Mine Neutralization System (AMNS), and underwater detonations of mine shapes by Explosive Ordnance Disposal (EOD) divers. The locations of these events in the VACAPES Study Area are described in Chapter 2 and depicted in the table below.

MIW training using AMNS and EOD underwater detonations in the VACAPES Study Area occur only during daylight hours in the locations described in Chapter 2 (**Figure 1**) as depicted in the table below:

MINE NEUTRALIZATION

Operation	Platform	System/ Ordnance	Number of Events
Mine Neutralization	MH-60S	AMNS	30 rounds
	EOD	20 lb charges	24 events

MH-60S with Airborne Mine Neutralization System (AMNS)

The AMNS (AN/ASQ-235) is deployed from an MH-60S helicopter in the area where threat mines have been previously located by other sources. AMNS is lowered into the water by the helicopter where the expendable, self-propelled neutralizer can reacquire the previously located mine shape with its sonar and video systems. These systems relay their data to the operator in the helicopter through a fiber-optic cable so the operator can then properly position the neutralizer onto the most vulnerable area of the mine. A shaped explosive charge on the neutralizer, 3.24-lbs. NEW, is then detonated to simulate neutralization of the mine shape. If the mine shape were an actual mine, it would explode due to the pressure and energy exerted in the water from the smaller AMNS explosive charge. The AMNS is used during daytime and nighttime training events in the VACAPES Study Area.

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 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-lbs 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 VACAPES Study Area.

1.3 Amphibious Warfare

Amphibious Warfare (AMW) involves the utilization of naval firepower and logistics in combination with U.S. Marine Corps landing forces to project military power ashore. AMW 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 VACAPES 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 Firing Exercise (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) system, a system of buoys that simulate a land mass. FIREX training using IMPASS in the VACAPES Study Area occurs only during daylight hours in the locations described in Chapter 2 (**Figure 1**) as depicted in the table below:

Operation	Platform	System / Ordnance	Number of Events
FIREX with IMPASS	CG, DDG	5" gun (IMPASS)	22 events (868 HE rounds)

The IMPASS system is a technology solution 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 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 four to six nm from the IMPASS buoy target area. One or more live 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). 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 lbs.) and 31 non-explosive rounds being fired for each event. The exercise is 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 Strike Warfare

Strike Warfare (STW) operations are the applications of offensive military power at any chosen time and place to help carry out national goals. The systems required to conduct STW include: weapons, launch platforms, and command and control systems, intelligence, surveillance, reconnaissance, and targeting systems, and pilots or crews to operate the systems.

In the VACAPES Study Area, STW that involve the use of explosive ordnance includes air-to-surface Missile Exercises (MISSILEX (A-S)).

HIGH-SPEED ANTI-RADIATION MISSILE EXERCISE (AIR-TO-SURFACE) [HARMEX (A-S)]

Strike fighter and electronic attack aircraft use sensors to detect radar signals from a simulated threat radar site and either simulate or actually launch an explosive or non-explosive HARM with the goal of destroying or disabling the threat radar site. HARM training events are conducted in the daytime and at night in the VACAPES Study Area in locations described in Chapter 2 (**Figure 1**) and as depicted in the table below:

Operation	Platform	System / Ordnance	Number of Events
HARM Missile Exercise (HARMEX)	F/A-18	AGM-88 (HARM)	26 sorties (26 missiles)

A HARMEX scenario may require the launching aircraft to employ the missile either offensively or defensively. In the offensive role, the HARM is employed against an electronic emitter (either actual threat radar equipment or a threat simulator) during a Suppression of Enemy Air Defenses (SEAD) mission. The HARM aircraft precedes other aircraft and vessels, “baiting” the enemy’s Integrated Air Defense System (IADS) to radiate its radar, so these threat weapons systems can be engaged and destroyed by HARM. In the defensive role, HARM is employed reactively and spontaneously against a previously unidentified emitter that poses an immediate threat to itself, or to other friendly aircraft or vessels.

F/A-18C/E/F with HARM (AGM-88)

Two to four aircraft approach the threat radar site at an altitude well above 3,000 feet. With a range greater than 57 nm, HARM allows the launching aircraft to stay outside the range of many antiaircraft weapons that may be defending the threat radar site. Once the target is located with onboard sensors, the HARM is launched against an active radar emission. The target is typically a barge that is towed to sea by a tug or range boat, set adrift, then recovered after the exercise and returned to port. The barge has a tower with an electronic emitter that the HARM will seek when it has been fired from the launch aircraft. The explosive HARM will explode about 30 feet in the air, near the emitter, and the remaining pieces will sink to the bottom. The NEW of HARM is 48-lbs.

1.5 Vessel Movement

Vessel movements are associated with most activities under the training operations in the VACAPES study area. Currently, the number of Navy vessels operating in the VACAPES 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 feet for a SSN to 1,092 feet for a CVN and speeds generally range from 10 to 14 knots. Operations involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to 2 weeks. These operations are widely dispersed throughout the OPAREA, which is a vast area encompassing 27,661 nm^2 (an area approximately the size of Indiana). The Navy logs about 1400 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 0.0004 ships/nm^2).

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CHAPTER 2 LOCATION AND DEFINITION OF EXPLOSION ACTIVITIES

2.1 Description of the Virginia Capes Study Area

The VACAPES Study Area geographically encompasses offshore, near-shore, and onshore OPAREAs, ranges, and Special Use Airspace (SUA) located near the east coast of the United States (U.S.) (**Figure 1**). The lower Chesapeake Bay is also part of the Study Area, although no training involving explosions would be performed in this area. Together, components of the VACAPES Study Area encompass:

- 27,661 square nautical miles (nm^2) of sea space (not including the portion of the Lower Chesapeake Bay); and
- 28,672 nm^2 of SUA warning areas

The portions of the VACAPES Study Area addressed in this LOA consist of the offshore OPAREA (surface and subsurface waters) and the SUA warning areas (and not the SUA associated with land ranges), and waters extending from the shoreline to the OPAREA boundary (**Table 1**). **Table 6** provides a list of marine mammal species that have been confirmed and/or have potential to occur in the VACAPES Study Area.

The VACAPES OPAREA is a set of operating and maneuver areas with defined ocean surface and subsurface operating areas described in detail in **Table 1**. The OPAREA is located in the coastal and offshore waters of the western North Atlantic Ocean adjacent to Delaware, Maryland, Virginia, and North Carolina (**Figure 1**; 27,661 nm^2 of surface waters). The northernmost boundary of the OPAREA is located 37 nautical miles (nm) off the entrance to Delaware Bay at latitude 38 degrees (°) 45 minutes (‘) North (N), the farthest point of the eastern boundary is 184 nm east of Chesapeake Bay at longitude 72° 41’ West (W), and the southernmost point is 105 nm southeast of Cape Hatteras, North Carolina, at latitude of 34° 19’ N. The western boundary of the OPAREA lies 3 nm from the shoreline at the boundary separating state and federal waters.

A warning area is airspace of defined dimensions, extending from 3 nm outward from the U.S. coast, which contains activity that may be hazardous to nonparticipating aircraft. The purpose of such warning area is to warn nonparticipating pilots of the potential danger. A warning area may be located over domestic or international waters or both.

Figure 1 High Explosives Ordnance Areas in the VACAPES Study Area

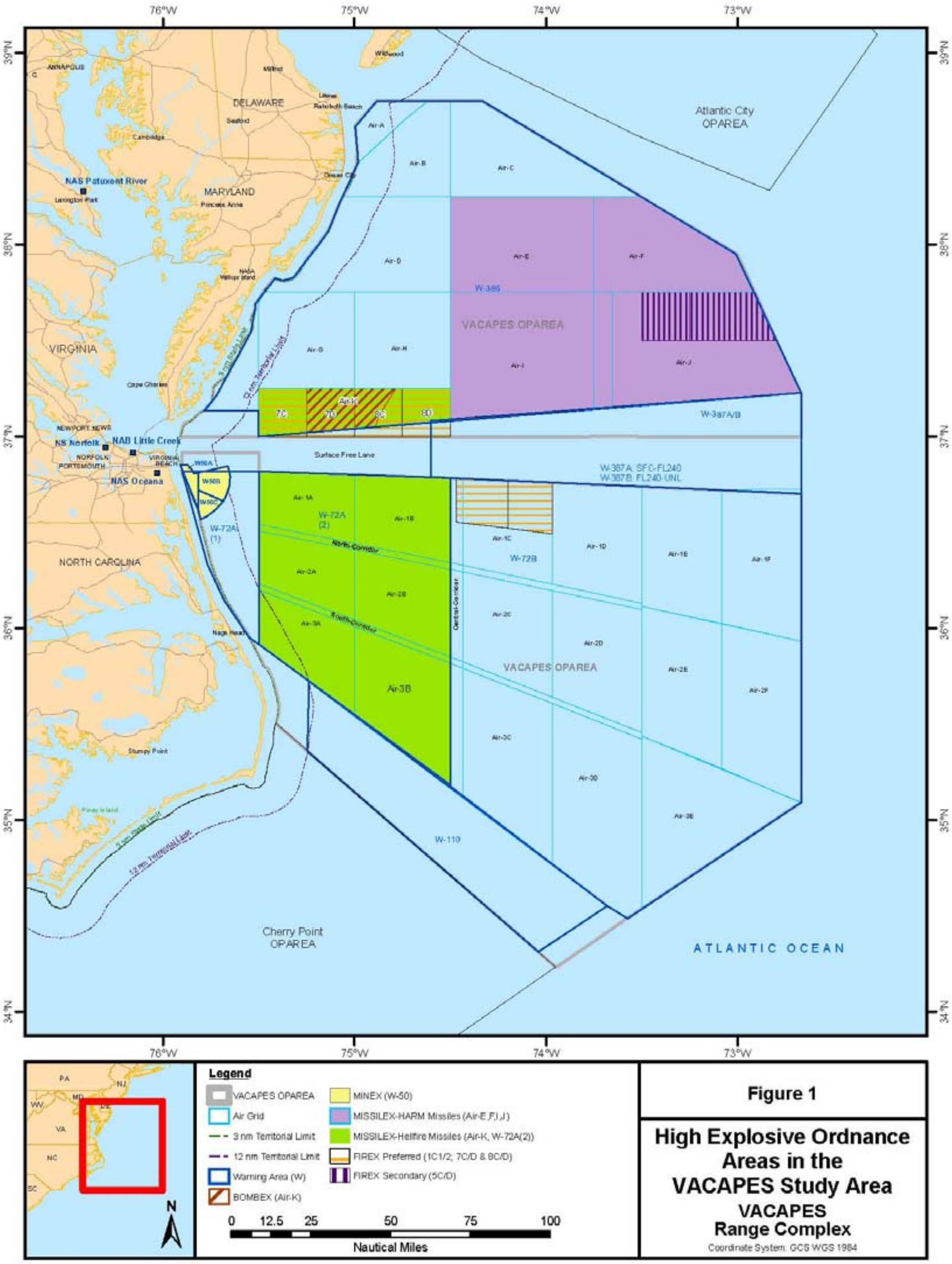


Table 1 VACAPES OPAREA and Warning Area Descriptions

Component	Description
Operating Area (OPAREA) - Surface Waters	The surface OPAREA within of the VACAPES Range Complex has an area of 27,661 nm2. The shoreward extent of the OPAREA is roughly aligned with 3 nm state territorial limits. See **Figure 1**.
Operating Area (OPAREA) - Subsurface Waters	This area of the VACAPES Range Complex is undersea space that underlies the surface OPAREA. The volume of undersea space associated with a particular portion of the VACAPES Range Complex OPAREA varies greatly based on the sea floor depth. The types of underwater environments include: shallow littoral waters (less than 60 feet) shallow offshore waters (less than 600 feet) deepwater sloping sea floor and canyons (up to 9,600 feet) deepwater ocean areas (up to 13,000 feet) This variety in water depth environments offers a challenging setting for submarine training.
Special Use Airspace (SUA) - Warning Areas	Warning Areas of the VACAPES Range Complex are large blocks of Special Use Airspace generally overlaying the VACAPES OPAREA from the surface to an unlimited altitude. Operations conducted in these Warning Areas include all-weather flight training, Unmanned Aerial Vehicle (UAV) flights, refueling, test flights, rocket and missile firing, bombing, fleet training, independent unit training, anti-submarine warfare, aircraft carrier, ship and submarine operations, and anti-air and surface gunnery. Conventional ordnance is permitted. The Warning Areas of the VACAPES Range Complex are: W–50A/B/C; W-72A/B; W-110; W-386A /B /C /D /E /F/ G/ H/ I /J; and W–387A/B.

2.2 Levels and Locations of Explosive Operations

Tables 2-5 describe the anticipated level of activity and locations for the different types of operations conducted in the VACAPES Study Area. Operations are organized by warfare area as described in Chapter 1.

Table 2 Operations Involving Explosions in the VACAPES Study Area

Operation	Platform	System or Ordnance	Preferred Alternative	Training Area
MINE WARFARE (MIW)				
Mine Neutralization	MH-60S	AMNS	140 sorties (30 rounds)	W-50
	Explosive Ordnance Disposal	20-lb charges	24 events	Surface Danger Zone (W-50)
SURFACE WARFARE (SUW)				
Bombing Exercise (BOMBEX) (Air-to-Surface)	F/A-18	MK-83/GBU-32 (1,000 lbs HE bomb)	5 events (20 bombs)	W-386 (Air-K)
Missile Exercise (MISSILEX) (Air-to-Surface)	MH-60S, HH-60H	AGM-114 (Hellfire missile; HE)	60 sorties (60 missiles)	W-386 (Air-K) (75%) W-72A (25%)
	F/A 18, P-3C and P-8	AGM-65 E/F (Maverick; HE)	20 sorties (20 missiles)	W-386 (Air-K)
Strike Warfare (STW)				
HARM Missile Exercise (HARMEX)	F/A-18	AGM-88 (HARM)	26 sorties (26 missiles)	W-386 (Air E,F,I,J)
FIREX with IMPASS	CG, DDG	5” gun	22 events (858 HE rounds)	W-386 (7C/D, 8C/D), W-72 (1C1/2) (Preferred Areas), W-386 (5C/D) (Secondary Areas)

Table 3 Summary of Explosive Ordnance in the VACAPES Study Area

Potential Stressor and Operational Parameter	Preferred Alternative
	(#/yr)
Underwater Explosions/High Explosive (HE) Use	
Bombs	
MK-83	20
Missiles	
HARM	26
Maverick	20
Hellfire	60
5-in. rounds	
Naval gun shells	858
Underwater detonation	
AMNS 3.24 lb NEW charges	30
20 lb NEW charges	24

Table 4 Summary of Explosive Ordnance Use by Training Area in the VACAPES Study Area

Training Area and Ordnance Type	Number of Rounds Per Year
	Preferred Alternative
W-50C	
AMNS	30
W-72A	
Missiles, Hellfire	15
W-72 (1C1 and 1C2)	
Naval gun shells (5 in)	286
W-386 (Air-E, F, I, J)	
Missiles, HARM	26
W-386 (Air-K)	
Bombs	20
Missiles, Hellfire	45
Missiles, Maverick	20
W-386 (5C and 5D)	
Naval gun shells (5 in)	286
W-386 (7C/7D and 8C/8D)	
Naval gun shells (5 in)	286

Table 5 Summary of Explosives and Their Net Explosive Weights by Training Area in the VACAPES Study Area

Training Area and Ordnance Type	Number of Events Per Year
	Preferred Alternative
W-386 (Air-E, F, I, J)	
HARM (48 lb NEW)	26
W-386 (Air-K)	
MK-83 (385 lb NEW)	5
Hellfire missiles (8 lb NEW)	45
Maverick missiles (100 lb NEW)	20
W-72 (1C1/2) and W-386 (5C/D, 7C/D, 8C/D)	
FIREX with IMPASS (8 lbs NEW)	22
W-50C	
AMNS Charge (3.24 lb NEW)	30
UNDET 20 lb NEW Charge	24
W-72A	
Hellfire missiles (8 lb NEW)	15

CHAPTER 3 MARINE MAMMAL SPECIES AND NUMBERS OCCURRING IN THE VIRGINIA CAPES STUDY AREA

Thirty-four marine mammal species have confirmed or potential occurrence in the VACAPES Study Area analyzed in this document. These include 33 cetacean species and one pinniped species (DoN, 2007a), which can be found in **Table 6**. Although it is possible that any of the 34 species of marine mammals may occur in the Study Area, only 24 of those species are expected to occur regularly in the region. Some cetacean species are resident in the Study Area 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 Operating Areas (OPAREAs). Specifically, the goal of the MRA program is to describe and document the marine resources present in each of the Navy's OPAREAs. The MRA for the Virginia Capes OPAREA was recently updated in 2007 (DoN, 2007a).

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 National Marine Fisheries Service (NMFS) reports including stock assessment reports, recovery plans, and survey reports.

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

Table 6 Marine Mammal Species Found in the VACAPES Range Complex

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 borealis	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	

Family and Scientific Name	Common Name	Federal Status
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 delphis	Common dolphin	
Lagenodelphis hosei	Fraser's dolphin	
Lagenorhynchus acutus	Atlantic white-sided 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	

Source: DoN, 2007a

3.2 Estimated Marine Mammal Densities

The density estimates that were used in previous Navy environmental documents have been recently updated to provide a compilation of the most recent data and information on the occurrence, distribution, and density of marine mammals. The updated density estimates presented in this LOA are derived from the *Navy OPAREA Density Estimates (NODE) for the Southeast OPAREAS* report (DON, 2007b).

Density estimates for cetaceans were either modeled using available line-transect survey data or derived using available data in order of preference: 1) through spatial models using line-transect survey data provided by NMFS; 2) using abundance estimates from Mullin and Fulling (2003); 3) or based on the cetacean abundance estimates found in the most current National Oceanic and Atmospheric Administration (NOAA) stock assessment report (SAR) (Waring et al. 2007).

The following shows how density estimates were modeled or derived:

Model-Derived Density Estimates - Line Transect Survey Data

- 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]

[1] Abundance estimates were geographically and seasonally partitioned

[2] Abundance estimates were uniformly distributed geographically and seasonally Source: DON, 2007b

Species for Which Density Estimates Are Not Available

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

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 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.

The analyses for cetaceans were based on sighting data collected through shipboard surveys conducted by NMFS-Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (NMFS-SEFSC) between 1998 and 2005. Species-specific density estimates derived through spatial modeling were compared with abundance estimates found in the most current NOAA SAR to ensure consistency. All spatial models and density estimates were reviewed by and coordinated with NMFS Science Center technical staff and scientists with the University of St. Andrews, Scotland, Centre for Environmental and Ecological Modeling (CREEM). For a more detailed description of the methodology involved in calculating the density estimates provided in this LOA, please refer to the NODE report for the Southeast (DON 2007b).

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 chlorophyll *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 marine mammal prey are attracted to the increased primary productivity associated with some of these features (Biggs et al., 2000; Wormuth et al., 2000; Davis et al., 2002). The warm Gulf Stream moves rapidly through the Florida Straits and extends northeast along the continental shelf. 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 VACAPES study area, 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). This area harbors two warmer-water and two colder-water *Mesoplodon* (beaked whale) species in the western North Atlantic (MacLeod, 2000b). 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). Some closely related species that occupy the same ecological niche, such as long-finned and short-finned pilot whales, have shifting distributions relative to the positions of cold-water and warm-water currents (Payne and Heinemann, 1993).

4.1 Threatened or Endangered Marine Mammal Species

Six marine mammal species that occur in the VACAPES study area and may be affected by the proposed activities are listed as endangered under the ESA. These include five baleen whale species (blue, fin, humpback, North Atlantic right, and sei whales) and one toothed whale species (sperm whale).

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).

Like other rorquals, blue whales feed by “gulping” (Pivorunas, 1979) almost exclusively on krill (Nemoto and Kawamura, 1977).

Status and management—The endangered blue whale was severely depleted by commercial whaling in the twentieth century (NMFS, 1998b). At least two discrete populations are found in the North Atlantic. One ranges from West Greenland to New England and is centered in eastern Canadian waters; the other is centered in Icelandic waters and extends south to northwest Africa (Sears et al., 2005). There are no current estimates of abundance for the North Atlantic blue whale (Waring et al., 2007); however, the nearly 400 photo-identified individuals from the Gulf of St. Lawrence area are considered to be a minimum population estimate for the western North Atlantic stock (Waring et al., 2007). The blue whale is under the jurisdiction of the NMFS. The recovery plan for the blue whale was issued in 1998 (NMFS, 1998b).

Habitat—Blue whales inhabit both coastal and oceanic waters in temperate and tropical areas (Yochem and Leatherwood, 1985). 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 in the Atlantic are primarily found in deeper, offshore waters and are rare in shallower, shelf waters (Wenzel et al., 1988). Important foraging areas for this species include the edges of continental shelves and upwelling regions (Reilly and Thayer, 1990; Schoenherr, 1991). Based on acoustic and tagging data from the North Pacific, relatively cold, productive waters and fronts attract feeding blue whales (Moore et al., 2002). In the Gulf of St. Lawrence, blue whales show strong preferences for the nearshore regions where strong tidal and current mixing leads to high productivity and rich prey resources (Sears et al., 1990). Clark and Gagnon (2004) determined that vocalizing blue whales show strong preferences, 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 Exclusive Economic Zone (EEZ) and the Gulf of Maine from August to October, which may represent the limits of their feeding range (CETAP, 1982; Wenzel et al., 1988). Sightings in the Gulf of Maine and U.S. EEZ have been made in late summer and early fall (August and October) (CETAP, 1982; Wenzel et al., 1988). Researchers using the Navy integrated undersea surveillance system 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).

VACAPES study area 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. 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°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.

VACAPES study area 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, 2007b).

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, 2006c).

Status and management—The NOAA stock assessment report estimates that there are 2,814 individual fin whales in the western North Atlantic stock (Waring et al., 2007); this is probably an underestimate, however, as the data were not corrected for animals missed while diving. Incorporation of a dive correction factor brings the estimate to 5,000 to 6,000 fin whales in the waters of the U.S. Atlantic (CETAP, 1982; Kenney et al., 1996). The fin whale is listed as endangered and is under jurisdiction of the NMFS. The draft recovery plan for the fin whale was released in June 2006 (NMFS, 2006c). NMFS recently initiated a 5-year review for the fin whale under the ESA (NMFS, 2007).

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

Distribution—Fin whales are broadly distributed throughout the world's oceans, usually in temperate to polar latitudes and less commonly in the tropics (Reeves et al., 2002). 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 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.

VACAPES study area fin whale occurrence—Fin whales are more commonly encountered north of Cape Hatteras (CETAP, 1982; Hain et al., 1992; Waring et al., 2007). 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 feet [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).

VACAPES study area fin whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 7**. Methods of how the density estimates were derived are detailed in NODE reports (DoN, 2007b). 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 7 Seasonal Density Estimates for the Fin Whale in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sep, Oct, Nov)
W-50	0.00000	0.00000	0.00000	0.00000
W-72A(2)	0.00033	0.00033	0.00033	0.00033
1C1/2	<0.00001	<0.00001	<0.00001	<0.00001
Air-E, F, I, J	0.00013	0.00013	0.00013	0.00013
Air-K	0.00154	0.00154	0.00154	0.00154
5C/D	0.00000	0.00000	0.00000	0.00000
7C/D and 8C/D	0.00182	0.00182	0.00182	0.00182

Source: DoN, 2007b

4.1.3 Humpback Whale

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

Status and management—The humpback whale is listed as endangered under the ESA. An estimated 11,570 humpback whales occur in the entire North Atlantic (Stevick et al., 2003a). Humpback whales in the western North Atlantic are thought to belong to five different strategic feeding stocks: Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland. There appears to be very little exchange between these separate feeding stocks (Katona and Beard, 1990). The best estimate of abundance for the Gulf of Maine stock is 902 individuals (Waring et al., 2007); this number is based on line-transect surveys conducted in 1999 (Clapham et al., 2003). The humpback whale 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 whales, 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).

VACAPES study area humpback whale occurrence—Humpback whales occur on the continental shelf and in deep waters of the VACAPES OPAREA in fall, winter, and spring during migrations between calving grounds in the Caribbean and feeding grounds off the northeastern U.S. During the summer, humpback whales are found further north at the feeding grounds. There is an increasing occurrence of humpback whale sightings and strandings during the winter (particularly January through April) 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). Humpback whales may occur throughout much of the nearshore and shelf waters of the VACAPES OPAREA. The area of greatest concentration includes shelf and slope waters off the coast of the Virginia/North Carolina border, as well as nearshore and shelf waters near Cape Hatteras (DoN, 2007a), and reflects the increased use of this region during the winter months. The concentration of whales here also supports the notion of the mid-Atlantic region as a supplemental winter feeding ground for humpbacks (Barco et al., 2002). During spring and fall, humpback whales may occur on the shelf, as well as further offshore, during migrations.

VACAPES study area humpback whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 8**. Methods of how the density estimates were derived are detailed in NODE Reports (DoN, 2007b). 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 8 Seasonal Density Estimates for the Humpback Whale in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sep, Oct, Nov)
W-50	0.00058	0.00116	0.00000	0.00116
W-72A(2)	0.00058	0.00116	0.00000	0.00116
Air-E, F, I, J	0.00058	0.00116	0.00000	0.00116
Air-K	0.00058	0.00116	0.00000	0.00116
1C1/2	0.00058	0.00116	0.00000	0.00116
5C/D	0.00058	0.00116	0.00000	0.00116
7C/D and 8C/D	0.00058	0.00116	0.00000	0.00116

Source: DoN, 2007b

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, from a review of the photo-id recapture database for October 2005, 306 individually recognized whales were known to be alive during 2001 (Waring et al., 2007). 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, 2005b).

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). In 1999, a Mandatory Ship Reporting System was implemented by the U.S. Coast Guard (USCG, 1999; USCG, 2001). This reporting system requires specified vessels (Navy ships are exempt) to report their location while in the nursery and feeding areas of the right whale (Ward-Geiger et al., 2005). At the same time, ships receive information on locations of North Atlantic right whale sightings in order to avoid whale collisions.

Reporting takes place in the southeastern U.S. from 15 November through 15 April. In the northeastern U.S., the reporting system is year-round and the geographical boundaries include the waters of Cape Cod Bay, Massachusetts Bay, and the Great South Channel east and southeast of Massachusetts. Proposed regulations include a speed restriction of 10 knots or less during certain times of the year along the U.S. east coast; these restrictions would only apply to vessels greater than 20 m in length and modification of key shipping routes into Boston (NMFS, 2006b; NOAA, 2006).

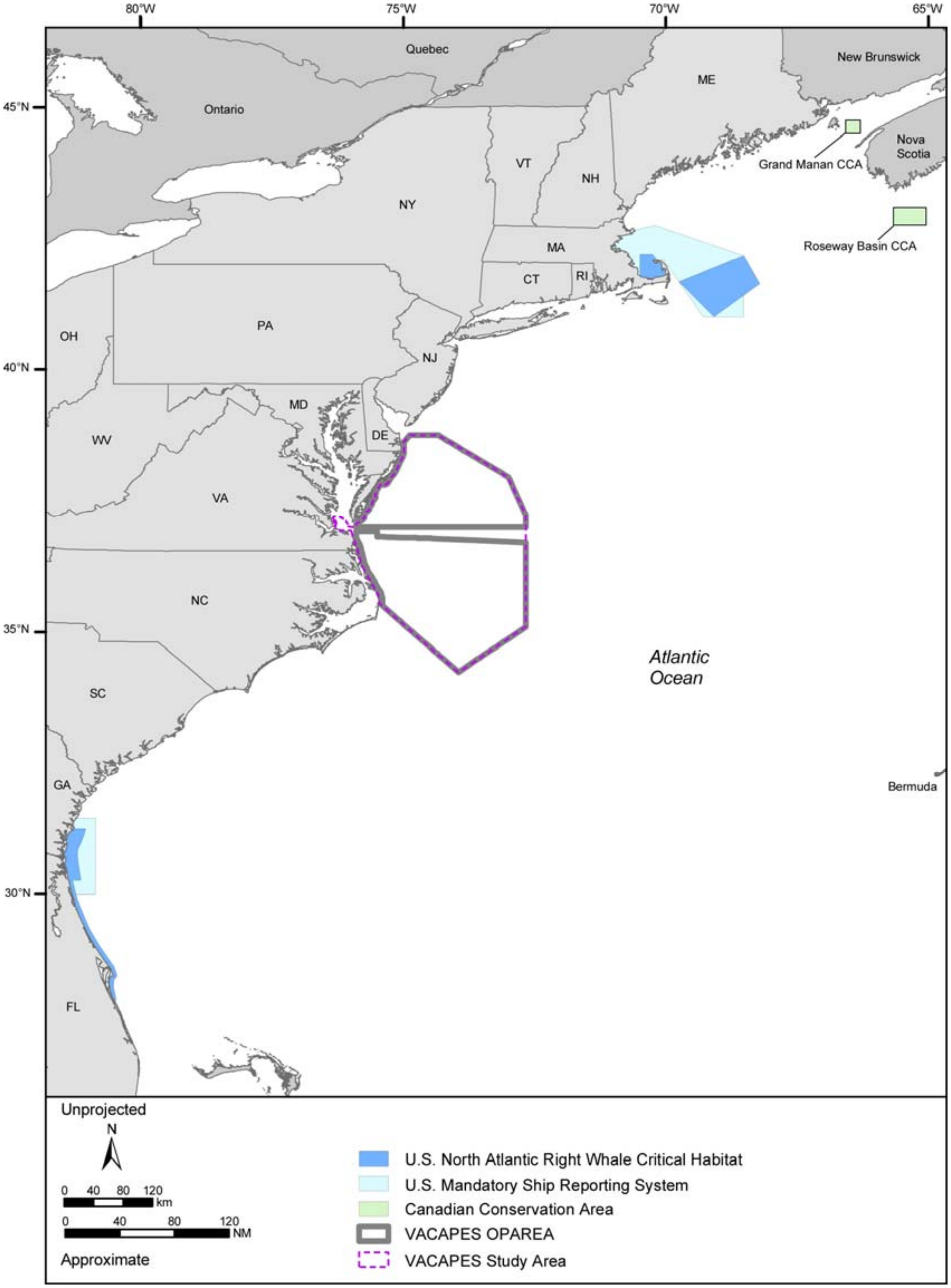
Habitat—North Atlantic right whales on the winter calving grounds are most often found in very shallow, nearshore waters in cooler sea surface temperatures inshore of a mid-shelf front (Kraus et al., 1993; Ward, 1999). High whale densities can extend more northerly than the current defined boundary of 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, 2006a; 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, 2005a) (**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).

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).

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).

VACAPES study area North Atlantic right whale occurrence—During winter, North Atlantic right whales may occur inshore of the shelf break throughout the VACAPES OPAREA. Sightings observed during spring and fall are likely of right whales transiting the area on their migration to and from breeding grounds farther south or feeding grounds farther north. Therefore, North Atlantic right whales would be expected to occur throughout the nearshore waters of the VACAPES OPAREA during these seasons. North Atlantic right whales should occur farther north on their feeding grounds during summer and are not expected in the Study Area. However, they can occasionally occur here during summer as evidenced by the few sighting and stranding records near the VACAPES OPAREA (DoN, 2007a). As noted by Gaskin (1982), North Atlantic right whales might be seen anywhere off the Atlantic U.S. throughout the year. 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.

VACAPES study area North Atlantic right whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 9**. Methods of how the density estimates were derived are detailed in NODE reports (DoN, 2007b). 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 9 Seasonal Density Estimates for the North Atlantic Right Whale in the VACAPES Study AREA Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sep, Oct, Nov)
W-50	0.00062	0.00035	0.00000	0.00017
W-72A (2)	0.00033	0.00019	0.00000	0.00009
Air-E, F, I, J	0.00006	0.00003	0.00000	0.00002
Air-K	0.00044	0.00025	0.00000	0.00012
1C1/2	0.00000	0.00000	0.00000	0.00000
5C/D	0.00000	0.00000	0.00000	0.00000
7C/D and 8C/D	0.00045	0.00025	0.00000	0.00012

Source: DoN, 2007b

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 range of the Nova Scotia stock includes U.S. Atlantic waters (Waring et al., 2007). There are no recent abundance estimates for this stock (Waring et al., 2007). The endangered sei whale is under the jurisdiction of the NMFS. A draft recovery plan for fin and sei whales was released in 1998 (NMFS, 1998a). 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 depleted throughout its range under the MMPA and 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).

VACAPES study area sei whale occurrence—The winter range of most rorquals (blue, fin, sei, and minke whales) is hypothesized to be in offshore waters (Kellogg, 1928; Gaskin, 1982). During the summer, sei whales are generally further north on feeding grounds around the eastern Scotian Shelf or Grand Banks; however, sightings within the VACAPES OPAREA during this time of year may represent individuals making early or late migrations to the feeding grounds (DoN, 2007a). Sei whales may occur throughout the VACAPES OPAREA year-round, but are probably more likely to occur in deeper offshore waters.

VACAPES study area 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 stock assessment report (DoN, 2007b). 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 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., 2007). 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, 2007).

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.

Sperm whale densities have been correlated with high secondary productivity and steep underwater topography (Jaquet and Whitehead, 1996). Data suggest that sperm whales adjust their movements to stay in or near these 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 24.9ºC 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 Exclusive Economic Zone 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 are generally distributed in Atlantic EEZ waters year-round.

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

VACAPES study area sperm whale occurrence—Worldwide, sperm whales exhibit a strong affinity for deep waters beyond the continental shelf break (Rice, 1989). Sighting records in the VACAPES OPAREA support this habitat preference (DoN, 2007a). Areas of greatest concentration are expected in waters over the continental slope and the continental rise near the center of the VACAPES OPAREA

(DoN, 2007a). These area concentrations are likely influenced by localized prey concentrations, due to upwelling associated within the Gulf Stream meanders and eddies, as well as areas of steep bottom topography. Sperm whales may occur seaward of the shelf break throughout the VACAPES OPAREA during all seasons.

VACAPES study area sperm whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 10**. Methods of how the density estimates were derived are detailed in the NODE reports (DoN, 2007b). 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.

Table 10 Seasonal Density Estimates for the Sperm Whale in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sep, Oct, Nov)
W-50	<0.00001	<0.00001	<0.00001	<0.00001
W-72A(2)	0.00933	0.00933	0.00975	0.00933
Air-E, F, I, J	0.01586	0.01586	0.02255	0.01586
Air-K	0.00054	0.00054	0.00078	0.00054
1C1/2	0.05959	0.05959	0.10951	0.05959
5C/D	0.00977	0.00977	0.01275	0.00977
7C/D and 8C/D	0.00072	0.00072	0.00116	0.00072

Source: DoN, 2007b

4.2 Non-Threatened or Endangered Marine Mammal Species

Twenty-seven non-threatened/non-endangered marine mammal species identified in **Table 6** may be affected by the proposed activities in the VACAPES OPAREA. These species include 2 baleen whale species, 25 toothed whale species, and 1 pinniped 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 the 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 kilometers (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., 2007). Recent genetic evidence suggests that there are at least two populations in the western North Atlantic (Adams and Rosel, 2006), as well as possible continental shelf and offshore segregations. Atlantic populations are divided along a latitudinal boundary corresponding roughly to Cape Hatteras (Adams and Rosel, 2006). The 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 northern New England to Venezuela, including the Gulf of Mexico and the Caribbean Sea (Perrin et al., 1987).

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

VACAPES study area Atlantic spotted dolphin occurrence—Atlantic spotted dolphins may occur in both continental shelf and offshore waters of the Study Area year-round. Atlantic spotted dolphins are commonly found in inshore waters south of Chesapeake Bay (Payne et al., 1984; Mullin and Fulling, 2003). The northern wall of the Gulf Stream and its associated warm-core ring features likely influences occurrence of Atlantic spotted dolphins in this region.

VACAPES study area Atlantic spotted dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 11**. Methods of how the density estimates were derived are detailed in the NODE reports (DoN, 2007b).

Table 11 Seasonal Density for Atlantic Spotted Dolphin in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.00110	0.00110	0.00110	0.00110
W-72A	0.29281	0.29281	0.29281	0.29281
Air-E, F, I, J	0.07583	0.07583	0.07583	0.07583
Air-K	0.00364	0.00364	0.00364	0.00364
1C1/2	1.05404	1.05404	1.05404	1.05404
5C/D	0.03612	0.03612	0.03612	0.03612
7C/D and 8C/D	0.00503	0.00503	0.00503	0.00503

Source: DoN, 2007b

4.2.2 Atlantic White-sided Dolphin

The Atlantic white-sided dolphin has a stocky body with a short, thick beak and tall, falcate dorsal fin. Adults reach 2.5 to 2.8 m in length (Jefferson et al., 1993). This species feeds on pelagic and benthipelagic fishes, such as capelin, herring, hake, sand lance, smelt, and cod, as well as squids (Katona et al., 1978; Sergeant et al., 1980; Kenney et al., 1985; Selzer and Payne, 1988; Waring et al., 1990; Weinrich et al., 2001).

Status and management—Based on the distribution of sightings, strandings, and bycatch records, three stocks have been suggested for Atlantic white-sided dolphins in the western North Atlantic: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea (Palka et al., 1997). However, recent mitochondrial deoxyribonucleic acid (DNA) analyses indicate no definite stock structure exists (Amaral et al., 2001). The total number of Atlantic white-sided dolphins along the U.S. and Canadian Atlantic coast is unknown. The best estimate of abundance for the Gulf of Maine stock is 51,640 individuals (Waring et al., 2007). The Atlantic white-sided dolphin is under the jurisdiction of NMFS.

Habitat—The Atlantic white-sided dolphin is found primarily in continental shelf waters up to 100 m deep (CETAP, 1982; Selzer and Payne, 1988; Mate et al., 1994). Atlantic white-sided dolphin occurrence in the northeastern U.S. probably reflects fluctuations in food availability, as well as oceanographic conditions (Selzer and Payne, 1988).

Distribution—Atlantic white-sided dolphins are found in cold-temperate to subpolar waters of the North Atlantic, from New England to France, north to southern Greenland, Iceland, and southern Norway (Jefferson et al., 1993). This species is most common over the continental shelf from Hudson Canyon north to the Gulf of Maine (Palka et al., 1997). Virginia and North Carolina appear to represent the southern edge of their range (Testaverde and Mead, 1980).

Calving occurs during the summer with peaks in the months of June and July (Jefferson et. al. 2008); however locations are largely unknown.

VACAPES study area Atlantic white-sided dolphin occurrence—Due to this species' preference for colder waters, the Gulf Stream may be a southern boundary for Atlantic white-sided dolphin distribution. This species may occur primarily in waters over the continental shelf throughout the VACAPES OPAREA year-round. However, distribution may also range further offshore which is evidenced by the sighting records offshore in waters over the continental slope in and near the VACAPES OPAREA (DoN, 2007a).

VACAPES study area Atlantic white-sided dolphin occurrence—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, 2007b). Lack of density estimates is not indicative of the absence of animals.

4.2.3 Beaked Whales

Based upon available data, the following five beaked whale species may be affected by the proposed activities in the VACAPES study area: Cuvier's beaked whales and four members of the genus *Mesoplodon* (True's, Gervais', Blainville's, and Sowerby's beaked whales). There is one extralimital stranding record of a northern bottlenose whale (*Hyperoodon ampullatus*) inshore of the VACAPES OPAREA (DoN, 2007a); however, this species is expected to occur in cold temperate to subarctic waters which are found much farther north of the VACAPES Study Area and are not likely to be affected by the proposed activities. Therefore, the northern bottlenose whale is not discussed further.

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

Status 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., 2007). A recent study of global phylogeographic structure of Cuvier's beaked whales suggested that some regions show a high level of differentiation (Dalebout et al., 2005); however, Dalebout et al., (2005) could not discern finer-scale population differences within the North Atlantic. The western North Atlantic stocks of the Cuvier's beaked whale and of *Mesoplodon* spp. are considered strategic stocks due to the uncertainty of stock size and the potential for human-induced mortality and serious injury because of acoustic activities (Waring et al., 2007). Beaked whales are under the jurisdiction of NMFS. Cuvier's beaked whales and *Mesoplodon* spp. are designated as strategic stocks (Waring et al., 2007).

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.

VACAPES study area beaked whale occurrence—Beaked whale may occur seaward of the continental shelf break throughout the VACAPES 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, 2007a; DoN, 2007c).

VACAPES study area beaked whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 12**. Methods of how the density estimates were derived are detailed in NODE reports (DoN, 2007b). Density is not expected to be uniform across the warning area. Beaked 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.

Table 12. Seasonal Density Estimates for Beaked Whale in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	**Spring (Mar, Apr, May)**	**Summer (Jun, Jul, Aug)**	**Fall Sep, Oct, Nov)**
W-50	0.00000	0.00000	0.00000	0.00000
W-72A	0.00010	0.00010	0.00065	0.00010
Air-E, F, I, J	0.00420	0.00420	0.00353	0.00420
Air-K	0.00000	0.00000	0.00001	0.00000
1C1/2	0.00016	0.00016	0.00064	0.00016
5C/D	0.00488	0.00488	0.00353	0.00488
7C/D and 8C/D	0.00000	0.00000	0.00002	0.00000

Source: DoN, 2007b

4.2.4 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., 2007). NMFS presently manages the offshore form as a single stock and the coastal form as a complex of migratory and resident stocks.

The NMFS provides abundance estimates for each management unit (MU) by season. During the summer, the best estimates of abundance for the Northern Migratory, Northern North Carolina, and Southern North Carolina MUs are 17,466, 7,079, and 3,786 individuals, respectively (Waring et al., 2007). During the winter, an estimated 16,913 individuals make up the Winter Mixed MU (Waring et al., 2007). Currently, a single western North Atlantic offshore stock is recognized seaward of 34 km from the U.S. coastline (Waring et al., 2007). The minimum population estimate for this stock is 70,775 individuals (Waring et al., 2007).

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). Tentative evidence suggests that the offshore stock does not inhabit waters closer than 12 km from shore during summer and 27 km from shore during winter (Garrison and Yeung, 2001). 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, 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.

VACAPES study area bottlenose dolphin occurrence—Bottlenose dolphins are abundant 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 (Kenney, 1990; Wells et al., 1999a), possibly even over the Hatteras Abyssal Plain just southeast of the VACAPES 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).

VACAPES study area bottlenose dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 13**. Methods of how the density estimates were derived are detailed in NODE reports (DoN, 2007b). Lower density estimates offshore are not necessarily indicative of fewer animals, but may reflect lower survey efforts in deep water areas.

Table 13 Seasonal Density Estimates for Bottlenose Dolphin in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.00436	0.00436	0.01526	0.00436
W-72A	0.39010	0.39010	0.39261	0.39010
Air-E, F, I, J	0.08107	0.08107	0.07070	0.08107
Air-K	0.01420	0.01420	0.02195	0.01420
1C1/2	0.16022	0.16022	0.11849	0.16022
5C/D	0.00871	0.00871	0.00447	0.00871
7C/D and 8C/D	0.01862	0.01862	0.03358	0.01862

Source: DoN, 2007b

4.2.5 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., 2007). 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.

VACAPES study area 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). A few unidentified Bryde's/sei whale records are also documented near the shelf break off the coast of Virginia (DoN, 1995). 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.

VACAPES study area 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, 2007b). 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.

4.2.6 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., 2007). The best estimate of abundance for the western North Atlantic stock of Clymene dolphins is 6,086 individuals (Waring et al., 2007). 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 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.

VACAPES study area Clymene dolphin occurrence—The oceanographic features of the Gulf Stream likely influence the distribution of Clymene dolphins in the Study Area. Based on confirmed sightings and the preference of this species for warm, deep waters, Clymene dolphins may occur in waters seaward of the shelf break south of the northern wall of the Gulf Stream. Clymene dolphins may occur north of the Gulf Stream's warm water influence, particularly during summer when water temperatures are generally warmer.

VACAPES study area Clymene dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 14**. Methods of how the density estimates were derived s are detailed in NODE reports (DoN, 2007b). 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 14 Seasonal Density Estimates for Clymene Dolphin in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.01063	0.01063	0.01063	0.01063
W-72A	0.01063	0.01063	0.01063	0.01063
Air-E, F, I, J	0.01063	0.01063	0.01063	0.01063
Air-K	0.01063	0.01063	0.01063	0.01063
1C1/2	0.01063	0.01063	0.01063	0.01063
5C/D	0.01063	0.01063	0.01063	0.01063
7C/D and 8C/D	0.01063	0.01063	0.01063	0.01063

Source: DoN, 2007b

4.2.7 Common Dolphin

Only the short-beaked common dolphin is expected to occur in the VACAPES 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., 2007). There is no information available for western North Atlantic common dolphin stock structure (Waring et al., 2007). 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 but can occur in association with the Gulf Stream (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). 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 primarily along the continental shelf break south of 40ºN in spring and north of this latitude in fall. During fall, this species is particularly abundant along the northern edge of Georges Bank (CETAP, 1982) but less common south of Cape Hatteras (Waring et al., 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.

VACAPES study area common dolphin occurrence—Common dolphins may 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., 2007). As noted in CETAP (1982) the common dolphin may occur shoreward, and they are found over the shelf throughout the year.

VACAPES study area common dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 15**. Methods of how the density estimates were derived are detailed in NODE reports (DoN, 2007b).

Table 15 Seasonal Density Estimates for Common Dolphin in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.00000	0.00000	0.00000	0.00000
W-72A	0.35755	0.35755	0.35755	0.35755
Air-E, F, I, J	0.40676	0.40676	0.40676	0.40676
Air-K	0.86488	0.86488	0.86488	0.86488
1C1/2	0.00263	0.00263	0.00263	0.00263
5C/D	0.00345	0.00345	0.00345	0.00345
7C/D and 8C/D	0.89301	0.89301	0.89301	0.89301

Source: DoN, 2007b

4.2.8 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., 2007). 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 movements of prey and shoreward flooding of warm ocean currents (Stacey et al., 1994).

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.

VACAPES study area 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 southern VACAPES OPAREA. 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, 2007a). False killer whales may occur seaward of the shelf break throughout the OPAREA year-round.

VACAPES study area 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, 2007b).

4.2.9 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., 1994a).

Status and management—No abundance estimate of Fraser's dolphins in the western North Atlantic is available (Waring et al., 2007). 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.

VACAPES study area Fraser's dolphin occurrence—Only one sighting is documented in the VACAPES Study Area; this sighting was recorded in deep waters (>3,000 m in depth) offshore of Cape Hatteras (NMFS-SEFSC, 1999). Fraser's dolphins may occur in the OPAREA in waters seaward of the continental shelf, and distribution is assumed to be similar year-round.

VACAPES study area 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 (Waring et.al. 2007).

4.2.10 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 30cm 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). The best estimate of abundance for the Gulf of Maine and Bay of Fundy stock is 89,700 individuals (Waring et al., 2007). The harbor porpoise is under the jurisdiction of NMFS.

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 over the continental shelf (NMFS, 2001b). 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, intermediate densities of harbor porpoises can be found in waters off New Jersey to North Carolina, and lower densities are found in waters off New York to New Brunswick, Canada (NMFS, 2001b). 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.

VACAPES study area 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 VACAPES study area. Occurrences of harbor porpoises in the mid-Atlantic are scattered (CETAP, 1982; Northridge, 1996). Based on distribution records and known habitat preferences, harbor porpoises may occur throughout the study area during most of the year (DoN, 2007a). 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.

VACAPES study area 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, 2007b).

4.2.11 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 fishes, cephalopods, seabirds, sea turtles, and other marine mammals (Katona et al., 1988; Jefferson et al., 1991; Visser and Bonoccorso, 2003; Pitman and Dutton, 2004; Visser, 2005).

Status and management—There are no estimates of abundance for killer whales in the western North Atlantic (Waring et al., 2007). Most cetacean taxonomists agree that multiple killer whale species or subspecies occur worldwide (Krahn et al., 2004; Waples and Clapham, 2004). However, at this time, further information is not available, particularly for the western North Atlantic. The 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 southward to Florida, the Lesser Antilles, and the Gulf of Mexico (Würsig et al., 2000), where they have been sighted year-round (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997; Würsig et al., 2000). 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.

VACAPES study area killer whale occurrence—Several killer whale sightings are recorded in both shallow and deep waters of the OPAREA and vicinity (DoN, 2007a). Strandings are also reported along the Outer Banks (DoN, 2007a). 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 available sighting data and the diverse habitat preferences of this species.

VACAPES study area 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, 2007b).

4.2.12 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., 2007). 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.

VACAPES study area melon-headed whale occurrence—The melon-headed whale is an oceanic species; it may occur seaward of the shelf break year-round throughout the study area. Based on warm water preferences, melon-headed whale occurrence in the study area during winter is likely influenced by the Gulf Stream. Two sightings of melon-headed whales are recorded in deep (>2,500 m) offshore waters along the path of the Gulf Stream in the southern VACAPES OPAREA (DoN, 2007a).

VACAPES study area 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, 2007b).

4.2.13 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 45ºW and south to the Gulf of Mexico (Waring et al., 2007). NMFS estimates the abundance of the Canadian East Coast stock to be 2,998 individuals (Waring et al., 2007). 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 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).

VACAPES study area 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.

Most sightings in the VACAPES study area and vicinity are recorded over the continental shelf; few are scattered in slope waters just beyond the shelf break (DoN, 2007a). Minke whales may occur in shelf and deep waters north of Cape Hatteras during winter. South of Cape Hatteras, minke whales may occur 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 OPAREA during spring and fall. During summer, minke whales may occur in shelf and offshore waters of the OPAREA, but are more likely to be at higher latitudes on their feeding grounds.

VACAPES study area minke whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 16**. Methods of how the density estimates were derived are detailed in NODE reports (DoN, 2007b).

Table 16 Seasonal Density Estimates for Minke Whale in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.00004	0.00004	0.00004	0.00004
W-72A	0.00004	0.00004	0.00004	0.00004
Air-E, F, I, J	0.00004	0.00004	0.00004	0.00004
Air-K	0.00004	0.00004	0.00004	0.00004
1C1/2	0.00004	0.00004	0.00004	0.00004
5C/D	0.00004	0.00004	0.00004	0.00004
7C/D and 8C/D	0.00004	0.00004	0.00004	0.00004

Source: DoN, 2007b

4.2.14 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 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., 2007). There is no information on stock differentiation for pantropical spotted dolphins in the U.S. Atlantic (Waring et al., 2007). 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.

VACAPES study area 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 OPAREA year-round.

VACAPES study area pantropical spotted dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 17**. Methods of how the density estimates were derived are detailed in Navy OPAREA Density Estimate (NODE) Reports (DoN, 2007b). 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 17 Seasonal Density Estimates for Pantropical Spotted Dolphin in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.02225	0.02225	0.02225	0.02225
W-72A	0.02225	0.02225	0.02225	0.02225
Air-E, F, I, J	0.02225	0.02225	0.02225	0.02225
Air-K	0.02225	0.02225	0.02225	0.02225
1C1/2	0.02225	0.02225	0.02225	0.02225
5C/D	0.02225	0.02225	0.02225	0.02225
7C/D and 8C/D	0.02225	0.02225	0.02225	0.02225

Source: DoN, 2007b

4.2.15 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., 2007). Neither the long-finned nor short-finned pilot whale is currently a strategic stock (Waring et al., 2007). 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). They also occur close to shore at oceanic islands where the shelf is narrow and deeper waters are nearby (Mignucci-Giannoni, 1998; Gannier, 2000; Anderson, 2005). While pilot whales are typically distributed along the continental shelf break, they are also commonly sighted on the continental shelf and inshore of the 100-m isobath, as well as seaward of the 2,000-m isobath north of Cape Hatteras (CETAP, 1982; Payne and Heinemann, 1993). Long-finned pilot whale sightings extend south to near Cape Hatteras through the VACAPES OPAREA (Abend and Smith, 1999) along the continental slope. Waring, et al., (1992) sighted pilot whales principally along the northern wall of the Gulf Stream and along the shelf break at thermal fronts. A few of these sightings were also made in the mid-portion of the Gulf Stream near Cape Hatteras (Abend and Smith, 1999).

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).

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).

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.

VACAPES study area pilot whale occurrence—The VACAPES OPAREA 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 OPAREA year-round. They may also occur between the shore and shelf break (CETAP, 1982) which is supported by opportunistic sightings and bycatch records inshore of the shelf break in the OPAREA (DoN, 2007a). 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, 2007a).

VACAPES study area pilot whale density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 18**. Methods of how the density estimates were derived are detailed in the NODE Reports (DoN, 2007b). Density is not expected to be uniform across the warning area. Pilot whales will likely be concentrated in waters near and seaward of the shelf break based on habitat preferences; however they may also occur in shelf waters in smaller numbers.

Table 18 Seasonal Density Estimates for Pilot Whales in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.00004	0.00004	0.00004	0.00004
W-72A	0.07438	0.07438	0.08958	0.07438
Air-E, F, I, J	0.07893	0.07893	0.07069	0.07893
Air-K	0.01207	0.01207	0.00302	0.01207
1C1/2	0.11408	0.11408	0.23862	0.11408
5C/D	0.09277	0.09277	0.09583	0.09277
7C/D and 8C/D	0.01314	0.01314	0.00369	0.01314

Source: DoN, 2007b

4.2.16 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. feeds 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., 2007). The best estimate of abundance for both species combined in the western North Atlantic is 395 individuals (Waring et al., 2007). Species-level abundance estimates cannot be calculated due to uncertainty of species identification at sea (Waring et al., 2007). 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 higher epipelagic zooplankton biomass may enhance the densities of squids, their primary prey (Baumgartner et al., 2001).

Distribution—Both *Kogia* spp. species apparently have a worldwide distribution in tropical and temperate waters (Jefferson et al., 1993). In the western Atlantic Ocean, the pygmy sperm whale has been documented as far north as the northern Gulf of St. Lawrence (Measures et al., 2004) and dwarf sperm whales as far south as Colombia (Muñoz-Hincapié et al., 1998).

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.

VACAPES study area Kogia spp. occurrence—*Kogia* spp. generally occurs along the continental shelf break and over the continental slope (Baumgartner et al., 2001; McAlpine, 2002). Few sightings are recorded in the OPAREA 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, 2007a). However, strandings are recorded inshore of the OPAREA boundaries during all seasons and support the likelihood of *Kogia* spp. occurrence in the OPAREA year-round (DoN, 2007a). *Kogia* spp. may occur seaward of the shelf break throughout the OPAREA year-round.

VACAPES study area Kogia spp. density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 19**. Methods of how the density estimates were derived are detailed in the NODE Reports (DoN, 2007b). Density is not expected to be uniform across the warning area. *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 19 Seasonal Density Estimates for *Kogia* Spp. in VACAPES Training Areas Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall Sep, Oct, Nov)
W-50	0.00101	0.00101	0.00101	0.00101
W-72A	0.00101	0.00101	0.00101	0.00101
Air-E, F, I, J	0.00101	0.00101	0.00101	0.00101
Air-K	0.00101	0.00101	0.00101	0.00101
1C1/2	0.00101	0.00101	0.00101	0.00101
5C/D	0.00101	0.00101	0.00101	0.00101
7C/D and 8C/D	0.00101	0.00101	0.00101	0.00101

Source: DoN, 2007b

4.2.17 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).

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Status and management—There are no abundance estimates for pygmy killer whales in the western North Atlantic (Waring et al., 2007). 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.

VACAPES study area pygmy killer whale occurrence—Only one confirmed record, a fall stranding north of Cape Hatteras, is documented for pygmy killer whales in the OPAREA and vicinity (DoN, 2007a). The pygmy killer whale is an oceanic species which may occur seaward of the shelf break year-round throughout the OPAREA. Based on warm water preferences, pygmy killer whale occurrence in the OPAREA during winter is likely influenced by the Gulf Stream.

VACAPES study area 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, 2007b).

4.2.18 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., 2007). 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. This is likely true along the eastern U.S. coast between Cape Hatteras and George's Bank where individuals were distributed along the northern wall of the Gulf Stream and associated with warm-core rings (Waring et al., 1992).

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 southward to the Gulf of Mexico, throughout the Caribbean, and around the equator (Würsig et al., 2000). In general, U.S. Atlantic Risso's dolphins occupy the mid-Atlantic continental shelf year-round, although they are rarely observed in the Gulf of Maine (Payne et al., 1984). Risso's dolphins are distributed along the continental shelf break from Cape Hatteras north to Georges Bank from March through December (CETAP, 1982; Payne et al., 1984). This range extends seaward in the mid-Atlantic Bight from December through February (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.

VACAPES study area Risso's dolphin occurrence—As mentioned above, 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, 2007a). Risso's dolphins may occur just inshore of the shelf break and seaward of the shelf break throughout the OPAREA year-round based on sighting data and the preference of this species for deep waters.

VACAPES study area Risso's dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 20**. Methods of how the density estimates were derived are detailed in the NODE Reports (DoN, 2007b). 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 20 Seasonal Density Estimates for Risso's Dolphin in the VACAPES Study Area Where Explosive Ordnance Use Occurs

Training Area	Density (animals/km2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sep, Oct, Nov)
W-50	0.00000	0.00000	0.00000	0.00000
W-72A	0.02277	0.02277	0.02277	0.02277
Air-E, F, I, J	0.03654	0.03654	0.03654	0.03654
Air-K	0.01956	0.01956	0.01956	0.01956
1C1/2	0.01894	0.01894	0.01894	0.01894
5C/D	0.04967	0.04967	0.04967	0.04967
7C/D and 8C/D	0.02516	0.02516	0.02516	0.02516

Source: DoN, 2007b

4.2.19 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., 2007). 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. Four stranded rough-toothed dolphins (three with satellite-linked transmitters) were rehabilitated and released in 1998 off the Gulf Coast of Florida (Wells et al., 1999b). Water depth at tracking locations of these individuals averaged 195 m off the Florida Panhandle (Wells et al., 1999b). In March 2005, Mote Marine Laboratory released three dolphins from the 2004 mass stranding at Hutchinson Island on the Atlantic Coast of Florida. The dolphins were tagged with satellite-linked transmitters and released southeast of Fort Pierce in waters with a bottom depth of about 110 m (Manire and Wells, 2005). The animals moved within the Gulf Stream and parallel to the continental shelf off Florida, Georgia, and South Carolina, in waters with a bottom depth of 400 to 800 m. They later moved northeast into waters with a bottom depth greater than 4,000 m (Manire and Wells, 2005). In April 2005, two dolphins from the March 2005 mass stranding in the Florida Keys were released by the Marine Animal Rescue Society off Miami, one with a satellite-linked transmitter (Wells, 2007). The tagged animal 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 (stranded with the previous group in the Florida Keys in March 2005 and rehabilitated) were satellite-tagged and released east of the Florida Keys by the Marine Mammal Conservancy (Wells, 2007). The tagging data demonstrated that these individuals 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; Würsig et al., 2000).

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

VACAPES study area rough-toothed dolphin occurrence —A few strandings and two sightings have been recorded in or near the OPAREA (DoN, 2007a). 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 OPAREA may follow the western edge of the standard deviation of the Gulf Stream. The rough-toothed dolphin may occur in the OPAREA year-round.

VACAPES study area rough-toothed dolphin occurrence—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 21**. Methods of how the density estimates were derived are detailed in the NODE Reports (DoN, 2007b). 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 21 Seasonal Density Estimates for Rough-toothed Dolphin in the VACAPES 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)
W-50	0.00048	0.00048	0.00048	0.00048
W-72A	0.00048	0.00048	0.00048	0.00048
Air-E, F, I, J	0.00048	0.00048	0.00048	0.00048
Air-K	0.00048	0.00048	0.00048	0.00048
1C1/2	0.00048	0.00048	0.00048	0.00048
5C/D	0.00048	0.00048	0.00048	0.00048
7C/D and 8C/D	0.00048	0.00048	0.00048	0.00048

Source: DoN, 2007b

4.2.20 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).

Status and management—No abundance estimates are currently available for the western North Atlantic stock of spinner dolphins (Waring et al., 2007). Stock structure in the western North Atlantic is unknown (Waring et al., 2007). The spinner dolphin is under the jurisdiction of NMFS.

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

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 poorly-known (Waring et al., 2007).

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.

VACAPES study area spinner dolphin occurrence—Several stranding, sighting, and bycatch records are documented in or near the OPAREA (DoN, 2007a). 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, 2007a). Spinner dolphins may occur from the vicinity of the continental shelf break to eastward of the OPAREA boundary in association with the Gulf Stream's northern boundary. No seasonal differences in occurrence are anticipated.

VACAPES study area 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, 2007b).

4.2.21 Striped Dolphin

The striped dolphin is uniquely marked with black lateral stripes from eye to flipper and eye to anus. There is also a white "spinal blaze" originating above and behind the eye and narrowing to a point below and behind the dorsal fin (Leatherwood and Reeves, 1983). 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., 2007). 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). Striped dolphins likely have a northern limit associated with the meanderings of the Gulf Stream (Perrin et al., 1994c; Archer and Perrin, 1999). 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 (Würsig et al., 2000). Off the northeastern U.S., striped dolphins are distributed along the continental shelf break from Cape Hatteras to the southern margin of Georges Bank, as well as offshore over the continental slope and continental rise in the mid-Atlantic region (CETAP, 1982).

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

VACAPES study area striped dolphin occurrence—The striped dolphin is a deep water species that is generally distributed north of Cape Hatteras (CETAP, 1982), which is supported by the known distribution of sightings in the OPAREA (DoN, 2007a). The southern edge of this species' predicted occurrence in the VACAPES OPAREA appears to be influenced by meanderings of the Gulf Stream (DoN, 2007a). Sightings predominately occur along the Gulf Stream's northern wall, where it travels through the southern part of the VACAPES OPAREA. Striped dolphins may occur near and seaward of the shelf break throughout the OPAREA year-round.

VACAPES study area striped dolphin density—The density estimates for training areas where explosions and/or ordnance use may occur in the VACAPES OPAREA are provided in **Table 22**. Methods of how the density estimates were derived are detailed in the NODE Reports (DoN, 2007b). 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 22 Seasonal Density Estimates for Striped Dolphin in the VACAPES 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)
W-50	0.00034	0.00034	0.00034	0.00034
W-72A	0.04396	0.04396	0.04396	0.04396
Air-E, F, I, J	0.53951	0.53951	0.53951	0.53951
Air-K	0.24305	0.24305	0.24305	0.24305
1C1/2	0.40708	0.40708	0.40708	0.40708
5C/D	0.59383	0.59383	0.59383	0.59383
7C/D and 8C/D	0.33568	0.33568	0.33568	0.33568

Source: DoN, 2007b

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., 2007).

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

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).

VACAPES study area harbor seal occurrence—Harbor seals occur seasonally along the southern New England and New York coasts from September through late May (Schneider and Payne, 1983; Waring et al., 2007). Harbor seals are considered rare in the VACAPES OPAREA, which is well south of the typical range of this species. Harbor seals may occur in the nearshore portions of the OPAREA.

VACAPES study area 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, 2007b).

CHAPTER 5 TAKE AUTHORIZATION REQUESTED

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

The National Defense Authorization Act of Fiscal Year 2004 (Public Law [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 Section 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 VACAPES 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").
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 USC 1362 (18)(B)(i)(ii)].

Modeling results from the analysis predict Level A mortalities for 1 common dolphin from use of explosive ordnance in MISSILEX activities. These modeling results do not take into account the mitigation measures (detailed in Chapter 11) that lower the potential for mortalities to occur given standard range clearance procedures and the likelihood that these species can be readily detected (e.g., small animals move quickly throughout the water column and are often seen riding the bow wave of large ships or in large groups).

Modeling results for use of explosive ordnance in MISSILEX, FIREX, and BOMBEX predict that for this LOA request, 1 Atlantic spotted dolphin, 25 common dolphins, 1 pantropical spotted dolphin, and 9 striped dolphins could be exposed to pressure in excess of permanent threshold shift (PTS) indicative of Level A injury. However, given standard mitigation measures presented in Chapter 11, and the increased likelihood that these species can be readily detected (e.g., small animals move quickly throughout the water column and are often seen riding the bow wave of large ships or in large groups), Level A exposures to these species are less likely to occur. Actual numbers of Level A exposures would likely be lower than the modeling results predict.

Modeling results for the use of explosive ordnance in MISSILEX and MINEX predict Level B temporary threshold shift (TTS) exposures for 6 Atlantic spotted dolphins, 9 bottlenose dolphins, 1 Clymene dolphin, 104 common dolphins, 4 pantropical spotted dolphins, 3 pilot whales, 3 Risso's dolphins, and 36 striped dolphins. These estimates are probably over estimates as they do not take into account the mitigation measures discussed in Chapter 11. Given the implementation of the mitigation measures, the actual exposures would likely be lower than the predicted amount.

Modeling results for the use of explosive ordnance in BOMBEX and FIREX predict Level B behavioral reaction without TTS exposures for 4 fin whales, 2 humpback whales, 4 sperm whales, 41 Atlantic spotted dolphins, 53 bottlenose dolphins, 32 Clymene dolphins, 2,541 common dolphins, 3 *Kogia* spp., 66 pantropical spotted dolphins, 34 pilot whales, 60 Risso's dolphins, 1 rough-toothed dolphin, and 745 striped dolphins. These estimates are probably over estimates as they do not take into account the mitigation measures discussed in Chapter 11. Given the implementation of the mitigation measures, the actual exposures would likely be lower than the predicted amount.

CHAPTER 6 NUMBERS AND SPECIES TAKEN

The VACAPES Range Complex EIS/OEIS analyzed the stressors associated with proposed exercises in the VACAPES Study Area. The EIS/OEIS concluded that explosions associated with BOMBEX, MISSILEX, FIREX, and MINEX were the activities with the potential to result in Level A or Level B harassment or mortality of marine mammals. Vessel strikes were also determined to have the potential to affect marine mammals. Consequently, only the use of explosive ordnance under these exercises and vessel strikes are addressed in this analysis.

6.1 Vessel Strikes

Ship strikes are known to affect large whales and sirenians in the VACAPES Study Area. The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., the sperm whale). In addition, some baleen whales, such as the North Atlantic right whale seem generally unresponsive to vessel sound, making them more susceptible to vessel collisions (Nowacek et al., 2004). These species are primarily large, slow moving whales. Smaller marine mammals-for example, Atlantic bottlenose and Atlantic spotted dolphins-move quickly throughout the water column and are often seen riding the bow wave of large ships. Marine mammal responses to vessels may include avoidance and changes in dive pattern (NRC, 2003).

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

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

Of 11 species known to be hit by ships, fin whales are struck most frequently; right whales, humpback whales, sperm whales, and gray whales are all hit commonly (Laist et al 2001). In some areas, one-third of all fin whale and right whale strandings appear to involve ship strikes. Sperm whales spend long periods (typically up to 10 minutes; Jacquet et al. 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 2006d).

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

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

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

The Navy includes marine species awareness as part of its training for its bridge lookout personnel on ships and submarines. Lookouts are trained how to look for marine species, and report sightings to the Officer of the Deck (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.

Additionally, the Navy implements additional mitigation measures to protect North Atlantic right whales. The east coast is a principal migratory corridor for North Atlantic right whales that travel between the calving/nursery areas in the Southeastern United States and feeding grounds in the northeast U.S. and Canada. Transit to the Study Area from mid-Atlantic ports requires Navy vessels to cross the migratory route of North Atlantic right whales. Southward right whale migration generally occurs from mid- to late November, although some right whales may arrive off the Florida coast in early November and stay into late March (Kraus et al., 1993). The northbound migration generally takes place between January and late March. Data indicate that during the spring and fall migration, right whales typically occur in shallow water immediately adjacent to the coast, with over half the sightings (63.%) 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 vessel collisions 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 collisions with North Atlantic right whales while transiting to and from mid-Atlantic ports during right whale migratory periods. Recent studies of right whales have shown that these whales tend to lack a response to the sounds of oncoming vessels (Nowacek et al., 2004). Although Navy vessel traffic generally represents only 2-3% of overall large vessel traffic, based on this biological characteristic and the presence of critical Navy ports along the whales' mid-Atlantic migratory corridor, the Navy was the first federal agency to proactively adopt additional mitigation measures for transits in the vicinity of mid-Atlantic ports during right whale migration. For purposes of these measures, the mid-Atlantic is defined broadly to include ports south and east of Block Island Sound southward to South Carolina.

Specifically, the Navy has unilaterally adopted the following measures:

- During months of expected Atlantic Ocean right whale occurrence, Navy vessels will practice increased vigilance with respect to avoidance of vessel-whale interactions along the mid-Atlantic coast, including transits to and from any mid-Atlantic ports.
- All surface units transiting within 56 kilometers (km) (30 Nautical Miles [NM]) of the coast in the mid-Atlantic will ensure at least two lookouts are posted, including at least one that has completed required marine mammal awareness training.

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

These measures are similar to vessel transit procedures in place since 1997 for Navy vessels in the vicinity of designated right whale critical habitat in the southeastern U.S. Based on the implementation of Navy mitigation measures, especially during times of anticipated right whale occurrence, and the relatively low density of Navy ships in the 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 National Marine Fisheries Service (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).

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

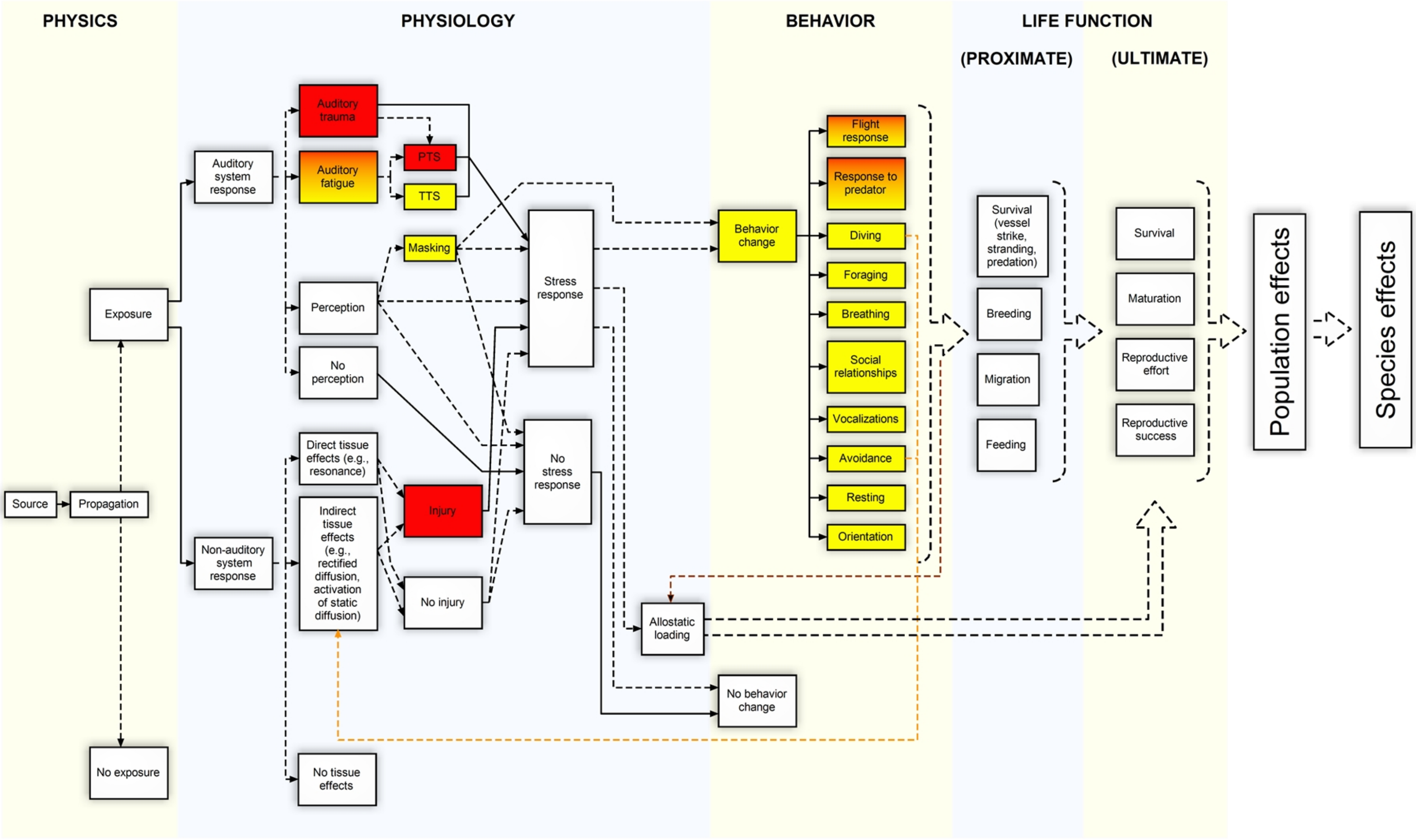

Figure 3 Analytical Framework Flow Chart

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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, permanent threshold shift [PTS], perception). Others will be necessarily qualitative, due to lack of information, or will need to be extrapolated from other species for which information exists.

Potential physiological responses to the sound exposure are ranked in descending order, with the most severe impact (auditory trauma) occurring at the top and the least severe impact occurring at the bottom (the sound is not perceived).

1. Auditory trauma represents direct mechanical injury to hearing related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma is always injurious but could be temporary and not result in PTS. Auditory trauma is always assumed to result in a stress response.
2. Auditory fatigue refers to a loss of hearing sensitivity after sound stimulation. The loss of sensitivity persists after, sometimes long after, the cessation of the sound. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic exhaustion of the hair cells and cochlear tissues. The features of the exposure (e.g., amplitude, frequency, duration, temporal pattern) and the individual animal’s susceptibility would determine the severity of fatigue and whether the effects were temporary (TTS) or permanent (PTS). Auditory fatigue (PTS or TTS) is always assumed to result in a stress response.
3. Sounds with sufficient amplitude and duration to be detected 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 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.

6.2.3 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 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 (see Section 4.6.1.4).

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.

6.2.4 Behavior

Acute stress responses may or may not cause a behavioral reaction. However, all changes in behavior are expected to result from an acute stress response. This expectation is based on the idea that some sort of physiological trigger must exist to change any behavior that is already being performed. The exception to this rule is the case of auditory masking. The presence of a masking sound may not produce a stress response, but may interfere with the animal's ability to detect and discriminate biologically relevant signals. The inability to detect and discriminate biologically relevant signals hinders the potential for normal behavioral responses to auditory cues and is thus considered a behavioral change.

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.

6.2.5 Life Function

6.2.5.1 Proximate Life Functions

Proximate life history functions are the functions that the animal is engaged in at the time of acoustic exposure. The disruption of these functions, and the magnitude of the disruption, is something that must be considered in determining how the ultimate life history functions are affected. Consideration of the magnitude of the 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.

6.2.5.2 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.

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.

6.2.6 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, BOMBEX, and MINEX. **Table 23** 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 45 Hellfire events per year that can take place in Air Kilo during any season, so there are 11.25 events modeled for each season. However, the 20 lb charge MINEX events are more likely to take place in the summer and this is represented in the seasonal allocation of events.

Table 23 Number of Explosive Events within the VACAPES OPAREA

Sub-Area	Ordnance	Winter	Spring	Summer	Fall	Annual Totals
	MISSILEX					**106**
Air-K	Hellfire	11.25	11.25	11.25	11.25	
W-72A (2)	Hellfire	3.75	3.75	3.75	3.75	
Air-E, F, I, J	Harm	6.50	6.50	6.50	6.50	
Air-K	Maverick	5	5	5	5	
	FIREX					**22**
5C/D	5" rounds	1.83	1.83	1.83	1.83	
7C/D and 8C/D	5" rounds	1.83	1.83	1.83	1.83	
1C1/2	5" rounds	1.83	1.83	1.83	1.83	
	MINEX					**54**
W-50 UNDET	5 LB*	7.50	7.50	7.50	7.50	
W-50 UNDET	20 LB	4.00	4.00	12.00	4.00	
	BOMBEX					**5**
Air-K	MK-83**	5.75	5.75	5.75	5.75	

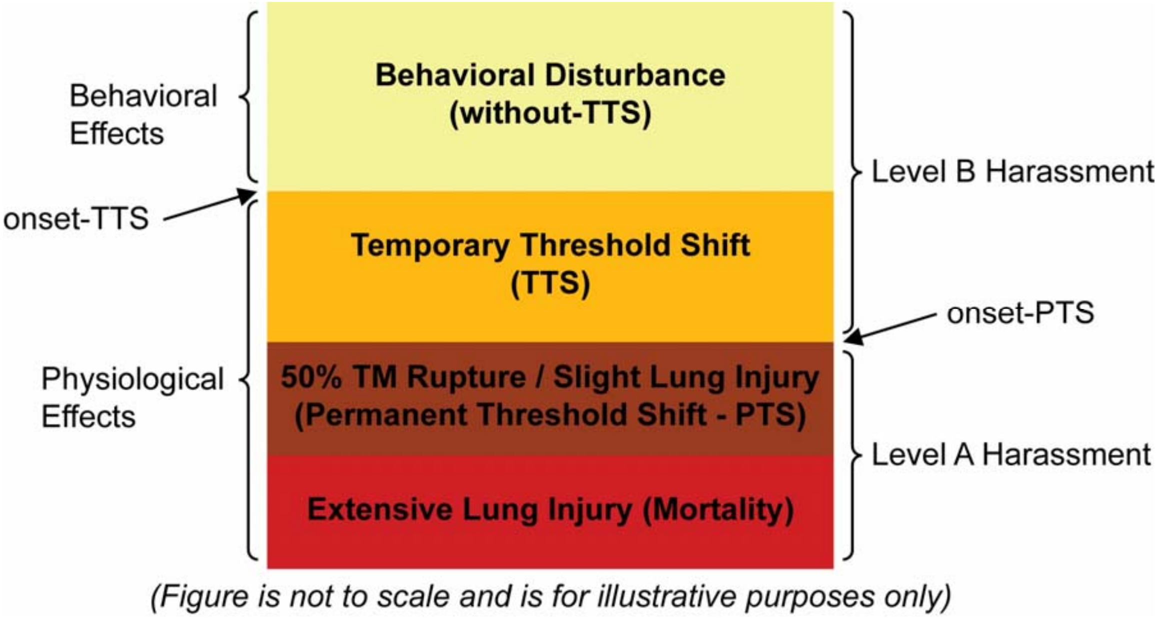
**The use of 3.24 lb charges during AMNS training were conservatively modeled as 5 lb charges.*

*** One event using the MK-83 bombs consists of 4 bombs being dropped in succession. For example, in VACAPES Air-K there are 5 MK-83 events, which mean that a total of 20 bombs will be dropped per year.*

6.3.1 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 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) and BOMBEX. In addition, this section reflects a revised acoustic criterion for small underwater explosions (i.e., 23 pounds per square inch [psi] instead of previous acoustic criteria of 12 psi for peak pressure over all exposures), which is based on the final rule issued to the Air Force by NMFS (NMFS, 2005c). 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



6.3.1.1 Thresholds and Criteria for Injurious Physiological Effects

Single Explosion

For injury, the Navy uses two 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 dB referenced to 1 micropascal squared second [dB re 1 μPa^2-sec]). 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 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 lbs), and is given in terms of the “Goertner modified positive impulse,” indexed to 13 psi-millisecond (msec) (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 marine species populations were 100% small animals. The TM rupture (energy threshold) and onset of slight lung injury are the dual criteria used in analysis to determine 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-msec. 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-msec index is a complicated calculation. To be conservative, the analysis used the mass of a calf dolphin (at 26.9 lbs) for 100% of the populations.

Multiple Explosions

For this analysis, the use of multiple explosions only applies to FIREX (with IMPASS) and the MK-83 bombs used in BOMBEX. Since FIREX and portions of BOMBEX 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; 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.

6.3.1.2 Thresholds and Criteria for Non-Injurious Physiological Effects

The Navy criterion for non-injurious harassment is TTS — a slight, recoverable loss of hearing sensitivity (DoN, 2001). In this case, there are two thresholds: Level B - TTS exposure is assumed to occur if either of the thresholds is exceeded.

Single Explosion –TTS-Energy Threshold

The first threshold is a 182 dB re 1 μPa^2-sec maximum energy flux density level in any 1/3-octave band at frequencies above 100 Hertz (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 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-sec in any 1/3-octave band. The energy threshold usually dominates and is used in the analysis to determine potential 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 referenced to 1 micropascal [dB re 1 μPa]). This criterion was adopted for Precision Strike Weapons (PSW) Testing and Training by Eglin Air Force Base in the Gulf of Mexico (NMFS, 2005b). 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 without-TTS (behavioral) impact range 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.

6.3.1.3 Thresholds and Criteria for Behavioral Effects

Single Explosion

For a single explosion, to be consistent with Churchill, TTS is the criterion for 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—without TTS

For this analysis, the use of multiple explosions only applies to FIREX (with IMPASS) and the MK-83 bombs used in BOMBEX. Because multiple explosions would occur within a discrete time period, a new 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 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 SSC tests, and is found to be 5 dB below the threshold for TTS, or 177 dB re 1 μPa^2-sec 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. For BOMBEX involving MK-83 bombs, behavioral disturbance (without TTS) (177 dB re 1 μPa^2-s) is the criteria that dominates in the analysis to determine potential Level B exposures due to the use of multiple explosions.

6.3.2 Summary of Thresholds and Criteria for Impulsive Sounds

Table 24 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 or a BOMBEX event involving MK-83 bombs.

Table 24 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 lbs)	Mortality
Physiological	50% Tympanic Membrane Rupture	Energy flux density	1.17 in-lb/in^2 (about 205 dB re 1 μPa^2-sec)	*MMPA* - Level A
Physiological	Onset Slight Lung Injury	Goertner modified positive impulse	indexed to 13 psi-msec (assumes 100% small animal at 26.9 lbs)	*MMPA* - Level A
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-sec	*MMPA* - Level B
Physiological	TTS	Peak pressure over all exposures	23 psi	*MMPA* - Level B
Behavioral	Multiple Explosions 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-sec	*MMPA* - Level B
MMPA = Marine Mammal Protection Act TTS = Temporary Threshold Shift				

6.3.3 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 (SVP) – 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.

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.

6.3.4 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 firing exercise (FIREX) mission, and determining the effects area based on the thresholds and criteria. Level B exposures were determined based on the 177 dB re 1 μPa^{2-}sec (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 missions (each with four to six rounds fired) and one pre-FIREX action (with six rounds fired). **Table 25** shows the Zone of Influence (ZOI) results of the model estimation.

Table 25 Estimated ZOIs (km^2) for a single FIREX (with IMPASS) Event (39 rounds)

Area	Level B ZOI @ 177 dB re 1 μPa^2-sec (multiple detonations only)	Level B ZOI @ 23 psi	Level A ZOI @ 205 dB re 1 μPa^2-sec or 13 psi
VACAPES			
5C/D	0*	3.7044	0.16464
7C/D and 8C/D	5.6595	3.7044	0.16464
1C1/2	0*	3.7044	0.16464

**In these areas, which occur in deeper water, the 23psi criteria dominates over the 177 dB re 1 μPa^2-sec behavioral disturbance criteria and therefore was used in the analysis.*

The ZOI, when multiplied by the animal densities (See Chapter 4) and the total number of events (**Table 23**), 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 two primary locations (1C1/2; 7C/D & 8C/D) and a secondary location (5C/D), (**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.

BOMBEX

Modeling was completed for one explosive source involved in BOMBEX, each assumed detonation at 1-m depth. The NEW used in simulations of the MK83 is 415.8-lb.

Determining the ZOI for the thresholds in terms of total energy flux density (EFD), impulse, peak pressure and 1/3-octave bands EFD must treat the sequential explosions differently than the single detonations. For the MK-83, two factors are involved for the sequential explosives that deal with the spatial and temporal distribution of the detonations as well as the effective accumulation of the resultant acoustics. In view of the ZOI determinations, the sequential detonations are model as a single point event with only the EFD summed incoherently:

$$Total\,EFD\,db = 10\log_{10}\sum_{i=1}^{n} 10^{(EFD_i/10)}$$

The multiple explosion energy criterion was used to determine the ZOI for the Level B without TTS exposure analysis.

Table 26 shows the ZOI results of the model estimation. The ZOI, when multiplied by the animal densities (see Chapter 4) and total number of events (**Table 23**), provides the exposure estimates for that animal species for the given bomb source.

BOMBEX is restricted one location (all of 7D and part of 8C) (Figure 1). In addition to other mitigation measures (see 11.4), aircraft will survey the target area for marine mammals and sea turtles before and during the exercise. Ships will not fire on the target until the area is sureveyed and determined to be free of marine mammals. The exercise will be suspended if any marine mammals enter the buffer area. Implementation of mitigation measures like these effectively reduce exposures in the ZOI.

.

Table 26 Estimated ZOIs (km^2) for BOMBEX

Area	Ordnance	Level B ZOI @ 177 dB re 1 μPa^2-sec (multiple detonations only)				Level B ZOI @ 182 dB re 1 μPa^2-sec or 23 psi				Level A ZOI @ 205 dB re 1 μPa^2-sec or 13 psi				Mortality ZOI @ 30.5 psi			
		Win	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**	**Win**	**Spr**	**Sum**	**Fall**
VACAPES																	
Air-K	MK-83*	135.04	555.51	713.99	912.05	NA	NA	NA	NA	4.28	4.01	6.39	4.55	0.05	0.05	0.05	0.05

**ZOIs for MK-83 bombs are modeled as multiple detonations (4 bombs dropped at same location).*

Note: Events were either modeled for 177 dB re 1 μPa^2-sec due to multiple detonations (BOMBEX and FIREX) or modeled for 182 dB re 1 μPa^2-sec or 23 psi due to single detonations (MISSILEX and MINEX). Therefore, for BOMBEX and FIREX the NA refers to the criteria that were less dominant and therefore not used in the analysis. For MISSILEX and MINEX the NA refers to the fact that these events are not multiple detonations and therefore not modeled at 177 dB re 1 μPa^2-sec.

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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, 2003). 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-sec) was dominant and therefore used to determine the ZOI for the Level B exposure analysis. **Table 27** shows the ZOI results of the model estimation.

Table 27 Estimated ZOIs (km^2) for MINEX

Threshold	ZOIs	
	5-lb shot	20-lb shot
Level A ZOI @ 13 psi	0.03 km^2 ± 10%	0.13 km^2 ± 10%
Level B ZOI @ 182 dB re 1 μPa^2-sec	0.2 km^2 ± 25%	0.8 km^2 ± 25%

The total ZOI, when multiplied by the animal densities (see Chapter 4) and total number of events (**Table 23**), 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 (W-50) (**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 minutes prior through 30 minutes post detonation. Detonations will be suspended if a marine mammal enters the Zone of Influence and will only restart after the area has been clear for a full 30 minutes. Implementation of mitigation measures like these reduce the likelihood of exposure and potential effects in the ZOI.

MISSILEX (Hellfire, Harm, and Maverick)

Modeling was completed for three explosive missiles involved in MISSILEX, each assumed detonation at 1-meter depth. The NEW used in simulations of the Hellfire, Harm, and Maverick missiles are 8 lbs, 48 lbs, 100 lbs, respectively. The single explosion TTS-energy criterion (182 dB re 1 μPa^2-sec) was used to determine the ZOI for the Level B exposure analysis. **Table 28** shows the ZOI results of the model estimation. MISSILEX is restricted two locations, a primary (Air-E, -F, -I, -J) and a secondary (Air-K, W-72A(2)), (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 28 Estimated ZOIs (km^2) for MISSILEX

Area	**Ordnance**	**Level B ZOI @ 182 dB re 1 μPa^2-s or 23 psi**				**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**
VACAPES													
Air-K	Hellfire	0.44	0.49	0.48	0.49	0.02	0.02	0.02	0.02	<0.01	<0.01	<0.01	<0.01
W-72A (2)	Hellfire	0.58	0.60	0.57	0.59	0.03	0.02	0.02	0.02	<0.01	<0.01	<0.01	<0.01
Air-E,F,I,J	Harm	0.73	0.73	0.52	0.67	0.05	0.05	0.05	0.05	<0.01	<0.01	<0.01	<0.01
Air-K	Maverick	1.99	2.80	10.56	1.64	0.09	0.07	0.07	0.09	0.04	0.02	0.04	0.04

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The total ZOI, when multiplied by the animal densities (see Chapter 4) and total number of events (**Table 23**), 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.

6.3.5 Summary of Potential Expsosures from Explosive Ordnance Use

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

An explosive analysis was conducted to estimate the number of marine mammals that could be exposed to impacts from explosions. **Table 29** provides a summary of the explosive analysis results. 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, Atlantic white-sided dolphin, and harbor porpoise) because density data could not be calculated due to the limited available data for these species. However, the likelihood of exposure should be even lower than that estimated for other species with given densities since 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. 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. Implementation of mitigation measures will reduce the likelihood of exposure and potential effects.

Table 29 Summary of Potential Exposures from Explosive Ordnance (per year) for Marine Mammals in the VACAPES OPAREA

Species/Training Operation	Potential Exposures @ 177 dB re 1 μPa^2-sec (multiple detonations only)	Potential Exposures @ 182 dB re 1 μPa^2-sec or 23 psi	Potential Exposures @ 205 dB re 1 μPa^2-sec or 13 psi	Potential Exposures @ 30.5 psi
Fin whale				
BOMBEX training	4	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	4	0	0	0
Humpback whale				
BOMBEX training	2	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	2	0	0	0

Table 29 (Continued) Summary of Potential Exposures from Explosive Ordnance (per year) for Marine Mammals in the VACAPES OPAREA

Species/Training Operation	Potential Exposures @ 177 dB re 1 μPa^2-sec (multiple detonations only)	Potential Exposures @ 182 dB re 1 μPa^2-sec or 23 psi	Potential Exposures @ 205 dB re 1 μPa^2-sec or 13 psi	Potential Exposures @ 30.5 psi
North Atlantic right whale				
BOMBEX training	0	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	0	0	0	0
Sperm whale				
BOMBEX training	2	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	2	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	4	0	0	0
Atlantic Spotted dolphin				
BOMBEX training	11	NA	0	0
MISSILEX training	NA	6	0	0
FIREX training	30	NA	1	0
MINEX training	NA	0	0	0
Total Exposures	41	6	1	0
Beaked whale				
BOMBEX training	0	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	0	0	0	0
Bottlenose dolphin				
BOMBEX training	48	NA	0	0
MISSILEX training	NA	9	0	0
FIREX training	5	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	53	9	0	0
Clymene dolphin				
BOMBEX training	31	NA	0	0
MISSILEX training	NA	1	0	0
FIREX training	1	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	32	1	0	0

Table 29 (Continued) Summary of Potential Exposures from Explosive Ordnance (per year) for Marine Mammals in the VACAPES OPAREA

Species/Training Operation	Potential Exposures @ 177 dB re 1 μPa^2-sec (multiple detonations only)	Potential Exposures @ 182 dB re 1 μPa^2-sec or 23 psi	Potential Exposures @ 205 dB re 1 μPa^2-sec or 13 psi	Potential Exposures @ 30.5 psi
Common dolphin				
BOMBEX training	2,504	NA	21	0
MISSILEX training	NA	104	3	1
FIREX training	37	NA	1	0
MINEX training	NA	0	0	0
Total Exposures	2,541	104	25	1
Kogia spp.				
BOMBEX training	3	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	3	0	0	0
Minke whale				
BOMBEX training	0	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	0	0	0	0
Pantropical spotted dolphin				
BOMBEX training	64	NA	1	0
MISSILEX training	NA	3	0	0
FIREX training	2	NA	0	0
MINEX training	NA	1	0	0
Total Exposures	66	4	1	0
Pilot whales				
BOMBEX training	27	NA	0	0
MISSILEX training	NA	3	0	0
FIREX training	7	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	34	3	0	0
Risso’s dolphin				
BOMBEX training	57	NA	0	0
MISSILEX training	NA	3	0	0
FIREX training	3	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	60	3	0	0

Table 29 (Continued) Summary of Potential Exposures from Explosive Ordnance (per year) for Marine Mammals in the VACAPES OPAREA

Species/Training Operation	Potential Exposures @ 177 dB re 1 μPa^2-sec (multiple detonations only)	Potential Exposures @ 182 dB re 1 μPa^2-sec or 23 psi	Potential Exposures @ 205 dB re 1 μPa^2-sec or 13 psi	Potential Exposures @ 30.5 psi
Rough-toothed dolphin				
BOMBEX training	1	NA	0	0
MISSILEX training	NA	0	0	0
FIREX training	0	NA	0	0
MINEX training	NA	0	0	0
Total Exposures	1	0	0	0
Striped dolphin				
BOMBEX training	704	NA	6	0
MISSILEX training	NA	36	1	0
FIREX training	41	NA	2	0
MINEX training	NA	0	0	0
Total Exposures	745	36	9	0

Note: Events were either modeled for 177 dB re 1 μPa^2-sec due to multiple detonations (BOMBEX and FIREX) or modeled for 182 dB re 1 μPa^2-sec or 23 psi due to single detonations (MISSILEX and MINEX). Therefore, for BOMBEX and FIREX the NA refers to the criteria that were less dominant and therefore not used in the analysis. For MISSILEX and MINEX the NA refers to the fact that these events are not multiple detonations and therefore not modeled at 177 dB re 1 μPa^2-sec.

6.3.6 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 (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). In addition, animals exposed to levels that constitute MMPA Level B may experience a temporary threshold shift (TTS), which may result in a slight, recoverable loss of hearing sensitivity (DoN, 2001).

Exposures that reach Level A may result in long-term injuries such as permanent threshold shift (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. 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.

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.

CHAPTER 7 IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

Consideration of negligible impact is required for the National Marine Fisheries Service (NMFS) to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates). 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 temporary threshold shift (TTS) or behavioral effects zones (MMPA Level B harassment).
- Although the numbers presented in **Table 29** represent estimated harassment and mortality under the Marine Mammal Protection Act (MMPA), the model calculates harassment without taking into consideration standard mitigation measures and is not indicative of a likelihood of either injury or harm.
- Additionally, the mitigation measures described in **Chapter 11** are designed to reduce exposure of marine mammals to potential impacts to achieve the least practicable adverse effect on marine mammal species or stocks.

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

- North Atlantic right whale
- Beaked whale
- Minke whale

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

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

The following species are predicted to have MMPA Level A exposures. Given the implementation of the mitigation measures discussed in **Chapter 11**, it is anticipated that actual numbers of exposures would be lower than those predicted. The actual level of exposures would likely not affect annual rates of recruitment or survival.

- Atlantic spotted dolphin
- Common dolphin
- Pantropical spotted dolphin
- Striped dolphin

For species that have a predicted mortality exposure (1 common dolphin), the number of animals impacted is low (and anticipated to be reduced further through implementation of mitigation measures) and even removal of these individuals from a population would likely not affect annual rates of recruitment or survival.

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).

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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 VACAPES Study Area.

9.1 Water Quality

The VACAPES 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 VACAPES 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 VACAPES 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 VACAPES 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 VACAPES 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 VACAPES 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 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

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 VACAPES 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 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 VACAPES 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 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 Department of the Navy (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[1].

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 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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[1] 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.

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 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 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 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 United States. The mitigation measures would apply to all Navy vessel transits, including those vessels that would transit to and from East Coast ports and OPAREAs. Seasonal migration of right whales is generally described by NMFS as occuring from October 15th through April 30th, when right whales migrate between feeding grounds farther north and calving grounds farther south. The Navy mitigation measures have been established in accordance with rolling dates identified by NMFS consistent with these seasonal patterns.

NMFS has identifed ports located in the western Atlantic Ocean, offshore of the southeastern United States, where vessel transit during right whale migration is of highest concern for potential ship strike. The ports include the Hampton Roads entrance to the Chesapeake Bay, which includes the concentration of Atlantic Fleet vessels in Norfolk, Virginia. Navy vessels are required to use extreme caution and operate at a slow, safe speed consistent with mission and safety during the months indicated in Table30 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 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 30 North Atlantic Right Whale Migration Port References

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

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)

Historically FIREX using IMPASS occurs in two areas in the VACAPES Study Area: the adjacent Areas of 1C1/2, 7C/D & 8C/D, and a separate area to the southeast, Area 5C/D. The locations were established to be far enough from shore to reduce civilian encounters (e.g., diving and recreational fishing), while remaining a reasonable day's distance from the homeport of Norfolk, Virginia of participating ships. 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 1C1/2, 7C/D, 8C/D and 5C/D.
2. Pre-exercise monitoring of the target area will be conducted with "Big Eyes"[2] 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.

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

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) until the area is cleared. If marine mammals or sea turtles are present, operations would be suspended. Visual observation will occur for approximately 45 minutes, 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.
7. The naval gunfire utilizing five-inch rounds will only be used in Beaufort Sea State three (3)[3] 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 At-Sea Bombing Exercises (385-lb NEW)

Historically this activity occurs in 7D and part of 8C in the VACAPES Study Area. The location was established to be far enough from shore to reduce civilian encounters (e.g., diving and recreational fishing), while remaining within 150 nm from shore-based facilities (the established flight distance restriction for F-A18 jets during unit level training events).

1. BOMBEX using explosive ordnance will only be conducted in Area 7D and in the center third of Area 8C.
2. If surface vessels are involved, lookouts will survey for *Sargassum* rafts, which may be inhabited by immature sea turtles. Ordnance shall not be targeted to impact within 5,100 yards of known or observed *Sargassum* rafts or coral reefs.
3. A buffer zone of 5,100-yd (4,663 m) radius will be established around the intended target zone.
4. At-sea BOMBEXs using live ordnance will occur during daylight hours only.
5. Aircraft will visually survey the target and buffer zone for marine mammals and sea turtles prior to and during the exercise. The survey of the impact area will be made by flying at 1,500 ft altitude or lower, if safe to do so, and at the slowest safe speed. Release of ordnance through cloud cover is prohibited: aircraft must be able to actually see ordnance impact areas. Survey aircraft should employ most effective search tactics and capabilities.
6. The exercises will be conducted only if the buffer zone is clear of sighted marine mammals and sea turtles.

11.4.3 Air-to-Surface Missile Exercises (explosive)

Historically this activity has occured in two locations: a primary area (Air-E, -F, -I, -J) and a secondary area (Air-K, W-72A2) in the VACAPES Study Area. These locations were established to be far enough from shore to reduce civilian encounters (e.g., diving and recreational fishing), while remaining within

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[3] 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.

60 nm from shore-based facilities (the established flight distance restriction for helicopters during unit level training events).

1. This activity will only occur in two locations, a primary area (Air-E, -F, -I, -J) and a secondary area (Air-K, W-72A2.
2. Ordnance shall not be targeted to impact within 1,800 yd (1,646 m) of known or observed *Sargassum* rafts, which may be inhabited by immature sea turtles, or coral reefs.
3. Aircraft will visually survey the target area for marine mammals and sea turtles. Visual inspection of the target area will be made by flying at 1,500 ft altitude or lower, if safe to do so, and at slowest safe speed. Firing or range clearance aircraft 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 sighted marine mammals and sea turtles.
4. Target towing craft shall maintain a lookout. If a marine mammal or sea turtle is sighted in the vicinity of the exercise, the tow craft will immediately notify the firing vessel in order to secure gunnery firing until the area is clear.

11.4.4 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. NMFS issued a Biological Opinion in 2002 for underwater detonations of up to 20-lb explosive charges related to MINEX training (NMFS, 2002). Historically this activity has occurred in shallow water portions of W-50 in the VACAPES Study Area per this BO. This location is just offshore from NAS Oceana Dam Neck Annex, a restricted-access Naval Installation and overlaps an established Surface Danger Zone for live ordnance use, therefore civilian encounters are minimized. This location has a low bathymetric relief and a sand-silt bottom.

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 one-day event that occurs only during daylight hours therefore the distance from shore is limited.

1. This activity will only occur in W-50.
2. Observers will survey the Zone of Influence, 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 Zone of Influence (minimum of 3 parallel tracklines 219 yd [200 m] apart) using support craft will be conducted at the detonation location 30 minutes prior through 30 minutes 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.
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 minutes 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 minutes prior to detonation.

6. No detonations will take place within 3.2 NM (6 km) of an estuarine inlet (Chesapeake Bay 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 Zone of Influence.

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. As part of those responsibilities, an assessment of the long-term and/or population-level effects of Navy training activities as well as the efficacy of mitigation measures is necessary. To address this need, the Navy is developing an Integrated Comprehensive Monitoring Program (ICMP) for marine species in order to assess the effects of training activities on marine species and investigate population-level trends in marine species distribution, abundance, and habitat use in various range complexes and geographic locations where Navy training occurs. 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 ICMP will establish the overarching structure and coordination that will facilitate the collection and synthesis of monitoring data from Navy training and research and development projects. 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. Monitoring methods across the ranges will include methods such as vessel and aerial surveys, tagging, and passive acoustic monitoring.

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 as well as geographically based longitudinal monitoring programs at select locations. 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.

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 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, the ICMP will also incorporate several geographically fixed longitudinal monitoring sites to assess potential effects to marine mammals both at the individual and population level. 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 Northeast Fisheries Science Center 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. Similar efforts may be developed for other Navy ranges to support the overall ICMP objectives.

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

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 after completion of explosives training activities.

CHAPTER 14 RESEARCH EFFORTS

The Navy provides a significant amount of funding and support to marine research. The agency provides over 10 million dollars annually to universities, research institutions, Federal laboratories, private companies, and independent researchers around the world to study marine mammals. The Navy sponsors approximately 70 percent of all U.S. research concerning the effects of human-generated sound on marine mammals and 50 percent of such research conducted worldwide. Major topics of Navy-supported research include the following:

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

This research is directly applicable to 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 Office of Naval Research currently coordinates six programs that examine the marine environment and are devoted solely to studying the effects of noise and/or the implementation of technology tools that will assist the Navy in studying and tracking marine mammals. The six programs are 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 Marine Resource Assessments (MRA) and the Navy OPAREA Density Estimate (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. All of this research helps in understanding the marine environment and aids in determining if there are effects that result from Navy training in the Pacific.

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 Marine Mammal Monitoring on Navy Ranges (M3R) program represents the most promising effort investigating the utility of passive acoustic monitoring specifically associated with Navy instrumented training ranges. The main objective of the M3R project is to develop a toolset for passive detection, localization, and tracking of marine mammals using existing Navy undersea range infrastructure. The project is funded by the Office of Naval Research (ONR) and Chief of Naval Operations (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 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 Virginia Capes (VACAPES) 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, Bombing Exercises (BOMBEX), Mine Neutralization Exercises (MINEX), and Missile Exercises (MISSILEX) in the Virginia Capes (VACAPES) 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. GUNEX), the number of events was evenly distributed over each of the sub-areas.

Figure 1-1 shows each of the areas where explosive ordnance is used in the Virginia Capes (VACAPES) Range Complex.

Figure 1-1 Explosive Ordnance Areas in the VACAPES Range Complex

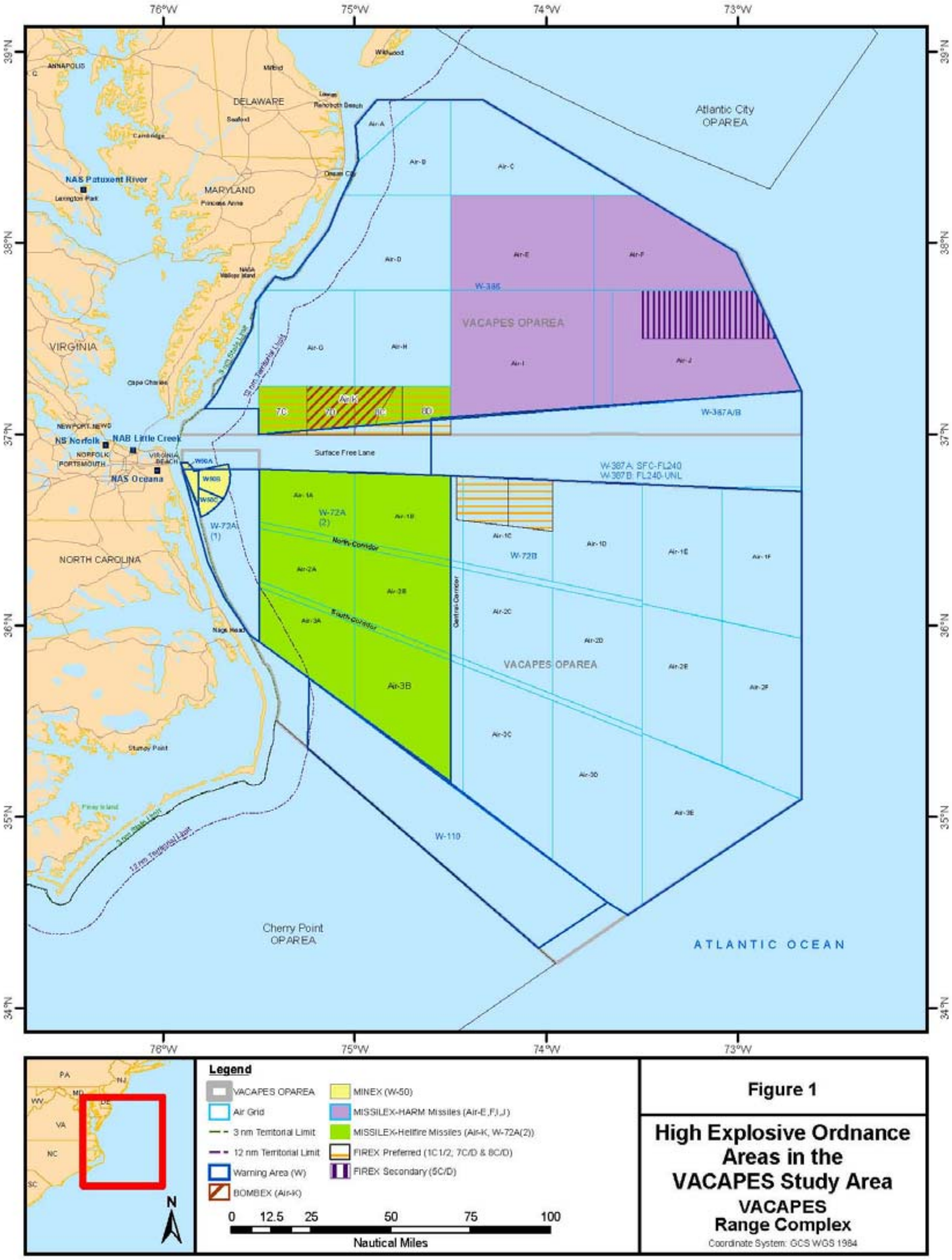


Table 1-1 summarizes the number of events (per year by season) and specific areas where each occurs for each type of explosive ordnance used for Alternative 2. For most of the operations, there is no difference in how many events take place between the different seasons. Therefore, fractional values are a result of evenly distributing the annual totals over the 4 seasons and multiple locations. For example, there are 45 Hellfire events per year for Alternatives 2 that can take place in Air-K during any season, so there are 11.25 events modeled for each season. However, the 20 lb charge MINEX events are more likely to take place in the summer and this is represented in the seasonal allocation of events.

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

OPAREA	Sub-Area	Ordnance	Winter	Spring	Summer	Fall	Annual Totals
VACAPES		MISSILEX					**106**
	Air-K	Hellfire	11.25	11.25	11.25	11.25	
	W-72A (2)	Hellfire	3.75	3.75	3.75	3.75	
	Air-E, F, I, J	Harm	6.50	6.50	6.50	6.50	
	Air-K	Maverick	5.00	5.00	5.00	5.00	
		GUNEX					**22**
	5C/D	5" rounds	1.83	1.83	1.83	1.83	
	7C/D and 8C/D	5" rounds	1.83	1.83	1.83	1.83	
	1C1/2	5" rounds	1.83	1.83	1.83	1.83	
		MINEX					**54**
	W-50 UNDET	5 LB*	7.50	7.50	7.50	7.50	
	W-50 UNDET	20 LB	4.00	4.00	12.00	4.00	
		BOMBEX					**5**
	Air-K	MK-83**	5.75	5.75	5.75	5.75	

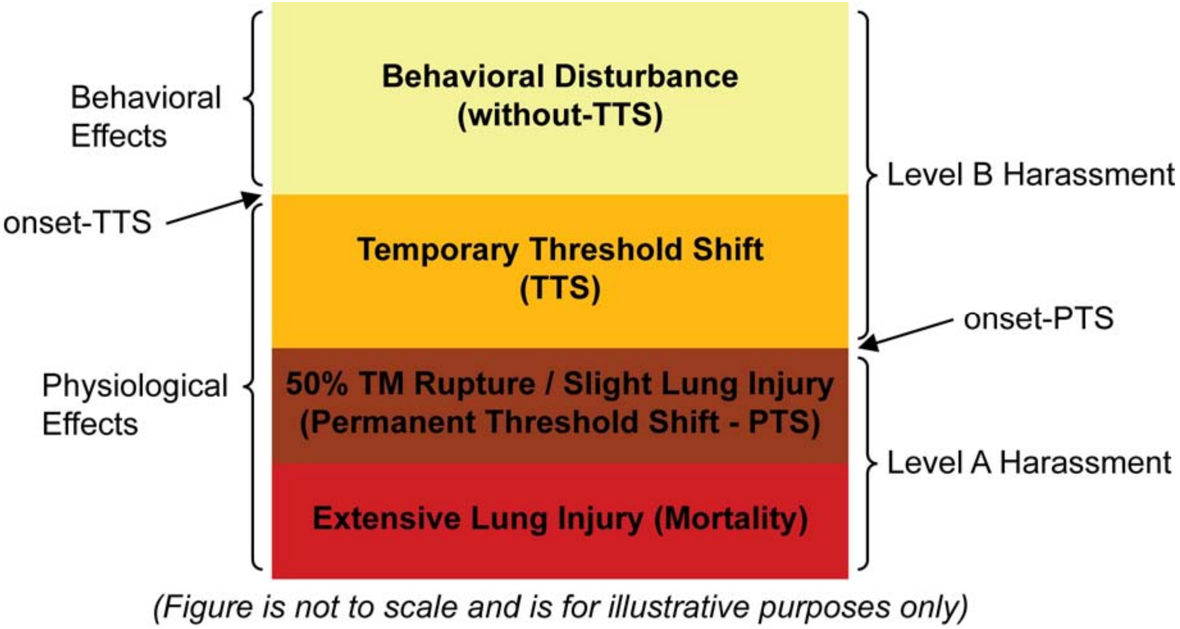
**The use of 3.24 lb charges during AMNS training were conservatively modeled as 5 lb charges.*

*** One event using the MK-83 bombs consists of 4 bombs being dropped in succession. For example, in VACAPES Air-K there are 5 MK-83 events, which mean that a total of 20 bombs will be dropped per year.*

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 with IMPASS and BOMBEX. In addition, this section reflects a revised acoustic criterion for small underwater explosions (< 1500 NEW) (i.e., 23 pounds per square inch [psi] instead of previous acoustic criteria of 12 psi for peak pressure over all exposures), which is based on an incidental harassment authorization (IHA) issued to the 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.

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



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 two 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 ($in\text{-}lb/in^2$) (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).

The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 26.9 lbs), 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 TM rupture (energy threshold) and onset of slight lung injury are the dual criteria used in analysis to determine Level A impacts.

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 percent 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 lbs) for 100% of the population.

Multiple Explosions

For this analysis, the use of multiple explosions only applies to FIREX with IMPASS and the MK-83 bombs used in BOMBEX. Since FIREX with IMPASS and portions of BOMBEX 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; 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.

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). In this case, there are two thresholds: Level B (with TTS) exposure is assumed to occur if either of the thresholds is exceeded.

Single Explosion –TTS-Energy Threshold

The first threshold is a 182 dB re 1 μPa2-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 μPa2-s in any 1/3-octave band. The energy threshold usually dominates and is used in the analysis to determine potential 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 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 with IMPASS and the MK-83 bombs used in BOMBEX. Because multiple explosions would occur within a discrete time period, a new 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 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 μPa2-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. For BOMBEX involving MK-83 bombs, behavioral disturbance (without TTS) (177 dB re 1 μPa^2-s) is the criteria that dominates in the analysis to determine potential Level B exposures due to the use of multiple explosions.

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 an FIREX with IMPASS event or a BOMBEX event involving MK-83 bombs.

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
Physiological	50% Tympanic Membrane Rupture	Energy flux density	1.17 in-lb/in2 (about 205 dB re 1 μPa2-s)	MMPA - Level A
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
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
Physiological	TTS	Peak pressure over all exposures	23 psi	MMPA - Level B
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			

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

2.1 Summary Description of the Action

A typical FIREX with IMPASS evolution is summarized below.

- The plan is for up to 22 events per year in the VACAPES Range Complex. 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-second cycle time. Error distance between where the shell impacts and the target point is assumed to be less than 100 yards (yards) (~ 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-second cycle time)
    - ***Danger Close*** (5 live rounds, 10-second cycle time)
    - ***Coordinated Illumination*** (4 live rounds, 20-second cycle time)
    - ***Counter Mech*** ((4 live rounds, 10-second cycle time)
    - ***SEAD*** (4 live rounds, 10-second cycle time)
    - ***Re-fire*** (4 live rounds, 10-second 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-inch 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 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:

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

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.

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 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 with IMPASS may be deployed in waters as shallow as 50 m (55 yards). To estimate impact areas for the variety of FIREX with 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. Examples of a province chart and province properties are found at the end of this Section.

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 yards) and 1,000 m [1,100 yards]).

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 OPAREA of interest includes 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 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 WITH 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:

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

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:

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

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

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 with 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 with 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 OPAREA 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.

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

Criterion and Threshold	Estimated Impact Range
Level A Harassment: 50% tympanic membrane (TM) rupture. Threshold: Energy above 1.17 in-lb/in2 [205 dB re 1 μPa2-s]	15-25 m (16 -28 yds)
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 yds)
Level B Harassment: TTS for baleen whales. Threshold: 1/3 octave-band energy flux density level above 10 Hz exceeds 182 dB re 1 μPa2-s	71-80 m (78-88 yds)
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 μPa2-s	71-80 m (78-88 yds)
Level B Harassment: TTS. Threshold: 23 psi peak pressure [225 dB re 1 μPa]	255-275 m (280-300 yds)
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 μPa2-s (multiple explosions only)	140-150 m (155-165 yds)
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 μPa2-s (multiple explosions only)	140-150 m (155-165 yds)

[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 with IMPASS Event (39 Explosions)

Impact 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 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 yards)). 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 WITH IMPASS OPAREA and representative depth strata.

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

The nominal FIREX WITH 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 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 yards (91m) for the Pre-FIREX rounds and 50 yards (46 m) for an entire mission's fire. Therefore, the six Pre-FIREX rounds should land within 100 yards (91 m) of the targeting point, and all 4-6 mission rounds should land within 50 yards (46 m) of the targeting point for that mission.

For small explosives detonated near the sea surface, the impact range for 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 yards (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 yards 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 yards 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 yards is the impact range for five shots. The peak pressure estimate assumes that the five rounds fall within 50 yards of the target, that the five rounds fall within 40 seconds, and that the average animal-swim distance for 40 seconds is about 68 yards (for a 3 knot or 1.7 yards/sec 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:

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

where 405 yards 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 yards 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 yards 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 yards 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 yards 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.

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 WITH 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.

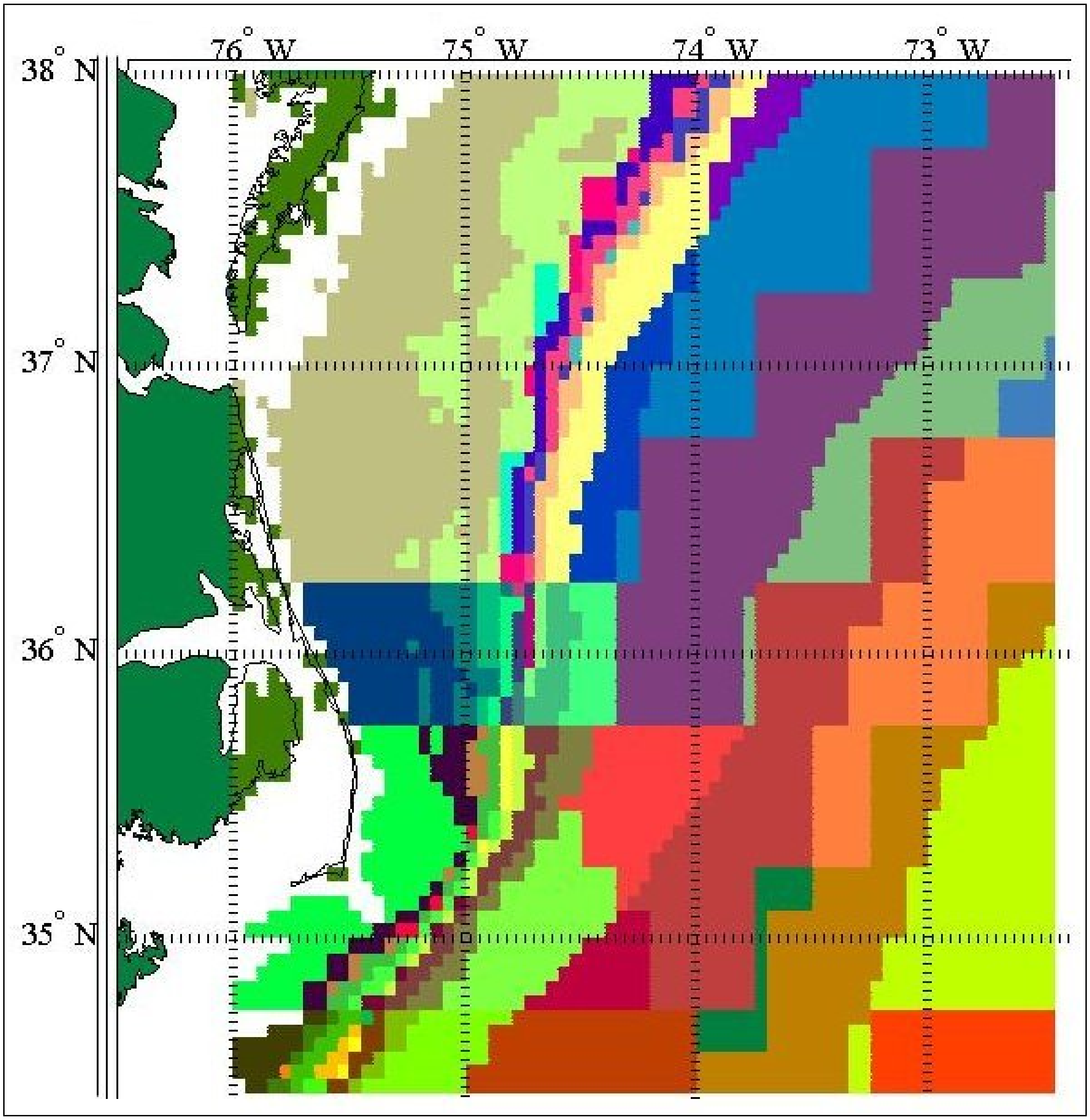
A summary of the resulting impact areas is given in **Table 2-2** for the VACAPES Range Complex and for selected depth strata.

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 Level @ 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)
VACAPES	50 m – 100 m	0.048-0.048	1.09-1.17	0.49-1.66
VACAPES	100 m – 1000 m	0.048-0.048	1.09-1.11	0.00-0.00
VACAPES	> 1000 m	0.048-0.048	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.



Example: Geographic Chart of Acoustic-Environmental Provinces for the VACAPES OPAREA

Example: Province Parameters for Depth Regime, Sound Speed, and Sediment Properties for First 40 Provinces in VACAPES

VACAPES OPAREA				
Province Number	**Average Water Depth (m) for Depth Regime**	**OAML Bottom Class**	**OAML Sound Speed Index**	**OAML Sediment Thickness (2-way travel time, in seconds)**
0	20	0	142	0.2
1	50	0	142	0.2
2	100	96	142	0.2
3	200	96	142	0.2
4	500	94	142	1.82
5	1000	97	142	2.48
6	2000	97	142	3.47
7	2000	78	142	4.62
8	4000	78	142	4.32
9	4000	80	142	3.5
10	4000	152	142	3.07
11	4000	152	145	2.91
12	100	0	142	0.2
13	500	96	142	0.39
14	1000	96	142	0.79
15	4000	79	142	3.81
16	500	97	142	1.07
17	20	0	132	0.2
18	50	0	132	0.2
19	100	96	132	0.2
20	200	96	132	0.33
21	500	96	132	0.56
22	1000	97	132	2.25
23	2000	97	132	3.3
24	2000	78	132	3.95
25	4000	78	132	4.17
26	4000	79	132	3.89
27	50	96	132	0.2
28	500	97	132	1.35
29	100	0	132	0.2
30	2000	79	132	4.23
31	4000	80	132	3.56
32	200	97	132	1.01
33	20	0	114	0.2
34	50	0	114	0.23
35	50	96	114	0.2
36	100	96	114	0.55
37	200	96	114	0.82
38	500	96	114	0.49
39	1000	97	114	3.6

CHAPTER 3 ACOUSTIC ANALYSIS FOR UNDERWATER EXPLOSIONS ASSOCIATED WITH BOMBEX AND 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 BOMBEX and 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 site used for BOMBEX and MISSILEX was identified as VACAPES Air-K with given latitude and longitude location as 37.13N, 74.99W, an additional Missilex site was identified as VACAPES Air E,F,I,J with given latitude and longitude location as 37.63N,73.74W.

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 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 BOMBEX and MISSILEX sites.

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

Site	Water Depth (m)	Bottom Sediment	Sound Speed Ratio	Density (gm/cm3)
VACAPES Air E,F,I,J	40	Sandy Silty Clay	1.057	1.740
VACAPES Air-K	35	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). However, the numbers of points were reduced accordingly to accommodate the shallower depth (35m) of the VACAPES Air Kilo site.

3.1.4 Marine Animal Data

All density estimates that were used in the analysis are presented in the species descriptions located in Ch. 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 BOMBEX modeling results of the impact areas for the VACAPES Range Complex. **Table 3-3** presents the MISSILEX modeling results of the impact ranges for the VACAPES Range Complex.

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

Area	Ordnance	Estimated ZOI @ 177 dB re 1 μPa2-s (multiple detonations only)				Estimated ZOI @ 182 dB re 1 μPa2-s or 23 psi				Estimated ZOI @ 205 dB re 1 μPa2-s or 13 psi				Estimated ZOI @ 30.5 psi			
		Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
VACAPES																	
Air-K	MK-83	135.04	555.51	713.99	912.05	NA	NA	NA	NA	4.28	4.01	6.39	4.55	0.05	0.05	0.05	0.05

NA: For BOMBEX the NA refers to the criterion that was less dominant and therefore not used in the analysis for non-injurious effects.

Note: ZOIs for MK-83 bombs are modeled as multiple detonations (4 bombs dropped at same location).

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

Area	Ordnance	Estimated ZOI @ 182 dB re 1 μPa2-s or 23 psi				Estimated ZOI @ 205 dB re 1 μPa2-s or 13 psi				Estimated ZOI @ 30.5 psi			
		Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
VACAPES													
Air-K	Hellfire	0.44	0.49	0.48	0.49	0.02	0.02	0.02	0.02	<0.01	<0.01	<0.01	<0.01
W-72A (2)	Hellfire	0.58	0.60	0.57	0.59	0.03	0.02	0.02	0.02	<0.01	<0.01	<0.01	<0.01
Air-E,F,I,J	Harm	0.73	0.73	0.52	0.67	0.05	0.05	0.05	0.05	<0.01	<0.01	<0.01	<0.01
Air-K	Maverick	1.99	2.80	10.56	1.64	0.09	0.07	0.07	0.09	0.04	0.02	0.04	0.04

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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 MINEX site in the VACAPES Range Complex. The driving sources of shock energy and noise in the water are from small (5 or 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 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 5 lb or 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 WITH 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 WITH 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 with IMPASS, the modified CASS-GRAB shot-propagation model was used, together with existing environmental provinces for the MINEX site. Because the site is 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 with 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 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.

Table 4-1. Estimated Impact Areas

Dominant Criterion	Impact Area for 5-lb shot	Impact Area for 20-lb shot
Estimated Impact Area @ 13 psi-msec	0.03 sq km ± 10%	0.13 sq km ± 10%
Estimated Impact Area @ 182 dB re 1 μPa^2-sec	0.2 sq km ± 25%	0.8 sq km ± 25%

Level A impact areas are dominated by onset slight lung injury criteria. TTS is the only criterion for Level B harassment, but there are multiple thresholds. Level B impact areas are dominated by the energy threshold.

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