REQUEST FOR LETTER OF AUTHORIZATION FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM NAVY TRAINING OPERATIONS CONDUCTED WITHIN THE GULF OF MEXICO STUDY AREA

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LIST OF ACRONYMS AND ABBREVIATIONS

°	Degree(s)
%	Percent
‘	Minute(s)
§	Section
A-S	Air-to-Surface
AUTEC	Atlantic Undersea Test and Evaluation Center
BOMBEX	Bombing Exercise
BRS	Behavior Response Study
C	Celsius
CEQ	Council of Environmental Quality
CFR	Code of Federal Regulations
Chl *a*	Chlorophyll *a*
CNIC	Commander Naval Installations Command
CNO	Chief of Naval Operations
CO	Commanding Officer
CREEM	Centre for Research into Ecological and Environmental Modelling
CVN	Carrier Vessel Nuclear
dB	Decibel(s)
dB re: 1 μPa	Decibel(s) Referenced to One Micropascal
dB re: 1 μPa^2-s	Decibel(s) Referenced to One Square Micropascal-Second
DoN	Department of the Navy
DVD	Digital Versatile Disk
EEZ	Exclusive Economic Zone
EFD	Energy Flux Density
EIS	Environmental Impact Statement
EL	Energy Flux Density Level
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
ft	Foot (Feet)
g/cm^3	Gram(s) per Cubic Centimeter
GAM	Generalized Additive Model
GOMEX	Gulf of Mexico
GUNEX	Gunnery Exercise
HARP	High Frequency Acoustic Recording Package
HE	High Explosive
HPA	Hypothalamic-Pituitary-Adrenal
hr	Hour(s)
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
$in.\text{-}lb/in.^2$	Inch-Pound(s) per Square Inch
IWC	International Whaling Commission
J/m^2	Joule(s) per Square Meter
JOOD	Junior Officer of the Deck
kg	Kilogram(s)

km	Kilometer(s)
km^2	Square Kilometer(s)
kt	Knot(s)
lb	Pound(s)
LOA	Letter of Authorization
m	Meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MESG	Mobile Expeditionary Security Group
MFAS	Mid-Frequency Active Sonar
min	Minute(s)
MIW	Mine Warfare
MMPA	Marine Mammal Protection Act
MRA	Marine Resource Assessment
ms	Millisecond(s)
MSAT	Marine Species Awareness Training
MSR	Mandatory Ship Reporting
N	North
NAS	Naval Air Station
NEFSC	Northeast Fisheries Science Center
NEW	Net Explosive Weight
nm	Nautical Miles
nm^2	Square Nautical Miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NODE	Navy Operating Area Density Estimate
NRC	National Research Council of the National Academies
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
OOD	Officer of the Deck
OPAREA	Operating Area
oz	Ounce(s)
Pa-s	Pascal-Second(s)
PL	Public Law
psi	Pounds per Square Inch
PSW	Precision Strike Weapon
PTS	Permanent Threshold Shift
R&D	Research and Development
RDT&E	Research, Development, Testing, & Evaluation
REFMS	Reflection and Refraction Multi-Layered Ocean/Ocean Bottoms with Shear Wave Effects
s	Second(s)
S	South
SAR	Stock Assessment Report
SCORE	Southern California Offshore Range
SEFSC	Southeast Fisheries Science Center
SI	International Standard
SNS	Sympathetic Nervous System

SOSUS	Sound Surveillance System
S-S	Surface-to-Surface
SSC	Space and Naval Warfare Systems Center
SSP	Sound Speed Profile
SST	Sea Surface Temperature
SUA	Special Use Airspace
SUW	Surface Warfare
SVP	Sound Velocity Profile
TM	Tympanic Membrane
TNT	Trinitrotoluene
TTS	Temporary Threshold Shift
U.S.	United States
U.S.C.	United States Code
UNDET	Underwater Detonation
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USWTR	Undersea Warfare Training Range
W	West
wk	Week(s)
XO	Executive Officer
yd	Yard(s)
yr	Year(s)
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) for the incidental 'taking' of marine mammals during the conduct of Atlantic Fleet training in the Gulf of Mexico (GOMEX) Range Complex. Training and operational activities evaluated in this document can span from brief, single unit training to weeks-long multiple platform exercises.

The Marine Mammal Protection Act (MMPA) of 1972, as amended (16 United States Code [U.S.C.] Section [§] 1371[a][5]), authorizes the issuance of regulations and LOAs for the incidental taking of marine mammals by a specified activity for a period of not more than 5 years (yr). The issuance occurs when the Secretary of Commerce, after notice has been published in the Federal Register 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 as a result of specific naval training and operational activities.

This document has been prepared in accordance with the applicable regulations and the MMPA, as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law [PL] 108-136). The objectives of this LOA are: (1) the analysis of spatial and temporal distributions of protected marine mammals in the GOMEX Range Complex (hereafter referred to as the GOMEX Study Area), (2) the review of training and operational activities that have the potential to incidentally take marine mammals per the Environmental Impact Statement (EIS)/Overseas EIS (OEIS), and (3) a technical risk assessment to determine the likelihood of effects. This chapter describes those training and operational 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 EIS/OEIS is being prepared for the GOMEX Range Complex to evaluate all components of the proposed training and operational activities. A description of each of the training and operational activities, for which an incidental take authorization is being requested, is provided in the following sections, and represent all training and operational activities conducted in the GOMEX Study Area that involve the use of explosive ordnance. This LOA request is based on the proposed training and operational 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 Bombing Exercises and surface-to-surface Gunnery Exercises (GUNEX) at sea.

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

Strike fighter aircraft, such as F/A-18s, deliver explosive bombs against at-sea surface targets with the goal of destroying the target. Bombing Exercise (Air-to-Surface) (BOMBEX [A-S]) training in the GOMEX Study Area occurs only during daylight hours in the location described in **Chapter 2** (**Figure 1**) as depicted in the **Table 1**.

Table 1 Details of BOMBEX operations involving explosive ordnance use in the GOMEX Study Area.

Operation	Platform	System / Ordnance	Number of Events/yr
Bombing Exercise (BOMBEX) (Air-to-Surface, At-Sea)	F/A-18	MK-83 (1,000-pound [lb] High Explosive [HE] bomb) 415.8 lbs NEW	1 event (4 bombs)

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

Two aircraft will approach an at-sea target from an altitude of between 15,000 feet (ft) to less than 3,000 ft and release a high explosive (HE) 1,000-pound (lb) bomb on the target. MK-83 bombs are used. MK-83 bombs have a net explosive weight (NEW) of 415.8 lbs. The typical bomb release altitude is below 3,000 ft and the target is usually a flare. The time in between bomb drops is approximately 3 minutes (min).

GUNNERY EXERCISE (SURFACE-TO-SURFACE) [GUNEX (S-S)] BOAT

Gunnery Exercise (Surface-to-Surface) (GUNEX [S-S]) are a part of quarterly reservist training and operational activities for the Mobile Expeditionary Security Group (MESG) that operates out of Corpus Christi Naval Air Station (NAS) (**Table 2**). The MESG trains with M3A2 (0.5-lb NEW) anti-swimmer concussion grenades. The M3A2 grenades are small and contain high explosives in an inert metal or plastic shell. They detonate at about 3 meters (m) under the water's surface within 4 to 5 seconds (s) of being deployed. The detonation depth may be shallower depending upon the speed of the boat at the time the grenade is deployed.

Table 2 Details of GUNEX operations involving explosive ordnance use in the GOMEX Study Area.

Operation	Platform	System / Ordnance	Number of Events/yr
Gunnery Exercise (GUNEX) (Surface-to-Surface, Boat)	Vessels such as, combat rubber raiding craft, rigid hull inflatable boats, and patrol craft	M3A2 concussion anti-swimmer grenades (8-ounce [oz] HE grenade) 0.5 lbs NEW	4 events (20 grenades)

1.2 Vessel Movement

Vessel movements are associated with most training and operational activities in the GOMEX Study Area. Currently, the number of Navy vessels operating in the GOMEX Study Area varies based on training schedules and can range from 0 to about 10 vessels at any given time. Vessel sizes range from small boats (<35 ft) for a harbor security boat to 1,092 ft for a CVN (carrier vessel nuclear) and speeds generally range from 10 to 14 knots (kt), but may be considerably faster, for example an aircraft carrier “making wind” while launching and recovering aircraft, and for small boat operations. Operations involving vessel movements occur intermittently and are variable in duration, ranging from a few hours up to 2 weeks (wk). These operations are widely dispersed throughout the GOMEX Study Area, which is an area encompassing 11,714 square nautical miles (nm^2). Most vessel movements occur in the offshore Operating Areas (OPAREAs), but vessel movements associated with MESG training in the underwater detonation (UNDET) Area E3 and Commander Naval Installations Command (CNIC) harbor security group training in the Panama City OPAREA occur between shore and 12 nautical miles (nm), including the nearshore zone (<3 nm). The Navy logs about 180 total vessel days within the GOMEX Study Area during a typical year. Consequently, the density of Navy vessels within the GOMEX Study Area at any given time is low (i.e., less than 0.0113 ships/nm^2).

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CHAPTER 2 LOCATION AND DEFINITION OF EXPLOSION ACTIVITIES

2.1 Description of the Gulf of Mexico Study Area

The GOMEX Study Area encompasses areas at sea, undersea, and Special Use Airspace (SUA) in the northern Gulf of Mexico off the coast of the United States (U.S.) (**Figures 1 and 2**). The portions of the GOMEX Study Area addressed in this LOA consist of the BOMBEX Hotbox (surface and subsurface waters) located within the Pensacola OPAREA, SUA warning areas W-151A/B/C and W-155A/B (surface waters), and UNDET Area E3 (surface and subsurface waters), located within the territorial waters off Padre Island, Texas, near Corpus Christi NAS (**Table 3**). The portions of the GOMEX Study Area addressed in this LOA encompass:

- 1,496 nm^2 of sea space (BOMBEX Hotbox, where HE occur, and UNDET Area E3 where underwater detonations occur); and
- 11,714 nm^2 of SUA warning areas (vessel movements only)

The BOMBEX Hotbox is an in-water operating and maneuvers area with defined air, ocean surface, and subsurface areas described in detail in **Table 3**. The BOMBEX Hotbox is located in the offshore waters of the northeastern Gulf of Mexico adjacent to Florida and Alabama (**Figure 1**; 1,482 nm^2 of surface waters). The northernmost boundary of the BOMBEX Hotbox is located 23 nm from the coast of the Florida panhandle at latitude 30 degrees (°) North (N), the eastern boundary is approximately 200 nm from the coast of the Florida peninsula at longitude 86°48 minutes (’) West (W).

The SUA warning areas, W-151A/B/C and W-155A/B, are in-water operating and maneuver areas with defined air and ocean surface described in detail in **Table 3**. W-151A/B/C and W-155A/B are located in and above the offshore waters of the northeastern Gulf of Mexico adjacent to Florida and Alabama (**Figure 1**; 15,948 nm^2 of surface waters).

The UNDET Area E3 is a defined surface and subsurface area (**Figure 2**; 14 nm^2 of surface waters) located in the waters south of Corpus Christi NAS and offshore of Padre Island, Texas, and is described in detail in **Table 3**. The westernmost boundary is located 7.5 nm from the coast of Padre Island at 97°9'33"W and 27°24'26"N at the Western most corner. It lies entirely within the territorial waters (0 to 12 nm) of the U.S. and the majority of it lies within Texas state waters (0 to 9 nm). It is a very shallow water training area with depths ranging from 20 to 26 m.

Figure 1 High Explosives Ordnance (BOMBEX) Use Areas and Associated SUA in the GOMEX Study Area

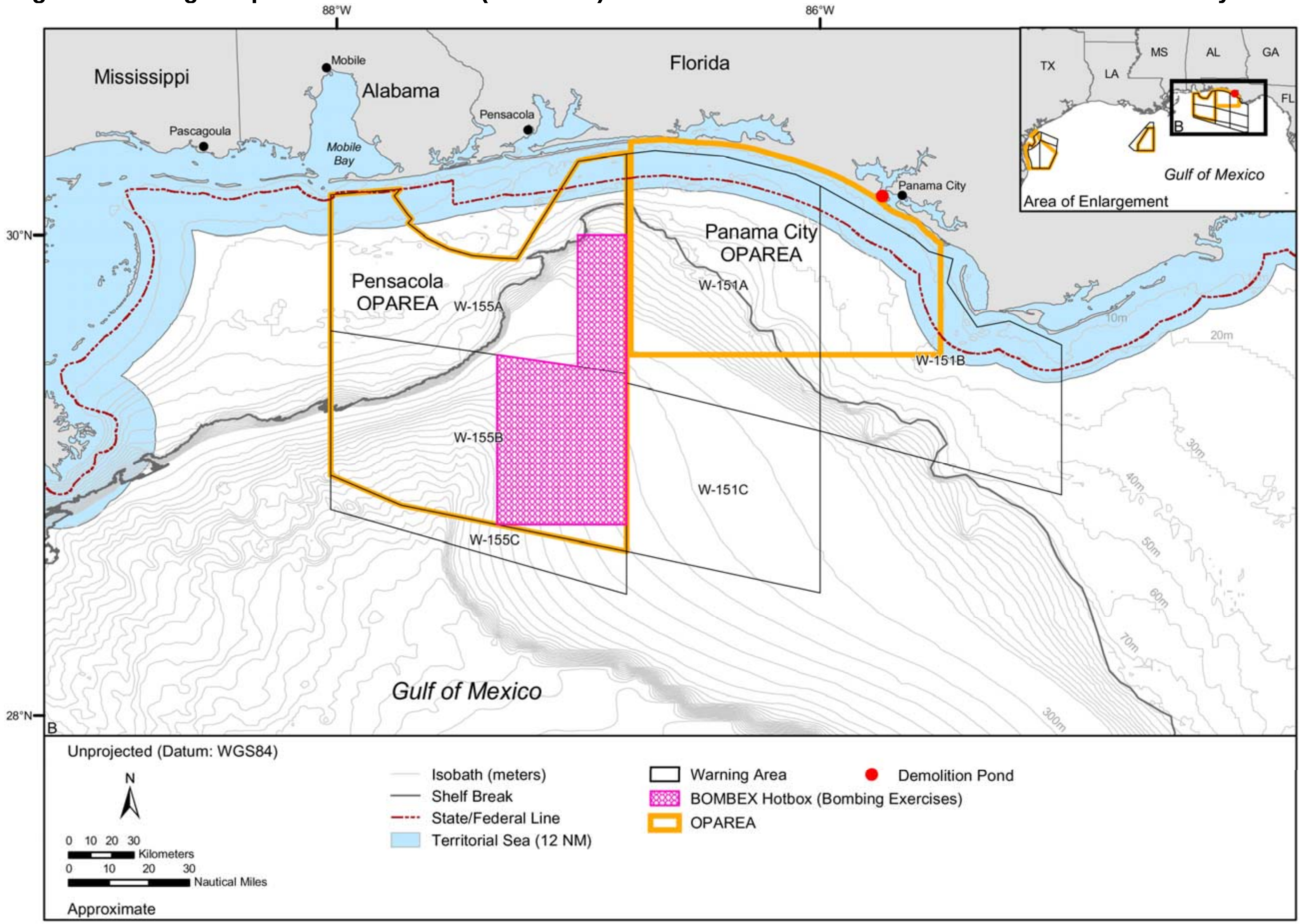

Figure 2 High Explosives Ordnance (GUNEX) Use Area and Associated OPAREA in the GOMEX Study Area

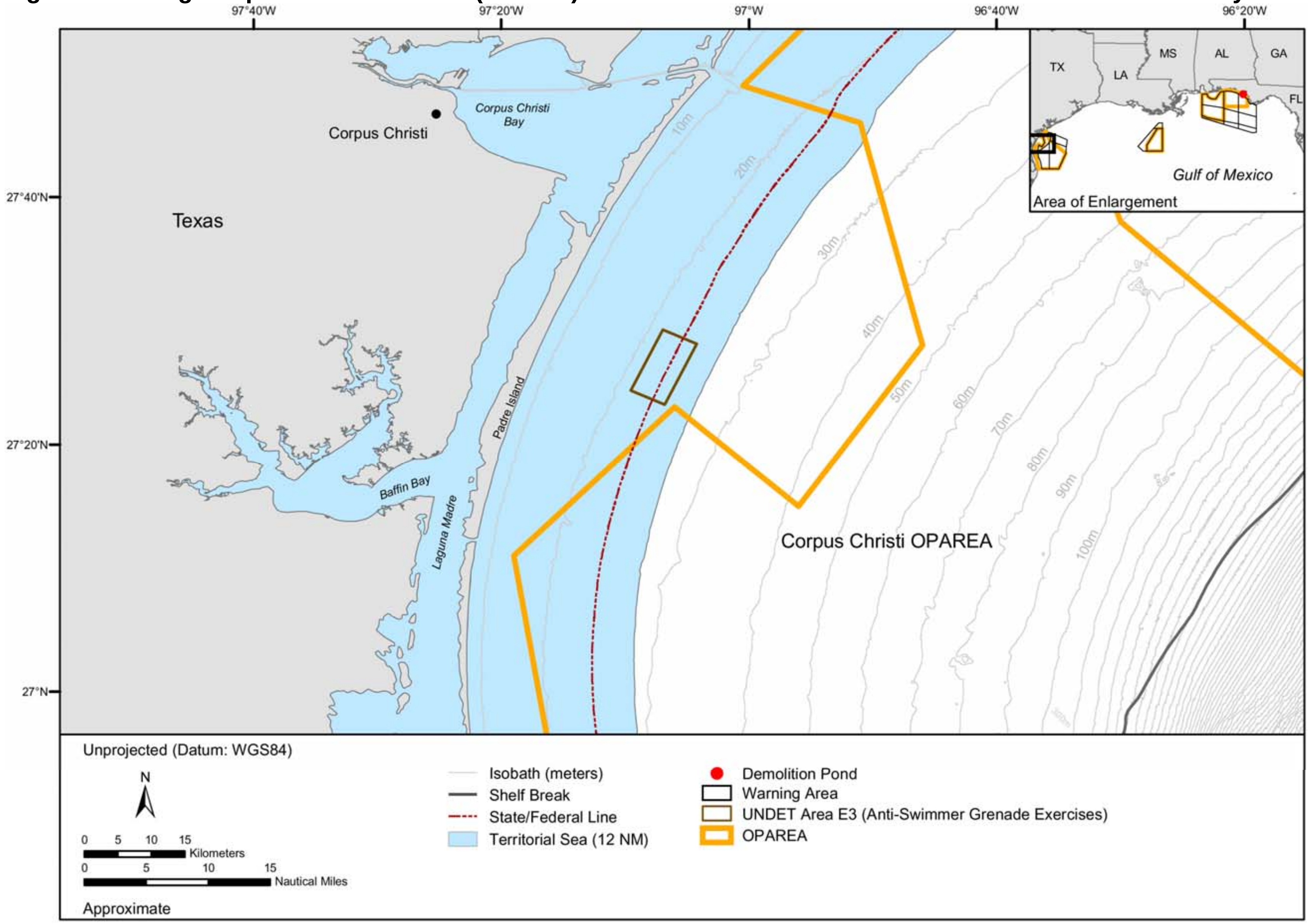

Table 3 GOMEX Study Area Descriptions

Component Area	Description
Operating Areas – Surface and Subsurface Waters	The Pensacola OPAREA (4,882 nm^2; 10 to 2,100-m depth range) and Panama City OPAREA (3,084 nm^2; 10 to 300 m depth range) are located along the Gulf Coast off Florida. See **Figure 1**. Vessel movements occur throughout these OPAREAs and training and operational activities using explosive ordnance in the Pensacola OPAREA are conducted within the BOMBEX Hotbox and include Air to Surface bombing exercises.
BOMBEX Hotbox – Surface and Subsurface Waters	The BOMBEX Hotbox includes surface and subsurface water and is located within the Pensacola OPAREA. The surface area of the BOMBEX Hotbox is 1,482 nm^2 and the volume of undersea space varies greatly based on the seafloor depth (120- to 1,200-m depth range). The types of underwater environments include: • Shallow offshore waters (from 120 to 183 m) • Deepwater sloping seafloor (up to 1,200 m)
UNDET Area E3 – Surface and Subsurface Waters	The UNDET Area E3 is located in the waters south of Corpus Christi NAS and offshore of Padre Island, Texas (**Figure 2**). It consists of surface and subsurface shallow waters with a total surface area of 14 nm^2. The maximum depth in UNDET Area E3 is 26 m. Explosive ordnance use occurs to depths of approximately three meters.
Special Use Airspace (SUA) – Warning Areas	Warning areas of the GOMEX Study Area are large blocks of SUA generally overlaying particular OPAREAs from the surface to an unlimited altitude. Vessel movements occur throughout the Warning Areas of the GOMEX Study Area. These include W-151A/B/C and W-155A/B.

2.2 Levels and Locations of Explosive Operations

Table 4 describes the anticipated level of activity and location for the different types of operations using explosive ordnance conducted in the GOMEX Study Area. Operations are organized by warfare area as described in **Chapter 1**.

Table 4 Operations Involving HE and underwater detonations in the GOMEX Study Area

Operation	Platform	System or Ordnance	Preferred Alternative	Training Area
SURFACE WARFARE (SUW)				
Bombing Exercise (BOMBEX) (Air-to-Surface) – At-Sea	F/A-18	MK-83 (1,000-lb HE bomb) 415.8 lbs NEW	1 event (4 bombs)/year	BOMBEX Hotbox
Gunnery Exercise (GUNEX) (Surface-to-Surface) - Boat	Vessels such as, combat rubber raiding craft, rigid hull inflatable boats, and patrol craft	M3A2 concussion grenades (8-oz HE grenade) 0.5 lbs NEW	4 events (20 grenades)/year	UNDET Area E3

CHAPTER 3 MARINE MAMMAL SPECIES AND NUMBERS OCCURRING IN THE GULF OF MEXICO STUDY AREA

Twenty-nine marine mammal species have confirmed or potential occurrence in the GOMEX Study Area analyzed in this document. These include 28 cetacean species and 1 sirenian species (DoN 2007a), which can be found in **Table 5**. Although it is possible that any of the 29 species of marine mammals may occur in the Study Area, only 21 of those species are expected to occur regularly in the region. Most cetacean species are in the Study Area year-round (e.g., sperm whales [*Physeter macrocephalus*] and bottlenose dolphins [*Tursiops truncatus*]), while a few (e.g., fin whales [*Balaenoptera physalus*] and killer whales [*Orcinus orca*]) have accidental or transient occurrence in the area.

Table 5 Marine Mammal Species Found in the GOMEX Study Area

Family and Scientific Name	Common Name	Federal Status
Order Cetacea		
Suborder Mysticeti (baleen whales)		
Family Balaenidae (right whales)		
Eubalaena glacialis	North Atlantic right whale	ENDANGERED
Family Balaenopteridae (rorquals)		
Megaptera novaeangliae	Humpback whale	ENDANGERED
Balaenoptera acutorostrata	Minke whale	
Balaenoptera brydei	Bryde's whale	
Balaenoptera 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	
Kogia sima	Dwarf sperm whale	
Family Ziphiidae (beaked whales)		
Ziphius cavirostris	Cuvier'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	
Lagenodelphis hosei	Fraser's dolphin	
Grampus griseus	Risso's dolphin	
Peponocephala electra	Melon-headed whale	
Feresa attenuata	Pygmy killer whale	
Pseudorca crassidens	False killer whale	
Orcinus orca	Killer whale	
Globicephala macrorhynchus	Short-finned pilot whale	
Order Sirenia		
Family Trichechidae (manatees)		
Trichechus manatus	West Indian manatee	ENDANGERED

The information contained in this Chapter relies heavily on the data gathered in the Marine Resources Assessments (MRAs). The Navy MRA Program was implemented by the Commander, Fleet Forces Command, to initiate collection of data and information concerning the protected and commercial marine resources found in the Navy's OPAREAs. Specifically, the goal of the MRA program is to describe and document the marine resources present in each of the Navy's OPAREAs. The MRA for the GOMEX OPAREA was published in 2007 (DoN, 2007a). The MRA data were used to provide a regional context for each species. The MRA represents a compilation and synthesis of available scientific literature (e.g., journals, periodicals, theses, dissertations, project reports, and other technical reports published by government agencies, private businesses, or consulting firms), and NMFS reports including stock assessment reports (SARs), recovery plans, and survey reports.

3.1 Marine Mammal Occurrence

The GOMEX MRA data were used to provide a regional context for each species. The GOMEX MRA represents a compilation and synthesis of available scientific literature (e.g., journals, periodicals, theses, dissertations, project reports, and other technical reports published by government agencies, private businesses, or consulting firms), and NMFS reports including SARs, recovery plans, and survey reports. This information was used to evaluate the potential for occurrence of marine mammal species in the GOMEX Study Area.

Due to the occurrence in the GOMEX Study Area of federally threatened and endangered species of marine mammals, the Navy has initiated formal consultation with the NMFS and the U.S. Fish and Wildlife Service (USFWS) in accordance with Section 7 of the Endangered Species Act (ESA).

3.2 Estimated Marine Mammal Densities

The density estimates that were used in previous Navy environmental documents were updated to provide a compilation of the most recent data and information on the occurrence, distribution, and density of marine mammals in Navy OPAREAs. The density estimates presented in this LOA are derived from the *Navy OPAREA Density Estimates (NODE) for the GOMEX OPAREA* 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); or 3) based on the cetacean abundance estimates found in the National Oceanic and Atmospheric Administration (NOAA) SARs for 2006 (Waring *et al.*, 2007).

The following shows how density estimates were modeled or derived:

Model-Derived Density Estimates - Line Transect Survey Data

- Sperm whale (*Physeter macrocephalus*)
- Dwarf and pygmy sperm whales (*Kogia* spp.)
- Beaked whales (Family Ziphiidae)
- Rough-toothed dolphin (*Steno bredanensis*)
- Bottlenose dolphin (*Tursiops truncatus*)
- Pantropical spotted dolphin (*Stenella attenuata*)
- Atlantic spotted dolphin (*Stenella frontalis*)
- Striped dolphin (*Stenella coeruleoalba*)

- Spinner dolphin (*Stenella longirostris*)
- Risso's dolphin (*Grampus griseus*)

Stock Assessment Report or Literature-Derived Density Estimates

- Bryde's whale (*Balaenoptera brydei/edeni*)
- Clymene dolphin (*Stenella clymene*)
- Fraser's dolphin (*Lagenodelphis hosei*)
- Killer whale (*Orcinus orca*)
- False killer whale (*Pseudorca crassidens*)
- Pygmy killer whale (*Feresa attenuata*)
- Melon-headed whale (*Peponocephala electra*)
- Short-finned pilot whale (*Globicephala macrorhynchus*)

Species for Which Density Estimates Are Not Available

- Fin whale (*Balaenoptera physalus*)
- North Atlantic right whale (*Eubalaena glacialis*)
- Humpback whale (*Megaptera novaeangliae*)
- Blue whale (*Balaenoptera musculus*)
- Sei whale (*Balaenoptera borealis*)
- Minke whale (*Balaenoptera acutorostrata*)
- West Indian manatee (*Trichechus manatus*)

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 (chl) *a* concentration was formulated using generalized additive models (GAMs). This relationship was then used to generate a two-dimensional density surface for the region by predicting densities in areas where no survey data exist.

The analyses for cetaceans were based on sighting data collected through shipboard surveys conducted by NMFS-Southeast Fisheries Science Center (SEFSC) between 1996 and 2004. Species-specific density estimates derived through spatial modeling were compared with abundance estimates found in the 2006 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 Research into Ecological and Environmental Modelling (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 GOMEX OPAREA (DON, 2007b).

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CHAPTER 4 AFFECTED SPECIES STATUS AND DISTRIBUTION

Marine mammal distribution is affected by demographic, evolutionary, ecological, habitat-related, and anthropogenic factors (Bjørge, 2002; Bowen *et al.*, 2002; Forcada, 2002; Stevick *et al.*, 2002). Movement of individuals is generally associated with feeding or breeding activity (Stevick *et al.*, 2002). Some baleen whale species, such as the humpback whale, make extensive annual migrations to low-latitude mating and calving grounds in the winter and to high-latitude feeding grounds in the summer (Corkeron and Connor, 1999). Migrations undoubtedly occur during these seasons due to the presence of highly productive waters and associated cetacean prey species at high latitudes and of warm water temperatures for calving at low latitudes (Corkeron and Connor, 1999; Stern, 2002); however, not all baleen whales migrate. Some individuals, age classes, or subsets of a population may stay in one area year-round (Tershy *et al*., 1993; Notarbartolo-di-Sciara *et al*., 2003).

Cetacean movements can also reflect the distribution and abundance of prey (Gaskin, 1982; Payne *et al*., 1986; Kenney *et al*., 1996). Cetacean movements have been linked to indirect indicators of prey, such as temperature variations, sea-surface chl *a* concentrations, and features such as bottom depth (Croll *et al*., 2005). Oceanographic features such as eddies, thermal fronts, and nearshore tidal mixing are important factors determining cetacean distribution since marine mammal prey are attracted to the increased primary productivity associated with some of these features (Wormuth *et al*., 2000; Davis *et al*., 2002; Johnston *et al*., 2005; Etnoyer *et al*., 2006). Several cetacean species have been shown to associate closely in space and time with areas of strong tidal mixing and oceanographic fronts, probably due to increased foraging efficiency resulting from the accumulation of prey in these regions (Mendes *et al*., 2002; Johnston *et al*., 2005; Etnoyer *et al*., 2006).

Specific bathymetric and oceanographic features in the Gulf of Mexico serve to attract and concentrate marine mammals. In the northern Gulf of Mexico, there are numerous cetacean sightings in waters over the continental shelf (particularly in nearshore waters), in the vicinity of the continental shelf break, over the continental slope, and out over the abyssal plain. The continental shelf and slope areas have been identified repeatedly as important cetacean habitat (Mullin *et al*., 1994; Davis and Fargion, 1996a,b; Davis *et al*., 1998; Davis *et al*., 2000; Fulling *et al*., 2003; Mullin and Fulling, 2004). The continental shelf is very narrow near the Mississippi River Delta, so the high-productivity area associated with the nutrient-rich river plume extends into deep waters (Baumgartner *et al*., 2001; Davis *et al*., 2002; Mullin and Fulling, 2004). This region appears to attract a large number of oceanic cetaceans, especially sperm whales (Davis *et al*., 2002). Regions of steep bathymetric relief such as offshore canyons and the continental slope are also areas of increased productivity where cetaceans are commonly sighted (Davis *et al*., 1998; Davis *et al*., 2002; Fulling *et al*., 2003; Mullin and Fulling, 2004). Risso's dolphin and short-finned pilot whales occur in mid-slope areas where the steep shelf break and deep water may result in concentrated areas of prey (Davis *et al.*, 1998). Shallower waters over the continental shelf and inshore waters provide habitat for Atlantic spotted and bottlenose dolphins (Fulling *et al*., 2003; Mullin and Fulling, 2004).

Warm-core eddies are persistent in the northern Gulf, moving westward and generating cold-core eddies as they reach the continental margin (Davis *et al*., 1998). These dynamic oceanographic features result in temperature and salinity gradients across the northern Gulf that attract cetaceans (Davis *et al*., 1998; 2002). Cetaceans probably track these features as they forage (Davis *et al.,* 2000; 2002). In the southeastern Gulf and west of the Dry Tortugas an area of upwelling driven by current movement and the periodic formation of the cyclonic Tortugas Gyre also is associated with above average marine mammal occurrence, particularly sperm whales (Mullin and Fulling, 2004).

4.1 Threatened or Endangered Marine Mammal Species

Seven marine mammal species that may occur in the GOMEX Study Area and may be affected by the preferred alternative training and operational activities are listed under the ESA. These include five baleen whale species (blue, fin, humpback, sei, and North Atlantic right whales), one toothed whale species (sperm whale), and one sirenian species (West Indian manatee).

4.1.1 Blue Whale

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

Status and management—The endangered blue whale was severely depleted by commercial whaling in the twentieth century (NMFS, 1998b). It is likely that at least two discrete populations are found in the North Atlantic. One population ranges from West Greenland to New England and is centered in eastern Canadian waters; the other includes individuals found in Icelandic waters and south to northwest Africa (Sears *et al.*, 1990; Ramp *et al.*, 2006). There are no current estimates of abundance for the North Atlantic blue whale (Waring *et al*., 2008); however, the 308 photo-identified individuals from the Gulf of St. Lawrence area (Sears *et al.*, 1987) are considered to be a minimum population estimate for the western North Atlantic stock (Waring *et al*., 2008). The blue whale is under the jurisdiction of the NMFS. The recovery plan for the blue whale was issued in 1998 (NMFS, 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 extends south to Florida and the Gulf of Mexico; however, the southern limit of this species' range in the North Atlantic Ocean 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 preference for the nearshore regions where strong tidal and current mixing leads to high productivity and rich prey resources (Sears *et al*., 1990). Clark and Gagnon (2004) determined that vocalizing blue whales show strong preferences for shelf breaks, seamounts, or other areas where food resources are known to occur, even during summer months.

Distribution—Blue whales are distributed from the ice edge to the tropics and subtropics in both hemispheres (Jefferson *et al*., 1993). 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). Very little is known about the winter distribution of blue whales in the North Atlantic Ocean (Rice, 1998). Researchers using the Navy integrated undersea surveillance system resources (Sound Surveillance System [SOSUS] hydrophones) 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).

The locations of breeding and calving grounds for blue whales are unknown.

GOMEX Study Area blue whale occurrence—This is one of the rarest cetacean species in the Gulf of Mexico (Würsig *et al*., 2000). There are two reliable records of blue whales in the Gulf of Mexico from stranding reports (Jefferson and Schiro, 1997). One was a blue whale that stranded along the east coast of Mexico just west of the Yucatan peninsula and the other a stranding on the coast of Louisiana.

Although occurrence is not likely, blue whales may be present in the Gulf of Mexico at any time of year. The presence of blue whales at higher latitudes during the summer suggests that occurrence in the Gulf of Mexico may be even less likely during these months (CETAP, 1982; Wenzel *et al*., 1988; Sears *et al*., 1990).

GOMEX Study Area blue whale density—There is not an abundance estimate in the NOAA SAR for blue whales in the Gulf of Mexico nor were there sufficient data available to estimate a density for the Study Area (DoN, 2007b; Waring *et al*., 2008).

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) (see review in Kenney *et al*., 1985; NMFS, 2006b).

Status and management—The NOAA SAR estimates that there are 2,269 individual fin whales in the western North Atlantic stock (Waring *et al*., 2008); this is probably extremely conservative due to incomplete survey coverage of known fin whale habitat and a lack of certainty regarding fin whale movement in the North Atlantic (Waring *et al*., 2008). Other estimates that adjust for uncertainty put the population at 5,000 to 6,000 fin whales in the waters of the U.S. Atlantic (CETAP, 1982; Kenney *et al*., 1997). There may be genetically distinct subpopulations of fin whales within the North Atlantic and Mediterranean Sea (Bérubé *et al*., 1998); however, these divisions are not recognized by governing bodies such as the NMFS or the International Whaling Commission (IWC) (Donovan, 1991; Waring *et al*., 2008). The fin whale is listed as endangered and is under the jurisdiction of the NMFS. The draft recovery plan for the fin whale was released in June 2006 (NMFS, 2006b). NMFS recently initiated a 5-yr status review for the fin whale as required by the ESA (NMFS, 2007b).

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). 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; Payne *et al*., 1990a; Kenney *et al*., 1996; 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.

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, 2006b). 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).

Based on passive acoustic detection using Navy 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 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.

GOMEX Study Area fin whale occurrence—Fin whales rarely occur in the Gulf of Mexico; during the summer, individuals should be found on their feeding grounds further north off the northeastern U.S. There are only four recorded strandings and two confirmed sightings in the GOMEX Study Area (Jefferson and Schiro, 1997). All other sightings records for the fin whale in the Study Area are not verified (Jefferson and Schiro, 1997). Jefferson and Schiro (1997) suggested that the Gulf might represent a part of the range of a low-latitude fin whale population in the northwestern Atlantic or that possibly a small relict population is resident in the Gulf. It is more likely that these fin whale individuals move into and out of the Gulf of Mexico from the North Atlantic population(s) (Jefferson and Schiro, 1997; Würsig *et al*., 2000). Although occurrence is not likely, fin whales may be present in the Gulf of Mexico at any time of year.

GOMEX Study Area fin whale density—There is not an abundance estimate in the NOAA SAR for fin whales in the Gulf of Mexico nor were there sufficient data available to estimate a density for the Study Area (DoN, 2007b; Waring *et al*., 2008).

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 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 North Atlantic are thought to belong to five different feeding stocks: Gulf of Maine, Gulf of St. Lawrence, Newfoundland/Labrador, western Greenland, and Iceland. There appears to be very little exchange between these separate feeding stocks (Katona and Beard, 1990). The best estimate of abundance for the Gulf of Maine Stock is 847 individuals based on line-transect surveys conducted in 2006 (Waring *et al*., 2008). 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*., 1990b; Hamazaki, 2002). The habitat requirements of wintering humpbacks appear to be determined by the conditions necessary for calving. Optimal calving conditions are warm waters (24 to 28° Celsius [C]) and relatively shallow, low-relief ocean bottom in protected areas (e.g., 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, much 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); however, significant numbers of humpbacks have been found at mid and high latitudes during this time, suggesting that not all individuals undergo the seasonal migration (Clapham *et al*., 1993; Swingle *et al*., 1993). An increasing occurrence of humpbacks, including juveniles, along the U.S. Atlantic coast from Florida north to Virginia suggests that this area may be a supplemental winter feeding ground (Clapham *et al.*, 1993; Swingle *et al.*, 1993; Wiley *et al*., 1995; Laerm *et al*., 1997; Barco *et al.*, 2002). It is not known whether the occurrence of humpbacks off the mid-Atlantic represents a change in distribution or is an artifact of increased survey effort or coverage (Waring *et al*., 2008).

Humpback whale breeding areas in the West Indies, especially around the Dominican Republic, are well known and humpbacks are spread throughout the Caribbean during the winter and spring. Würsig *et al*. (2000) note that humpbacks were hunted near the southern tip of Florida but were uncommon within the Gulf. While there is little likelihood that there is a resident population within the Gulf, as humpback populations increase individuals may begin to overwinter or stray into the Gulf as they move between feeding and wintering grounds (Würsig *et al*., 2000).

GOMEX Study Area humpback whale occurrence—Humpbacks occur sporadically in the Gulf of Mexico and individuals in the Gulf of Mexico generally are considered strays from the breeding grounds in the Caribbean (Weller *et al.*, 1996; Jefferson and Schiro, 1997; Würsig *et al.*, 2000); however, it should be noted that recent reports of humpback whales are occurring more often than expected (DoN, 2007b). The western-most sighting of a humpback whale in the Gulf of Mexico was made in February 1992 off Galveston, Texas (Weller *et al.*, 1996). There are at least 19 additional reports of humpback whales in the Gulf, mostly from the Florida panhandle region. Reports include a stranding east of Destin, Florida, in mid-April 1998, a confirmed sighting of six humpback whales in May 1998 near DeSoto Canyon, and a handful of sightings during spring 2006 (MMS, 2001; Pitchford, 2006). In February 2004, an individual was sighted off the west coast of Florida. This individual was identified as "Fingerpaint", a humpback whale known to inhabit the Gulf of Maine. Fingerpaint was resighted in September later that year in the Gulf of Maine (Guinta, 2006). Although the individuals sighted in the Gulf of Mexico are probably stray juveniles from the breeding grounds and thus are more likely to be present during the winter and spring (Weller *et al.*, 1996), a review of the available records suggests that humpback whales may occur during any time of the year.

GOMEX Study Area humpback whale density—There is not an abundance estimate in the NOAA SAR for humpback whales in the Gulf of Mexico nor were there sufficient data available to estimate a density for the Study Area (DoN, 2007b; Waring *et al*., 2008).

4.1.4 North Atlantic Right Whale

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

Status and management—The North Atlantic right whale is one of the most endangered cetaceans in the world (Clapham *et al.*, 1999; Perry *et al.*, 1999; IWC, 2001). According to the North Atlantic right whale report card released annually by the North Atlantic Right Whale Consortium, approximately 393 individuals are thought to occur in the western North Atlantic (NARWC, 2007). The most recent NOAA SAR states that in a review of the photo identification recapture database for June 2006, 313 individually recognized whales were known to be alive during 2001 (Waring *et al.*, 2008). There is evidence of modest population growth (Neuhauser, 2007); however, Kraus *et al.* (2005) noted that the recent increases in birth rate were probably insufficient to counter the recent spike in human-caused mortality of right whales. 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).

One calving and two feeding areas in U.S. waters are designated as critical habitat for the North Atlantic right whale (NMFS, 1994; NMFS, 2005a). None of these areas is in the Gulf of Mexico.

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 (MSR) system was implemented by the U.S. Coast Guard (USCG, 1999; USCG, 2001). This reporting system requires vessels larger than 300 gross registered tons (Navy ships are exempt) to report their location when entering the nursery and feeding areas of the right whale (Ward-Geiger *et al.*, 2005). At the same time, ships receive information on locations of North Atlantic right whale sightings in order to avoid whale collisions. Reporting takes place in the southeastern U.S. from 15 November through 15 April. In the northeastern U.S., the reporting system is year-round and the geographical boundaries include the waters of Cape Cod Bay, Massachusetts Bay, and the Great South Channel east and southeast of Massachusetts.

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

NOAA and the U.S. Coast Guard (USCG) have implemented recommended two-way routes into the harbors in both northern and southern right whale habitat areas to try to mitigate the chance of shipstrike to right whales. NMFS also recently released a proposed rule to reduce vessel speed in areas along the east coast to minimize the mortality rate from shipstrike to right whales (NARWC, 2007).

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

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 (e.g., NMFS, 2006b; Reeves *et al.*, 2007). North Atlantic right whales are found primarily in continental shelf waters between Florida and Nova Scotia (Winn *et al.*, 1986). Most sightings are concentrated within five high-use areas: coastal waters of the southeastern U.S. (Georgia and Florida), Cape Cod and Massachusetts Bays, the Great South Channel, the Bay of Fundy, and the Nova Scotian Shelf (Winn *et al.*, 1986; Silber and Clapham, 2001). 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). 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.

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

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

GOMEX Study Area North Atlantic right whale occurrence—The North Atlantic right whale rarely occurs in the Study Area. There are five confirmed records for the Gulf of Mexico; all of them occurred in winter and spring, including one stranding on the Texas coast in 1972 (Schmidly *et al.*, 1972; Zoodsma, 2006). Three of the sightings were of cow-calf pairs. One pair seen in late January 2004 off Miami, Florida, and in mid-March to early April off the Florida Panhandle was later resighted in June in waters off Cape Cod (Neuhauser, 2007). More recently, a cow-calf pair was photographed in Corpus Christi Bay off southern Texas and sighted a few weeks later off Long Boat Key, Florida (NOAA and FWC, 2006; Zoodsma, 2006). These records likely represent strays from the wintering grounds though they may reflect a more extensive historic range beyond the known calving and wintering ground in the waters of the southeastern U.S. (Jefferson and Schiro, 1997; Waring *et al.*, 2008). Although individuals sighted in the Gulf of Mexico are considered strays from the wintering grounds, it should be noted that recent reports of North Atlantic right whales in the Gulf of Mexico are occurring more often than expected (DoN, 2007b). Sightings records indicate that this species is most likely to occur in the Gulf of Mexico during the winter and spring. During the summer months, individuals should be found further north on their feeding grounds off the northeastern U.S. and Canada.

GOMEX Study Area North Atlantic right whale density—There is not an abundance estimate in the NOAA SAR for North Atlantic right whales in the Gulf of Mexico nor were there sufficient data available to estimate a density for the Study Area (DoN, 2007b; Waring *et al*., 2008).

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). The sei whale is atypical in that it primarily "skims" its food, although it is known to exhibit "gulping" feeding behavior like the other rorquals (Pivorunas, 1979).

Status and management—Sei whales are listed as endangered under the ESA. The 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.*, 2008). The most recent estimate of abundance for the Nova Scotia stock is 207 individuals; this is an extremely conservative estimate due to incomplete coverage of the entire range of the species and the uncertainty regarding movement in the North Atlantic Ocean (Waring *et al.*, 2008). The sei whale is under the jurisdiction of the NMFS. A draft recovery plan for fin and sei whales was released in 1998 (NMFS, 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.

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

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

In the western North Atlantic Ocean, the Nova Scotia Stock of the sei whale occurs primarily from Georges Bank north to Davis Strait (northeast Canada, between Greenland and Baffin Island) (Perry *et al.*, 1999; Waring *et al.*, 2007) but may be distributed as far south as North Carolina (NMFS, 1998a). Sei whales are not common in 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). Sei whales are known for occasional irruptive occurrences in areas followed by disappearances that may last for decades (Horwood, 1987; Schilling *et al.*, 1992; Clapham *et al.*, 1997; Gregr *et al.*, 2005). 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).

GOMEX Study Area sei whale occurrence—The sei whale is represented by only three reliable records in the northern Gulf of Mexico. There are two stranding records near Louisiana and one stranding on the Florida Panhandle (Mead, 1977; Jefferson and Schiro, 1997). The preferential mid-latitude distribution of the sei whale suggests that occurrence in the Gulf of Mexico is unlikely; however, the records of the sei whale in the Gulf indicate that this species may occur at any time of year.

GOMEX Study Area sei whale density—There is not an abundance estimate in the NOAA SAR for sei whales in the Gulf of Mexico nor were there sufficient data available to estimate a density for the Study Area (DoN, 2007b; Waring *et al*., 2008).

4.1.6 Sperm Whale

The sperm whale is the largest toothed whale species. Sperm whales are significantly sexually dimorphic with adult females reaching 12 m in length and adult males as much as 18 m (Jefferson *et al.*, 2008). Sperm whales prey on mesopelagic squids and other cephalopods, as well as demersal fishes and benthic invertebrates (Rice, 1989; Clarke, 1996).

Status and management**—**Sperm whales are listed as endangered under the ESA. Sperm whales in the northern Gulf of Mexico are managed by NMFS as a separate stock with a current best population estimate of 1,665 individuals (Waring *et al.*, 2008). Based on mark-recapture analyses of photo-identified individuals, an estimated 398 individuals use the region south of the Mississippi River Delta between the Mississippi Canyon and DeSoto Canyon along the 1,000-m isobath (Jochens *et al.*, 2006). There is no designated critical habitat for this species. The draft recovery plan for the sperm whale was released in June 2006 for public comment (NMFS, 2006a). A 5-yr status review as required by the ESA was initiated in 2007 for the sperm whale (NMFS, 2007a).

Habitat—Sperm whale habitat use varies, but is generally associated with waters over the continental shelf edge, continental slope, and offshore (CETAP, 1982; Hain *et al.*, 1985; Smith *et al.*, 1996; Waring *et al.*, 2001; Davis *et al.*, 2002). 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 cold-core rings, perhaps in response to prey density (Davis *et al.*, 2000; 2002). Griffin (1999) showed that sperm whales are five times more likely to occur near oceanographic features such as eddies and thermal fronts than in the remainder of his study area, suggesting that oceanographic features have a significant impact on the habitat use of sperm whales.

Distribution—Sperm whales are found from tropical to polar waters in all oceans of the world between approximately 70°N and 70° South (S) (Rice, 1998). Females are normally restricted to areas with SST greater than approximately 15°C, whereas males can be found in waters as far poleward as the pack ice with temperatures close to 0°C (Rice, 1989). The thermal limits of female distribution correspond approximately to the 40° parallels (Whitehead, 2003). Some sperm whales may have preferred "territories" demonstrated by home-range fidelity; this has been noted in the Galapagos (Lettevall *et al.*, 2002), the Gulf of California (Jaquet *et al.*, 2002), and the Gulf of Mexico (Würsig *et al.*, 2000).

Mating may occur December through August, with the peak breeding season falling in the spring (NMFS, 2006a); however, the location of specific breeding grounds is unknown. In the Gulf of Mexico, the Mississippi River Delta region has been identified as a possible calving area (e.g., Davis *et al.*, 2002).

GOMEX Study Area occurrence—Worldwide, sperm whales exhibit a strong affinity for deep waters beyond the continental shelf break (NMFS, 2006a). The recorded observations of sperm whales in the Gulf of Mexico support this trend, with sightings consistently recorded in waters beyond the 200-m isobath (DoN, 2007a). Sperm whales may occur year-round in the deepest waters of the northern Gulf of Mexico and the outer continental shelf waters in the region off the Mississippi River Delta. They are associated with dynamic features such as eddies that concentrate zooplankton and may be indicative of an increased density of prey (Davis *et al.*, 2002). Satellite-tag studies of sperm whales in the northern Gulf of Mexico confirm their strong preference for deep water over the continental slope and submarine canyons as well as offshore habitats (Mate, 2003; Ortega-Ortiz *et al.*, 2005). Sperm whales tend to be observed most often near the 1,000-m isobath (Jochens *et al.*, 2006). In addition to the aggregations of sperm whales seen here, the Mississippi River Delta region appears to represent an important calving and nursery area for these animals (Townsend, 1935; Collum and Fritts, 1985; Mullin *et al.*, 1994b; Würsig *et al.*, 2000; Baumgartner *et al.*, 2001; Davis *et al.*, 2002; Mullin *et al.*, 2004; Jochens *et al.*, 2006). On the basis of photo-identification of sperm whale flukes and acoustic analyses, it is likely that some sperm whales are resident to the Gulf of Mexico (Weller *et al.*, 2000; Jochens *et al.*, 2006). Tagging data demonstrated that some individuals spend several months at a time in the Mississippi River Delta and the Mississippi Canyon, while other individuals move to other locations the rest of the year (Jochens *et al.*, 2006). Segregation between the sexes was noted during one year of survey by Jochens *et al.* (2006); females and juveniles showed high site fidelity to the region south of the Mississippi River Delta and Mississippi Canyon and in the western Gulf of Mexico, while males were mainly found in the DeSoto Canyon and along the Florida slope.

GOMEX Study Area sperm whale density—The density estimates for sperm whale in the training areas, where HE use may occur in the GOMEX Study Area, are provided in **Table 6.** Methods and results are detailed in the GOMEX NODEs report (DoN, 2007b). Density is not expected to be uniform across the BOMBEX Hotbox and associated warning areas. Sperm whales will likely be concentrated in waters near and seaward of the shelf break as well as around DeSoto Canyon based on habitat preferences. Density may shift in relation to dynamic oceanographic features. Sperm whales are not expected to occur in UNDET Area E3 where underwater detonations occur.

Table 6 Seasonal Density Estimates for Sperm Whale in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/square kilometer [km^2])			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00152	0.00086	0.00152	0.00152

Source: (DoN 2007b)

4.1.7 West Indian Manatee

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

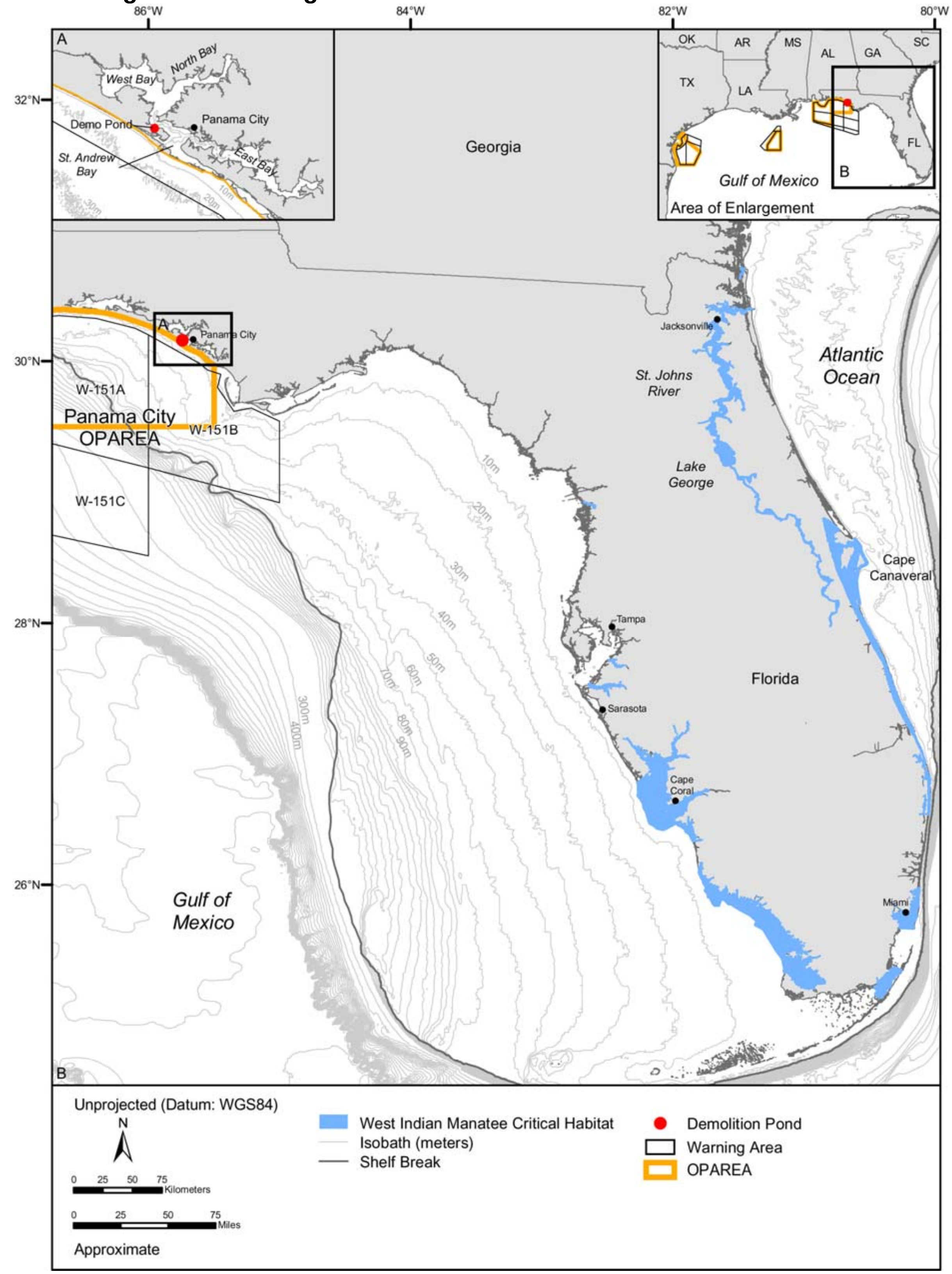
Status and management—West Indian manatees are listed as endangered under the ESA and fall under the jurisdiction of the USFWS. Manatee numbers are assessed by aerial surveys during the winter months when they are concentrated in warm-water refuges. Aerial surveys conducted in 2007 produced a preliminary abundance estimate of 2,812 West Indian manatees in Florida (FMRI, 2007). Along Florida's Gulf Coast, observers counted 1,400 West Indian manatees, while observers on the Atlantic coast counted 1,412 (FMRI, 2007).

In the most recent revision of the West Indian manatee recovery plan, manatees around Florida were divided into four relatively discrete management units or subpopulations, each representing a significant portion of the species' range (USFWS, 2001). West Indian manatees found along the Atlantic U.S. coast make up two subpopulations: the Atlantic Region and the Upper St. Johns River Region (USFWS, 2001). West Indian manatees from the western coast of Florida make up the other two subpopulations: the Northwest Region and the Southwest Region (USFWS, 2001). There are areas of critical habitat for the West Indian manatee along the Atlantic and Gulf coasts of Florida in coastal and inshore waters (**Figure 3**).

Habitat—West Indian manatees occur in very shallow waters of 2 to 4 m in depth, generally close to shore (Beck *et al.*, 2004). Shallow seagrass beds close to deep channels are preferred feeding areas in coastal and riverine habitats (e.g., Lefebvre *et al.*, 2000; USFWS, 2001). West Indian manatees are frequently located in secluded canals, creeks, embayments, and lagoons near the mouths of coastal rivers and sloughs. These areas serve as locations of feeding, resting, mating, and calving (USFWS, 2001).

Estuarine and brackish waters, including natural and artificial freshwater sources, are typical West Indian manatee habitat (USFWS, 2001). West Indian manatees rarely occur in offshore waters, where abundant seagrass and vegetation are not available (Reynolds and Odell, 1991). When ambient water temperatures drop below about 20°C in fall and winter, migration to natural or anthropogenic warm-water sources takes place (Irvine, 1983).

Figure 3 Designated Critical Habitat for West Indian Manatee



Source: USFWS (1976); Map adapted from USFWS (2007).

Distribution—The West Indian manatee occurs in warm, subtropical, and tropical waters of the western North Atlantic Ocean, from the southeastern U.S. to Central America, northern South America, and the West Indies (Lefebvre *et al.*, 2001). West Indian manatees occur along both the Atlantic and Gulf coasts of Florida. West Indian manatees are sometimes reported in the Florida Keys; these sightings are typically in the upper Florida Keys, with some reports as far south as Key West (Moore, 1951b, 1951a; Beck, 2006). During winter months, the West Indian manatee population confines itself to inshore and inner shelf waters of the southern half of peninsular Florida and to springs and warm water outfalls (e.g., power plant cooling water outfalls) farther north along both coasts. As water temperatures rise in spring, West Indian manatees disperse from winter aggregation areas. West Indian manatees are frequently reported in coastal rivers of Georgia and South Carolina during warmer months (Lefebvre *et al.*, 2001). Along the GOMEX coast, West Indian manatees occur year-round in coastal waters from Pensacola, Florida, south to the tip of Florida, although some sporadic occurrences have been documented as far west as Texas (Fertl *et al.*, 2005). Sightings are becoming more common along the coasts of Texas, Louisiana, and Mississippi. Although West Indian manatees are expected to inhabit nearshore areas, some have been sighted offshore as well, indicating that some individuals are capable of wide-ranging movements (e.g., Reid, 2000; Lefebvre *et al.*, 2001; Fertl *et al.*, 2005; Alvarez-Alemán *et al.*, 2007).

GOMEX Study Area West Indian manatee occurrence—On the Gulf coast of Florida, the West Indian manatee normally occurs in nearshore waters from Pensacola south to the Florida Keys (DoN, 2007a). Though West Indian manatees are most commonly found east and south of the panhandle region of Florida, they are known to occur in Bay County, Florida (USFWS, 2007). The West Indian manatee occurs normally in the nearshore waters of the Pensacola and Panama City OPAREAs and in the vicinity of the Demolition Pond. Since occasional occurrences are documented in nearshore waters as far west as Texas (Fertl *et al.*, 2005), West Indian manatees may also occur periodically in nearshore waters throughout the rest of the Study Area.

West Indian manatee distribution is limited by ready access to food and fresh water, confining them to rivers, estuaries, and nearshore waters in the northern Gulf of Mexico (Reid, 2000). Additionally, offshore currents and lack of suitable resources make it unlikely that West Indian manatees deliberately travel offshore (Lefebvre *et al.*, 2001). Occurrences of the West Indian manatee seaward of 12 nm from shore are considered extralimital (Reid, 2000; Lefebvre *et al.*, 2001; DoN, 2007a). West Indian manatees in the southeastern U.S. are divided into discrete populations based upon geographic boundaries; it is likely that any West Indian manatees affected by proposed actions in the GOMEX Study Area would be from the Northwest Region subpopulation; however, West Indian manatees are known to make extensive movements; therefore, any discussion of the West Indian manatees in this LOA includes any and all individuals from the Florida population and is not limited to those occurring in the Northwest Region management unit.

GOMEX Study Area West Indian manatee density—There is not an abundance estimate in the NOAA SAR for West Indian manatees in the Gulf of Mexico nor were there sufficient data available to estimate a density for the Study Area (DoN, 2007b; Waring *et al*., 2008).

4.2 Non-Threatened or Endangered Marine Mammal Species

Twenty-two non-threatened/non-endangered marine mammal species identified in **Table 3** may be affected by the preferred alternative training and operational activities in the GOMEX Study Area. These species include 2 baleen whale species and 20 toothed whale species.

4.2.1 Atlantic Spotted Dolphin

Atlantic spotted dolphins are born spotless and develop spots as they age (Perrin *et al.*, 1994a; Dudzinski, 1996; Herzing, 1997). Adults are up to 2.3 m long (Jefferson *et al.*, 2008); there is marked regional variation in the adult body size of the Atlantic spotted dolphin (Perrin *et al.*, 1987). There are two forms: a robust, heavily spotted form that inhabits the continental shelf and is usually found within 350 kilometers (km) of the coast and a smaller, less-spotted form that inhabits offshore waters (Perrin *et al.*, 1987; Perrin *et al.*, 1994a). The larger form is known specifically from the continental shelf of North America, including the U.S. east coast, the Gulf of Mexico, and the Atlantic coast of Central America. The smaller form occurs in more oceanic areas and around offshore islands such as the Azores (Jefferson *et al.*, 2008). Atlantic spotted dolphins feed on small cephalopods, fishes, and benthic invertebrates (Perrin *et al.*, 1994a).

Status and management—The best estimate of abundance for the Atlantic spotted dolphin in the northern Gulf of Mexico is 27,393 individuals (Waring *et al.*, 2008). The northern GOMEX management stock is genetically distinct from the western North Atlantic populations (Adams and Rosel, 2006; Waring *et al.*, 2008). The Atlantic spotted dolphin is under the jurisdiction of the NMFS.

Habitat—Atlantic spotted dolphins occupy both continental shelf and offshore habitats. The large, heavily spotted coastal form of the Atlantic spotted dolphin typically occurs over the continental shelf inside or near the 185-m isobath, usually at least 8 to 20 km offshore (Perrin *et al.*, 1994a; Davis *et al.*, 1998; Würsig *et al.*, 2000; Perrin, 2002). There are also often sightings of this species beyond the shelf break in the Caribbean, Gulf of Mexico, and off the Atlantic coast of the U.S. (Mills and Rademacher, 1996; Roden and Mullin, 2000; Fulling *et al.*, 2003; Mullin and Fulling, 2004).

Distribution—Atlantic spotted dolphins are distributed in tropical and warm-temperate waters of the Atlantic Ocean from approximately 45°N to 35°S. In the western North Atlantic, it ranges from northern New England to the Gulf of Mexico and the Caribbean, and southward to the coast of Venezuela (Perrin *et al.*, 1987; Rice, 1998).

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

GOMEX Study Area Atlantic spotted dolphin occurrence—Atlantic spotted dolphins in the northern Gulf of Mexico are abundant in continental shelf waters (Fulling *et al.*, 2003; Waring *et al.*, 2007). Known densities of Atlantic spotted dolphins are highest in the eastern Gulf of Mexico, east of Mobile Bay (Fulling *et al.*, 2003). In oceanic waters, this species usually occurs near the shelf break and upper continental slope waters (Davis *et al.*, 1998; Mullin and Hansen, 1999). On the West Florida shelf, Atlantic spotted dolphins are more common in deeper waters than bottlenose dolphins (Griffin and Griffin, 2003); Griffin and Griffin (2004) reported higher densities of Atlantic spotted dolphins in this area during cool months (November to May) than during warm months (June to October). Würsig *et al.* (2000) note that this species is normally found at least 8 to 20 km offshore, but may move inshore in the late spring and summer, perhaps in response to prey distribution. The Atlantic spotted dolphin is expected to occur year-round in the northern Gulf of Mexico.

GOMEX Study Area Atlantic spotted dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 7**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density estimates for the BOMBEX Hotbox and associated warning areas are indicative of the common occurrence of Atlantic spotted dolphins in the northern Gulf of Mexico. Density will not be uniform across the BOMBEX Hotbox and associated warning areas as Atlantic spotted dolphins are normally found outside the 100-m isobath in waters over the continental slope and shelf break. Atlantic spotted dolphins may occur in UNDET Area E3 where underwater detonations occur.

Table 7 Seasonal Density for Atlantic Spotted Dolphin in the GOMEX Study Area Where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.02188	0.02188	0.02188	0.02188

Source: DoN (2007b)

4.2.2 Beaked Whales

Based upon available data, the following four beaked whale species may be affected by the preferred alternative training and operational activities in the GOMEX Study Area: Cuvier's beaked whale (*Ziphius cavirostris*), Sowerby's beaked whale (*Mesoplodon bidens*), and two other members of the genus *Mesoplodon* [Blainville's beaked whale (*Mesoplodon densirostris*) and Gervais' beaked whale (*Mesoplodon europaeus*)]. Sowerby's beaked whale (*Mesoplodon bidens*) is endemic to the North Atlantic and is considered to be a temperate species (MacLeod *et al.*, 2006). There is one reported stranding of Sowerby's beaked whale on the Gulf coast of Florida that is considered extralimital (Jefferson and Schiro, 1997; MacLeod *et al.*, 2006); therefore, this species 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* spp. have maximum reported adult lengths of 6.2 m (Mead, 1989). Blainville's and Gervais' beaked whales are nearly indistinguishable at sea (Coles, 2001). 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 abundance for Cuvier's beaked whale in the northern Gulf of Mexico is 65 individuals (Waring *et al.*, 2008). The best estimate of abundance for the 2 *Mesoplodon* species (Blainville's and Gervais' beaked whales) in the northern Gulf of Mexico is 57 individuals (Waring *et al.*, 2008). Species-specific estimates for *Mesoplodon* beaked whales in the Gulf of Mexico are not available due to the difficulty of identification at sea. Beaked whales are under NMFS jurisdiction.

Habitat—Beaked whales normally inhabit continental slope and deep oceanic waters (>200 m) (Waring *et al.*, 2001; Cañadas *et al.*, 2002; Pitman, 2002; MacLeod and Herman, 2004; Ferguson *et al.*, 2006; MacLeod and Mitchell, 2006). Beaked whales are only occasionally reported in waters over the continental shelf (Pitman, 2002). In the Gulf of Mexico, beaked whales are seen in waters with a bottom depth ranging from 420 to 3,487 m (Ward *et al.*, 2005).

Distribution—Cuvier's beaked whales are the most widely distributed of the beaked whales and are present in most regions of all major oceans, with a preference for deepwater areas (Heyning, 1989; MacLeod and Mitchell, 2006). This species occupies almost all temperate, subtropical, and tropical waters, as well as subpolar and even polar waters in some areas (MacLeod and Mitchell, 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).

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

GOMEX Study Area beaked whale occurrence—Beaked whales may occur seaward of the shelf break throughout the Study Area year-round based on their preference for deep waters. A few beaked whale sightings have been recorded on the continental shelf (Esher *et al.*, 1992); however, these sightings are suspect, and one of the sightings in shallow water may have been of an individual which later stranded (DoN, 2007a). The northern GOMEX continental shelf margin is considered a "key area" for beaked whales (MacLeod *et al.*, 2006). Gervais' beaked whale comprises most of the records of *Mesoplodon* spp. from the Gulf of Mexico (Jefferson and Schiro, 1997).

GOMEX Study Area beaked whale density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 8**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density is not expected to be uniform across the BOMBEX Hotbox and associated warning areas. Beaked whales will likely be concentrated in waters near and seaward of the shelf break based on habitat preferences. Beaked whales are not expected to occur in UNDET Area E3 where underwater detonations occur.

Table 8 Seasonal Density Estimates for Beaked Whales in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	<0.00001	<0.00001	<0.00001	<0.00001

Source: DoN (2007b)

4.2.3 Bottlenose Dolphin

Bottlenose dolphins are medium-sized, relatively robust dolphins that vary in color from light gray to charcoal. There is striking regional variation in body size with adult body length ranging from 1.9 to 3.8 m (Jefferson *et al.*, 2008). Bottlenose dolphins are opportunistic feeders that use numerous feeding strategies to prey upon a variety of fishes, cephalopods, and shrimps (Shane, 1990; Wells and Scott, 1999). Bottlenose dolphins in the Gulf of Mexico exhibit at least two morphotypes: a nearshore form and an offshore form (Würsig *et al.*, 2000).

***Status and management*—**Bottlenose dolphins are under the jurisdiction of the NMFS. Two forms of bottlenose dolphins are recognized in the northern Gulf of Mexico: nearshore (coastal) and offshore morphotypes. The following stocks are recognized in the northern Gulf of Mexico: coastal stocks; a continental shelf stock; an oceanic stock; and bay, sound, and estuarine stocks (Waring *et al.*, 2008).

The bay, sound, and estuarine stocks are provisionally identified in the 33 areas of contiguous, enclosed, or semi-enclosed bodies of water adjacent to the Gulf of Mexico. There are no recent estimates of abundance for these stocks, but previous minimum population estimates for each stock are summarized in the NOAA SARs for the Gulf of Mexico (Waring *et al.*, 2008).

There are three coastal stocks in the northern Gulf of Mexico that occupy waters from the shore to the 20-m isobath but not necessarily within the bays, sounds and estuaries: eastern (84°W to Key West, Florida), northern (Mississippi River mouth to approximately 84°W), and western (Texas/Mexico border to the Mississippi River mouth) stocks. The coastal stocks may consist of both nearshore and offshore morphotypes and may co-mingle with the bay, sound, and estuarine stocks and the continental shelf stock. Current abundance estimates are not known; however, best estimates of abundance from

1992 to 1994 surveys are as follows: eastern stock (9,912 individuals), northern stock (4,191), and western stock (3,449) (Waring *et al.*, 2008).

The continental shelf stock is defined as dolphins inhabiting the waters from the Texas/Mexico border to Key West, Florida, between the 20 and 200-m isobaths and may consist of a mixture of both morphotypes. The best population estimate for this stock is 21,531 individuals (Waring *et al.*, 2008).

The oceanic stock is provisionally defined as bottlenose dolphins inhabiting waters from the 200-m isobath to the seaward extent of the EEZ. The best population estimate for the oceanic stock is 3,708 individuals (Waring *et al.*, 2008).

Habitat—Bottlenose dolphins are seen in both coastal and oceanic waters over the continental slope (Mullin and Fulling, 2004) and appear to have an almost bimodal distribution in the Gulf of Mexico: over the shallow continental shelf (0 to 150 m, with a peak at 75 m) and just seaward of the shelf break (200 to 750 m) (Baumgartner *et al.,* 2001). These regions may represent the individual depth preferences for the nearshore and offshore forms (Baumgartner *et al.*, 2001). Bottlenose dolphins are one of only two species of cetaceans encountered regularly over the continental shelf in the northern Gulf of Mexico (Baumgartner *et al.,* 2001). This species probably has the widest range of habitat preferences of any dolphin species that occurs in the Gulf of Mexico. They occur in brackish, estuarine, coastal, and open ocean habitats. Finer scale habitat use is probably influenced by risk of predation and food availability (Shane *et al.*, 1986; Wells *et al.*, 1987; Allen *et al.*, 2001; Heithaus and Dill, 2002).

Distribution—In the western North Atlantic Ocean, 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). Seasonal shifts in distribution have been noted in some areas, such as the U.S. mid-Atlantic coast (Torres *et al.*, 2005).

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.

GOMEX Study Area bottlenose dolphin occurrence—The bottlenose dolphin is by far the most widespread and common cetacean in coastal waters of the Gulf of Mexico (Würsig *et al.*, 2000). They are frequently sighted near the Mississippi River Delta (Baumgartner *et al.*, 2001) and have even been known to travel several kilometers up the Mississippi River (Jefferson, 2002a). Bottlenose dolphins are abundant in continental shelf waters throughout the northern Gulf of Mexico (e.g., Fulling *et al.*, 2003; Waring *et al.*, 2008). Mullin and Fulling (2004) noted that in oceanic waters, bottlenose dolphins are encountered primarily in upper continental slope waters (<1,000 m in bottom depth) and that highest densities are in the northeastern Gulf of Mexico. The bottlenose dolphin occurs throughout the Gulf of Mexico year-round over the continental shelf and continental slope (Baumgartner *et al.*, 2001) as well as in the bays and sounds along the coast (Waring *et al.*, 2008). Baumgartner *et al.* (2001) noted that bottlenose dolphins are more likely to be found in areas of high sea surface temperature variability.

GOMEX Study Area bottlenose dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 9**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Bottlenose dolphin occurrence in the Gulf of Mexico is year-round. Seasonal density shifts may be due to a shift in habitat preferences based on oceanographic features (such as SST variability) or may be an artifact of survey effort. Much higher densities within UNDET Area E3 are indicative of the nearshore form's preference for shallow waters (0-150m), but may also be a result of much higher survey effort in nearshore waters. Bottlenose dolphins are expected to occur in UNDET Area E3 where underwater detonations occur.

Table 9 Seasonal Density Estimates for Bottlenose Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.12408	0.12408	0.02658	0.12408

Source: DoN (2007b)

4.2.4 Bryde's Whale

Bryde's whales usually have three prominent ridges on the rostrum (other rorquals generally have only one) (Jefferson *et al.*, 1993). Adults can be up to 15.5 m in length (Jefferson *et al.*, 1993). Bryde's whales are often 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—The best estimate of abundance for the Bryde's whale in the northern Gulf of Mexico is 15 individuals (Waring *et al.*, 2008). It has been suggested that the Bryde's whales found in the northern Gulf of Mexico may represent a resident stock (Schmidly, 1981), but there is no information on stock differentiation (Waring *et al.*, 2008). The Bryde's whale is under the jurisdiction of the 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 tropical and subtropical waters, generally not moving poleward of 40° in either hemisphere (Jefferson *et al.*, 2008). Long migrations are not typical of Bryde's whales although limited shifts in distribution toward and away from the equator in winter and summer, respectively, have been observed (Cummings, 1985).

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

GOMEX Study Area Bryde's whale occurrence—In the Gulf of Mexico, all Bryde's whale sightings have been near the shelf break in and near DeSoto Canyon (Mullin *et al.*, 1994b; Davis and Fargion, 1996a; Jefferson and Schiro, 1997; Davis *et al.*, 1998; Davis *et al.*, 2000). Mead (1977) and Schmidly (1981) both postulated that the Gulf of Mexico hosts a resident population of Bryde's whale, but more data are needed to confirm this. There are 12 confirmed sightings of Bryde's whales in the Gulf of Mexico, making it the most commonly sighted baleen whale species in this area (Jefferson and Schiro, 1997; Würsig *et al.*, 2000). Most sightings of Bryde's whales are from the spring, but strandings are reported year-round indicating the presence of Bryde's whales in the Gulf of Mexico throughout the year (Mead, 1977; Jefferson and Schiro, 1997; Würsig *et al.*, 2000).

GOMEX Study Area Bryde's whale density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 10**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Bryde's whales are more likely to be found near the shelf break in areas of steep bathymetric relief. Density is not expected to be uniform across the BOMBEX Hotbox and associated warning areas. Uniform density across seasons may be indicative of the suspected year-round occurrence of this species in the Gulf of Mexico. Bryde's whales will not occur in UNDET Area E3, where underwater detonations occur.

Table 10 Seasonal Density Estimates for Bryde's Whale in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00009	0.00009	0.00009	0.00009

Source: DoN (2007b)

4.2.5 Clymene Dolphin

Due to similarity in appearance, Clymene dolphins are easily confused with spinner and short-beaked common dolphins (Fertl *et al.*, 2003). The Clymene dolphin, however, is smaller and more robust, with a much shorter and stockier beak. The Clymene dolphin reaches at least 2 m in length and weights of at least 80 kilograms (kg) (Jefferson *et al.*, 2008). 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 best estimate of abundance for Clymene dolphins in the northern Gulf of Mexico is 6,575 individuals (Waring *et al.*, 2008). This species is under the jurisdiction of the NMFS.

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). 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 are likely to be strongly influenced by oceanographic features (Mullin and Fulling, 2003).

Distribution—The Clymene dolphin has a tropical and subtropical distribution in the Atlantic Ocean (Perrin and Mead, 1994). 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 are unknown.

GOMEX Study Area Clymene dolphin occurrence—The Clymene dolphin is a deepwater species (Perrin and Mead, 1994; Würsig *et al.*, 2000; Reeves *et al.*, 2002; Fertl *et al.*, 2003). Mullin and Hansen (1999) noted that the majority of sightings for this species in the Gulf of Mexico are west of the Mississippi River. Although Jefferson *et al.* (1995) did not identify seasonal shifts in distribution, Wursig *et al.* (2000) note a wider, though still oceanic, distribution in the western Gulf during spring and in the northeastern Gulf during summer and winter. In a study of habitat preferences in the Gulf of Mexico, Clymene dolphins were found more often on the lower slope and deepwater areas in regions of cyclonic or confluence circulation (Davis *et al.*, 2002). Two mass strandings of Clymene dolphins were reported in the Florida Keys: one in July 1983 and the other in December 1992 (Jefferson *et al.*, 1995). The vast majority of known records of the Clymene dolphin come from the northern Gulf of Mexico, though this is probably indicative of research effort rather than any actual density or distribution pattern (Jefferson *et al.*, 1995; Würsig *et al.*, 2000; Fertl *et al.*, 2003).

GOMEX Study Area Clymene dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 11**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Clymene dolphin density in the BOMBEX Hotbox and associated warning areas is not expected to be uniform. Clymene dolphins show a strong preference for deep waters beyond the shelf break and may associate preferentially with dynamic oceanographic features. The seasonal uniformity of Clymene dolphin density may be indicative of their year-round presence in the Gulf of Mexico. Clymene dolphins will not occur in UNDET Area E3, where underwater detonations occur.

Table 11 Seasonal Density Estimates for Clymene Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.04020	0.04020	0.04020	0.04020

Source: DoN (2007b)

4.2.6 False Killer Whale

The false killer whale is a large, dark gray to black dolphin with adult body length reaching 6 m (Jefferson *et al.*, 2008). It has a long slender body, a rounded overhanging forehead, and little or no beak. External coloration includes a faint gray patch on the chest and light gray areas on the head (Jefferson *et al.*, 1993). The flippers have a “hump” on the leading edge that is useful for species identification (Reeves *et al.*, 2002). The distinctive flipper shape is perhaps the best characteristic for distinguishing this species from other dark, round-headed delphinid species (i.e., 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.

Status and management—The best estimate of abundance for false killer whales in the northern Gulf of Mexico is 777 individuals (Waring *et al.*, 2008). This species is under the jurisdiction of the 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°N and 50°S 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.

GOMEX Study Area false killer whale occurrence—The false killer whale is an oceanic species. Most sightings in the Gulf of Mexico have been made seaward of the shelf break, although there are also sightings from over the continental shelf (Davis and Fargion, 1996a; Jefferson and Schiro, 1997; Mullin and Fulling, 2004). Mullin and Fulling (2004) reported most sightings east of the Mississippi River. There is the possibility of encountering false killer whales between the 50-m isobath and the shelf break based on the fact that false killer whales sometimes make their way into shallower waters, as well as the many sightings reported by sport fishermen in the mid-1960s of “blackfish” (most likely false killer whales based on the descriptions) in waters offshore of Pensacola and Panama City, Florida (Brown *et al.*, 1966). Stranding and sighting records are from the spring and summer (Jefferson and Schiro, 1997; Würsig *et al.*, 2000; Mullin and Fulling, 2004; Waring *et al.*, 2008), but there are not enough data to determine whether there is a significant seasonal component to the distribution of this species in the northern Gulf of Mexico (Jefferson and Schiro, 1997; Würsig *et al.*, 2000). False killer whales are expected to occur year-round in the Gulf of Mexico seaward of the shelf break, though they may be encountered over the continental shelf as well.

GOMEX Study Area false killer whale density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 12**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). The uniform seasonal density of false killer whales may be indicative of its year round occurrence. Density in the BOMBEX Hotbox and associated warning areas will not be uniform; there is a stronger likelihood of occurrence seaward of the shelf break. Within W-155A/B, false killer whales are more likely to be found east of Mobile Bay. False killer whales will not occur in UNDET Area E3, where underwater detonations occur.

Table 12 Seasonal Density Estimates for False Killer Whale in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00240	0.00240	0.00240	0.00240

Source: DoN (2007b)

4.2.7 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.*, 2008). They feed on mesopelagic fishes, squids, and shrimps (Jefferson and Leatherwood, 1994; Perrin *et al.*, 1994c).

Status and management—There is no current estimate of abundance for Fraser's dolphins in the northern Gulf of Mexico (Waring *et al.*, 2008). This species is under the jurisdiction of the NMFS.

Habitat—Fraser's dolphin is a deep-water species found beyond the continental shelf break; it does not occur in shallow nearshore waters (Perrin *et al.*, 1994c; Jefferson and Schiro, 1997; Würsig *et al.*, 2000); however, they may be seen nearshore in areas where deep waters are close to the coast (Dolar, 2002).

Distribution—The Fraser's dolphin has a pantropical distribution, typically between 30°N and 30°S (Jefferson *et al.* 2008). 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.

GOMEX Study Area Fraser's dolphin occurrence—In the Gulf of Mexico, this species occurs mostly in very deep waters well beyond the continental shelf break (Jefferson, 2002a). There are verified stranding and sighting records for Fraser's dolphin in the Gulf of Mexico from all seasons (Jefferson and Schiro, 1997; Würsig *et al.*, 2000). Leatherwood *et al.* (1993) reported sightings over the abyssal plain in the southern Gulf of Mexico. Mullin and Fulling (2004) noted that this is a rare species, but it is thought to occur in the northern Gulf of Mexico even during years with survey effort when they are not sighted. Fraser's dolphins are expected to occur year round in the Study Area.

GOMEX Study Area Fraser's dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 13**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Fraser's dolphin density in the BOMBEX Hotbox and associated warning areas is not expected to be evenly distributed. Fraser's dolphins will be found in the deeper portions of the BOMBEX Hotbox and associated warning areas. The seasonal uniformity may be indicative of the year-round presence of this species in the Gulf of Mexico. Fraser's dolphins will not occur in UNDET Area E3, where underwater detonations.

Table 13 Seasonal Density Estimates for Fraser's Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00168	0.00168	0.00168	0.00168

Source: DoN (2007b)

4.2.8 Killer Whale

Killer whales are the largest delphinids and are one of the most recognizable species of 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) (Jefferson *et al.*, 1993). Killer whales are sexually dimorphic with males reaching a maximum length of 9.8 m and females 8.5 m (Jefferson *et al.*, 2008). Killer whales feed on fishes, cephalopods, seabirds, sea turtles, and other marine mammals (Katona *et al.*, 1988; Jefferson *et al.*, 1991; Estes *et al.*, 1998; Visser and Bonoccorso, 2003; Pitman and Dutton, 2004; Visser, 2005).

Status and management—The best estimate of abundance for killer whales in the northern Gulf of Mexico is 49 individuals (Waring *et al.*, 2008). Most cetacean taxonomists agree that multiple killer whale species or subspecies occur worldwide (Krahn *et al.*, 2004; Waples and Clapham, 2004). There is some evidence that there may be distinct stocks in the North Atlantic Ocean but none differentiating killer whales in the Gulf of Mexico (Waring *et al.*, 2008). The killer whale is under the jurisdiction of the NMFS.

Habitat—Killer whales have the most ubiquitous distribution of any species of marine mammal. 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 farther offshore (Katona *et al.*, 1988; Mitchell and Reeves, 1988). Their movements may also reflect the movements of their prey species, particularly migratory fishes (Katona *et al.*, 1988; Gormley, 1990).

Distribution—Killer whales are found throughout all oceans and contiguous seas, from equatorial regions to the polar pack ice zones of both hemispheres. Although found in tropical waters and the open ocean, the killer whale as a species is most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning, 1999). 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). A year-round killer whale population may exist in the western North Atlantic south of around 35°N.

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

GOMEX Study Area killer whale occurrence—Killer whales in the Gulf of Mexico are sighted most often in waters with a bottom depth greater than 200 m (averaging 1,242 m; range of 256 to 2,652 m), although there have also been occasional sightings over the continental shelf (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997). Killer whale sightings in the northern Gulf of Mexico are generally clumped in a broad region south of the Mississippi River Delta (O'Sullivan and Mullin, 1997); however, it should be noted that southern Texas (specifically, the Port Aransas area) seems to be an area where there are a number of anecdotal reports of killer whale sightings. There are sightings of killer whales from all seasons in the northern Gulf of Mexico (Jefferson and Schiro, 1997; O'Sullivan and Mullin, 1997; Würsig *et al.*, 2000). It is not known whether killer whales in the Gulf of Mexico stay within its confines or range more widely into the Caribbean and adjacent portions of the North Atlantic Ocean (Würsig *et al.*, 2000). Killer whales may occur in the Gulf of Mexico at any time of year, particularly beyond the shelf break.

GOMEX Study Area killer whale density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 14**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Killer whale density in the Gulf of Mexico is expected to be concentrated seaward of the shelf break. Killer whales are not expected to occur in UNDET Area E3, where underwater detonations occur.

Table 14 Seasonal Density Estimates for Killer Whale in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00031	0.00031	0.00031	0.00031

Source: DoN (2007b)

4.2.9 Melon-headed Whale

Melon-headed whales are medium-sized delphinids that may reach 2.8 m in total body length (Jefferson *et al.*, 2008). They closely resemble pygmy killer whales and may be extremely difficult to differentiate at sea based on morphology (Perryman *et al.*, 1994). 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 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—The best estimate of abundance for melon-headed whales in the northern Gulf of Mexico is 2,283 individuals (Waring *et al.*, 2008). This species is under the jurisdiction of the NMFS.

Habitat—Melon-headed whales are most often found in offshore waters. Sightings in the Gulf of Mexico have been well beyond the edge of the continental shelf break (Mullin *et al.*, 1994; Davis and Fargion, 1996; 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 deep tropical and subtropical waters (Reeves *et al.*, 2002). 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 in the western North Atlantic Ocean (Perryman *et al.*, 1994; Jefferson and Barros, 1997).

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

GOMEX Study Area melon-headed whale occurrence—The first two occurrence records for this species in the Gulf of Mexico were strandings in Texas and Louisiana during 1990 and 1991, respectively (Barron and Jefferson, 1993). Most melon-headed whale sightings in the Gulf of Mexico are well beyond the edge of the continental shelf (Mullin *et al.*, 1994a; Davis and Fargion, 1996a; Davis *et al.*, 2000) and include waters out over the abyssal plain (Jefferson, 2002a). Würsig *et al.* (2000) noted melon-headed whales occurring in water depths of 200 to 2,000 m in large groups (up to 400 animals) and often in association with Fraser's dolphins. Mullin and Hansen (1999) noted that melon-headed whales appear to be more frequently sighted west of the Mississippi River. The melon-headed whale is expected to occur seaward of the shelf break year-round in the Gulf of Mexico.

GOMEX Study Area melon-headed whale density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 15**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Based on sightings of this species in the Gulf of Mexico, melon-headed whale density is expected to be greater well beyond the shelf break in the deepest portions of the BOMBEX Hotbox and associated warning areas. This species will not occur in UNDET Area E3, where underwater detonations occur.

Table 15 Seasonal Density Estimates for Melon-headed Whale in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00799	0.00799	0.00799	0.00799

Source: DoN (2007b)

4.2.10 Minke Whale

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

Habitat—The minke whale occupies waters over the continental shelf, including inshore bays and some estuaries (Mitchell and Kozicki, 1975; Ivashin and Votrogov, 1981; Murphy, 1995; Mignucci-Giannoni, 1998; Calambokidis *et al.*, 2004); however, global whaling records and surveys indicate that minke whales also use deep-water habitats (Slijper *et al.*, 1964; Horwood, 1990; Mitchell, 1991),

Distribution—Minke whales are distributed in polar, temperate, and tropical waters (Jefferson *et al.*, 1993), though they are less common in the tropics than in temperate and polar regions. Along the U.S. east coast, minke whales are distributed throughout the U.S. EEZ with more sightings occurring in New England waters than in the mid-Atlantic (Hamazaki, 2002; Waring *et al.*, 2008). Minke whales off the U.S. Atlantic Coast apparently migrate offshore and southward in winter (Mitchell, 1991; Mellinger *et* *al.*, 2000) and are known to occur in the western North Atlantic from Bermuda to the West Indies during the winter months (November through March) (Mitchell, 1991; Mellinger *et al.*, 2000).

Mating is thought to occur from October to March but has never been observed (Stewart and Leatherwood, 1985); the locations of specific breeding grounds are unknown but they are thought to be in areas of low latitude (Jefferson *et al.*, 2008).

GOMEX Study Area minke whale occurrence—Minke whale occurrence in the Gulf of Mexico is supported by ten confirmed stranding records, all of which occurred during the winter and spring months. This supports the supposition that minke whales move to lower latitudes during the colder months of the year. Based on their known habitat preferences, minke whales might occur anywhere from nearshore waters seaward into deeper waters in the eastern Gulf of Mexico but are considered extralimital to the western Gulf of Mexico. Minke whales are not expected in the Gulf of Mexico during the summer when these whales should occur on feeding grounds farther north. Due to the timing of the strandings, these individuals may represent individuals moving into the Gulf of Mexico during their migrations (Würsig *et al.*, 2000; Jefferson, 2006). While it is most likely that individuals will occur in the Study Area during the winter months, minke whales may occur in the Gulf of Mexico at any time of year.

GOMEX Study Area minke whale density—There is not an abundance estimate in the NOAA SAR for minke whales in the Gulf of Mexico nor were there sufficient data available to estimate a density for the Study Area (DoN, 2007b; Waring *et al*., 2008).

4.2.11 Pantropical Spotted Dolphin

The pantropical spotted dolphin is a slender, spotted dolphin. Adults may reach 2.6 m in length (Jefferson *et al.*, 2008). Pantropical spotted dolphins are born spotless and develop spots as they age, although the degree of spotting varies geographically (Perrin and Hohn, 1994) and some populations may be virtually unspotted (Jefferson, 2006). 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 for the pantropical spotted dolphin in the northern Gulf of Mexico is 34,067 individuals (Waring *et al*., 2008). Pantropical spotted dolphins are under NMFS jurisdiction.

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; NMFS-SWFSC, 2007). Most sightings of this species in the Gulf of Mexico, Caribbean, and off Brazil occur over the lower continental slope (Davis *et al.*, 1998; Mignucci-Giannoni *et al.*, 2003; Mullin and Fulling, 2004; Moreno *et al.*, 2005).

Distribution—The pantropical spotted dolphin is distributed between about 40°N and 40°S in all oceans but is more abundant in the lower latitudes of its range (Jefferson *et al.*, 2008).

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.

GOMEX Study Area pantropical spotted dolphin occurrence—The pantropical spotted dolphin is the most abundant and commonly-sighted cetacean in deep waters of the northern Gulf of Mexico (Davis and Fargion, 1996a; Jefferson, 1996; Mullin and Hansen, 1999; Davis *et al.*, 2000; Würsig *et al.*, 2000; Mullin and Fulling, 2004). Mullin and Fulling (2004) reported that in the northeastern Gulf of Mexico, the pantropical spotted dolphin was two times more abundant during the summer than the rest of the year. Mullin *et al.* (2004) reported sighting pantropical spotted dolphins in the Gulf of Mexico in waters with bottom depths ranging from 435 to 2,121 m. Studies of this species in the northern Gulf of Mexico have shown both a uniform distribution with respect to effort (Baumgartner *et al.*, 2001) and higher encounter frequency in warm- and cold-core eddies with respect to effort (Davis *et al.*, 2000). The pantropical dolphin is expected to occur over the continental slope and in deeper waters seaward of the slope year-round.

GOMEX Study Area pantropical spotted dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 16**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density of pantropical spotted dolphins in the BOMBEX Hotbox and associated warning areas is expected to be concentrated in very deep waters and in the vicinity of the DeSoto Canyon. The decreased density during the spring is likely an artifact of increased survey effort during this season and may represent the most accurate for pantropical spotted dolphins in the northern Gulf of Mexico. Pantropical spotted dolphins are not expected to occur in UNDET Area E3, where underwater detonations occur.

Table 16 Seasonal Density Estimates for Pantropical Spotted Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.23178	0.06431	0.23178	0.23178

Source: DoN (2007b)

4.2.12 Pygmy and Dwarf Sperm Whales

Dwarf (*Kogia sima*) and pygmy (*Kogia breviceps*) sperm whales are very difficult to distinguish from one another and sightings of either species are often categorized generally as *Kogia* spp. (Jefferson *et al.*, 2008). The difficulty in identifying dwarf and pygmy sperm whales is exacerbated by their avoidance reaction towards ships and change in behavior towards approaching survey aircraft (Würsig *et al.*, 1998). Pygmy and dwarf sperm whales reach body lengths of around 3 and 2.5 m, respectively (Plön and Bernard, 1999). Both species feed on cephalopods and, less often, on deep-sea fishes and shrimps (Caldwell and Caldwell, 1989; McAlpine *et al.*, 1997; Willis and Baird, 1998; Santos *et al.*, 2006).

Status and management—The best estimate of abundance for *Kogia* spp. in the Gulf of Mexico is 453 individuals (Waring *et al.*, 2008). Separate estimates of abundance for the pygmy sperm whale or the dwarf sperm whale cannot be calculated due to uncertainty of species identification at sea (Waring *et al.*, 2008). Both the pygmy and the dwarf sperm whale are under the jurisdiction of the NMFS.

Habitat—World-wide, *Kogia* spp. generally occur in waters along the continental shelf break and over the continental slope (McAlpine, 2002). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf break, while dwarf sperm whales tend to occur closer to shore, often over the outer continental shelf (Rice, 1998; Wang *et al.*, 2002; MacLeod *et al.*, 2004); however, the difference in habitats may be more in terms of a difference between juveniles and adults instead of a difference between the two species of the genus (Ross, 1984). Distribution at sea in relation to the shelf break requires further study.

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

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

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

GOMEX Study Area Kogia spp. occurrence—*Kogia* spp. generally occur along the continental shelf break and over the continental slope in the Gulf of Mexico (Baumgartner *et al.*, 2001; Fulling and Fertl, 2003). Data suggest that *Kogia* spp. may associate with frontal regions along the shelf break and upper continental slope in the Gulf of Mexico where higher epipelagic zooplankton biomass may enhance the densities of squids, their primary prey (Baumgartner *et al.*, 2001). *Kogia* spp. are expected to occur seaward of the shelf break throughout the Gulf of Mexico year-round (DoN, 2007a).

GOMEX Study Area Kogia spp. density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 17**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). *Kogia* 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. *Kogia* spp. are not expected to occur in UNDET Area E3, where underwater detonations occur.

Table 17 Seasonal Density Estimates for *Kogia* spp. in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00268	0.00333	0.00268	0.00268

Source: DoN (2007b)

4.2.13 Pygmy Killer Whale

The pygmy killer whale is a mid-sized delphinid that reaches 2.6 m in body length (Jefferson *et al.*, 2008). 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 eat predominantly fishes and squids, and sometimes take large fish. They are known occasionally to attack other dolphins (Perryman and Foster, 1980; Ross and Leatherwood, 1994).

Status and management—The best estimate of abundance for pygmy killer whales in the northern Gulf of Mexico is 323 individuals (Waring *et al.*, 2008). This species is under the jurisdiction of the NMFS.

Habitat—Pygmy killer whales generally occupy offshore habitats. Their habitat includes waters seaward of the shelf break deeper than 1,500 m (Hansen *et al.*, 1994).

Distribution—The pygmy killer whale has a worldwide distribution in deep tropical, subtropical, and warm temperate oceans. Pygmy killer whales generally do not range north of 40°N or south of 35°S (Jefferson *et al.*, 2008). There are few records of this species in the western North Atlantic (Caldwell and Caldwell, 1971; Ross and Leatherwood, 1994). Most of the records outside the tropics are associated with unseasonable intrusions of warm water (Ross and Leatherwood, 1994).

Evidence suggests that calving occurs in the summer months (Ross and Leatherwood, 1994). Location of breeding is unknown.

GOMEX Study Area pygmy killer whale occurrence—In the northern Gulf of Mexico, the pygmy killer whale is found primarily in deeper waters beyond the continental shelf (Davis and Fargion, 1996a; Davis *et al.*, 2000; Würsig *et al.*, 2000) extending out to waters over the abyssal plain (Jefferson, 2002a). The pygmy killer whale does not appear to be common in the Gulf of Mexico (Davis and Fargion, 1996a; Jefferson and Schiro, 1997; Davis *et al.*, 2000; Würsig *et al.*, 2000). There is a seasonal peak in strandings during the winter, but there is no evidence to suggest (or refute) seasonal distribution changes (Jefferson and Schiro, 1997). Also relevant is the difficulty in distinguishing pygmy killer whales and melon-headed whales; often sightings of these two species are lumped together when individual species cannot be determined. The pygmy killer whale is expected to occur in the Study Area seaward of the shelf break year-round.

GOMEX Study Area pygmy killer whale density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 18**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density of the pygmy killer whale in the Gulf of Mexico is expected to be concentrated seaward of the shelf break. Uniform density across seasons may be indicative of this species suspected year-round occurrence in the northern Gulf of Mexico. This species will not occur in UNDET Area E3, where underwater detonations occur.

Table 18 Seasonal Density Estimates for Pygmy Killer Whale in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00095	0.00095	0.00095	0.00095

Source: DoN (2007b)

4.2.14 Risso's Dolphin

Risso's dolphins are mid-sized delphinids that can reach as much as 3.8 m length (Jefferson *et al.*, 2008). Cephalopods are their primary prey (Clarke, 1996).

Status and management—The best estimate of abundance for Risso's dolphins in the northern Gulf of Mexico is 1,589 individuals (Waring *et al.*, 2008). Risso's dolphins are under the jurisdiction of the NFMS.

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). Habitat use of the Risso's dolphin may reflect prey distribution (Baumgartner, 1997; 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 (Payne *et al.*, 1984).

In the North Atlantic, there appears to be a summer calving peak (Jefferson *et al.*, 1993; Würsig *et al.*, 2000); however locations of breeding areas are unknown.

GOMEX Study Area Risso's dolphin occurrence—There are numerous sighting and stranding records for Risso's dolphins in the Study Area (DoN, 2007a). Jefferson and Schiro (1997) noted a possible seasonal increase of this species over the upper continental slope during the spring. Baumgartner (1997) hypothesized that the strong correlation between Risso's dolphin distribution and the steeper portions of the upper continental slope in the Gulf is most likely the result of cephalopod distribution in the same area. Würsig *et al.* (2000) identified a general preference among Risso's dolphins for deep continental slope waters, but recent sightings near the Mississippi River Delta near the 200-m isobath may represent a shift in distribution. Risso's dolphins are expected to occur along the shelf break and continental slope and in deep waters farther offshore in the Gulf of Mexico year-round.

GOMEX Study Area Risso's dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 19**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density is not expected to be uniform across the BOMBEX Hotbox and associated warning areas. Risso's dolphins will likely be concentrated in waters near and seaward of the shelf break based on habitat preferences. Risso's dolphins are not expected to occur in UNDET Area E3, where underwater detonations occur.

Table 19 Seasonal Density Estimates for Risso's Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.01207	0.01207	0.01207	0.01207

Source: DoN (2007b)

4.2.15 Rough-toothed Dolphin

The rough-toothed dolphin is relatively robust with a cone-shaped head and no demarcation between the melon and beak (Jefferson *et al.*, 2008). The rough-toothed dolphin reaches 2.8 m in length (Jefferson *et al.*, 2008), and feeds 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—The best estimate of abundance for rough-toothed dolphins in the northern Gulf of Mexico is 2,942 individuals (Waring *et al.*, 2008). Rough-toothed dolphins are under the jurisdiction of the NMFS.

Habitat—The rough-toothed dolphin is regarded as an offshore species that prefers deep waters; however, it can occur in shallow waters (e.g., Gannier and West, 2005, Banick and Borger, 2005). Tagging data for this species from the Gulf of Mexico and western North Atlantic indicate wide-ranging movements over variable bottom depths (<110 m to >4,000 m in depth) (Wells *et al.*, 1999; Manire and Wells, 2005; 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, 2002a). Not many records for this species exist from the western North Atlantic, but they indicate that rough-toothed dolphins occur 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 are unknown.

GOMEX Study Area rough-toothed dolphin occurrence—In the Gulf of Mexico, the rough-toothed dolphin primarily occurs seaward of the shelf break (Davis *et al.*, 1998; Mullin and Fulling, 2004), although sighting and tagging data indicate the use of continental shelf waters as well (Wells *et al.*, 1999; Fulling *et al.*, 2003). Rough-toothed dolphins are expected to occur in the northern Gulf of Mexico year-round.

GOMEX Study Area rough-toothed dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 20**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density of this species in the BOMBEX Hotbox and associated warning areas is not expected to be uniform. Rough-toothed dolphins may occur in UNDET Area E3, where underwater detonations occur.

Table 20 Seasonal Density Estimates for Rough-toothed Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00009	0.00009	0.00009	0.00009

Source: DoN (2007b)

4.2.16 Short-finned Pilot Whale

Short-finned pilot whales may reach 5.5 m (females) and 7.2 m (males) in length (Jefferson *et al.*, 2008). The flippers of the short-finned pilot whale are long and sickle-shaped and range in length from 16 percent (%) to 22% of the total body length (Jefferson *et al.*, 1993). Pilot whale species feed primarily on squids but also take fishes (Bernard and Reilly, 1999).

Status and management—The best estimate of abundance for the short-finned pilot whale in the northern Gulf of Mexico is 716 individuals (Waring *et al.*, 2008). The short-finned pilot whale is under the jurisdiction of the NMFS.

Habitat—Pilot whales are found on the continental shelf break, in slope waters, and in areas of high topographic relief (Olson and Reilly, 2002). While pilot whales typically occur along the continental shelf break, movements over the continental shelf are commonly observed in the northeastern U.S. (CETAP, 1982; Payne and Heinemann, 1993). A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Hui, 1985; Payne and Heinemann, 1993; Waring and Finn, 1995; Bernard and Reilly, 1999).

Distribution—The short-finned pilot whale is found worldwide in tropical to warm-temperate seas and usually does not range north of 50°N or south of 40°S (Jefferson *et al.*, 2008). Distribution in the North Atlantic Ocean may shift seasonally, moving southward during the colder months of the year (Würsig *et al.*, 2000).

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.

GOMEX Study Area short-finned pilot whale occurrence—There are many pilot whales in the historical records for the northern Gulf of Mexico, but there have been fewer sightings in recent years (Jefferson and Schiro, 1997; Würsig *et al.*, 2000). The reason for this apparent decline is not known, but Jefferson and Schiro (1997) suggested that abundance or distribution patterns might have changed over the past few decades, perhaps due to changes in available prey species. There are no confirmed records of long-finned pilot whales (*Globicephala melas*) in the Gulf of Mexico (Würsig *et al.*, 2000); however, many pilot whale specimen records from the Gulf of Mexico and most or all sightings have not been shown unequivocally to be of the short-finned pilot whale (Jefferson and Schiro, 1997). Based on known distribution and habitat preferences of pilot whales, it is assumed that all of the pilot whale records in the northern Gulf of Mexico are of the short-finned pilot whale (Jefferson and Schiro, 1997; Würsig *et al.*, 2000). Short-finned pilot whales are expected to occur in the Gulf of Mexico year-round, particularly in areas of steep bathymetric relief (DoN, 2007a).

GOMEX Study Area short-finned pilot whale density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 21**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density is not expected to be uniform across the BOMBEX Hotbox and associated warning areas. 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. Pilot whales will not occur in UNDET Area E3, where underwater detonations occur.

Table 21 Seasonal Density Estimates for Short-finned Pilot Whale in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.00553	0.00553	0.00553	0.00553

Source: DoN (2007b)

4.2.17 Spinner Dolphin

The spinner dolphin generally has a dark eye-to-flipper stripe and dark lips and beak tip (Jefferson *et al.*, 2008). 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.*, 2008). Spinner dolphins feed primarily on small mesopelagic fishes, squids, and sergestid shrimps (Perrin and Gilpatrick, 1994).

Status and management—The best estimate of abundance for spinner dolphins in the northern Gulf of Mexico is 1,989 individuals (Waring *et al.*, 2008). Spinner dolphins are under the jurisdiction of the 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).

Distribution—The spinner dolphin is found in tropical and subtropical waters worldwide with different geographical forms in various ocean basins. Limits are near 40°N and 40°S (Jefferson *et al.*, 2008). Distribution in the Gulf of Mexico appears to be oceanic (Waring *et al.*, 2008).

Breeding occurs across all seasons 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.

GOMEX Study Area spinner dolphin occurrence—Spinner dolphins occur year-round in deep waters of the Gulf of Mexico. Mullin and Fulling (2004) noted that the vast majority of spinner dolphin sightings were over the continental slope in the northeastern Gulf of Mexico. Würsig *et al.* (2000) also noted that sightings of spinners in the Gulf of Mexico come primarily from east and southeast of the Mississippi River Delta. Spinners typically occur in water depths greater than 100 m (Würsig *et al.*, 2000). Davis *et al.* (2002) noted the presence of spinner dolphins at intermediate depths along the continental slope; they venture farther offshore than oceanic bottlenose dolphins but not as far as other stenellids (Clymene, striped, and pantropical spotted dolphins). Previous studies noting spinner dolphins in shallower waters (<200 m) (Fritts *et al.* 1983) likely misidentified this species (Jefferson and Schiro, 1997; Würsig *et al.*, 2000). It is probable that these dolphins were actually Atlantic spotted dolphins (Jefferson, 2006).

GOMEX Study Area spinner dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 22**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Spinner dolphin density is not expected to be uniform across the BOMBEX Hotbox and associated warning areas. They are expected to be concentrated over the continental slope and shelf break based on their habitat preferences. Spinner dolphins are not expected to occur in UNDET Area E3, where underwater detonations occur.

Table 22 Seasonal Density Estimates for Spinner Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.20251	0.20251	0.20251	0.20251

Source: DoN (2007b)

4.2.18 Striped Dolphin

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

Status and management—The best estimate of abundance for striped dolphins in the northern Gulf of Mexico is 3,325 individuals (Waring *et al.*, 2008). Striped dolphins are under the jurisdiction of the NMFS.

Habitat—Striped dolphins are usually found beyond the continental shelf, typically over the continental slope out to oceanic waters; they prefer areas of oceanographic variability including convergence and upwelling zones (Au and Perryman, 1985). They are also associated with seasonal changes in SST and thermocline depth (Perrin *et al.*, 1994b) and appear to avoid waters with SST of less than 20°C (Van Waerebeek *et al.*, 1998).

Distribution—The striped dolphin occurs in tropical, sub-tropical and temperate waters of all major ocean basins (Rice, 1998; Würsig *et al.*, 2000; Reeves *et al.*, 2002). In the western North Atlantic, this species ranges from Newfoundland southward to the Caribbean, the Gulf of Mexico, and Brazil (Würsig *et al.*, 2000).

Information from Pacific populations suggests that breeding occurs seasonally with peaks in calving rates during the summer and the winter (Perrin *et al.*, 1994b). In the western North Atlantic, breeding times and locations are largely unknown.

GOMEX Study Area striped dolphin occurrence—The striped dolphin is an oceanic species and is expected to occur seaward of the shelf break in the Gulf of Mexico year-round. Würsig *et al.* (2000) noted a higher concentration of this species in the vicinity of the DeSoto Canyon east of the Mississippi River Delta. There is probably no seasonal difference in distribution (Jefferson and Schiro, 1997) although in other areas of the world, striped dolphins are known to follow migrating convergence zones (Perrin *et al.*, 1994b). Fritts *et al.* (1983) recorded many sightings of striped dolphins over the continental shelf off southern Florida, but these were probably all misidentifications of Atlantic spotted dolphins (Jefferson and Schiro, 1997; Würsig *et al.*, 2000).

GOMEX Study Area striped dolphin density—The density estimates for the training areas, where HE ordnance use may occur in the GOMEX Study Area, are provided in **Table 23**. Methods of how the density estimates were derived are detailed in the GOMEX NODE report (DoN, 2007b). Density of striped dolphins is not expected to be uniform across the BOMBEX Hotbox and associated warning areas. Based on habitat preferences, striped dolphins are expected to occur seaward of the shelf break and may occur in greater densities near the DeSoto Canyon. Striped dolphins are not expected to occur in UNDET Area E3, where underwater detonations occur.

Table 23 Seasonal Density Estimates for Striped Dolphin in the GOMEX Study Area where HE Ordnance Use Occurs

Training Area	Density (animals/km^2)			
	Winter (Dec, Jan, Feb)	Spring (Mar, Apr, May)	Summer (Jun, Jul, Aug)	Fall (Sept, Oct, Nov)
BOMBEX Hotbox	0.06161	0.06161	0.06161	0.06161

Source: DoN (2007b)

CHAPTER 5 TAKE AUTHORIZATION REQUESTED

A LOA for the incidental taking of marine mammals is requested pursuant to § 101 (a)(5)(A) of the MMPA. The request is for a 5-yr period commencing upon issuance of the permit. The term "take," as defined in § 3 (16 U.S.C. 1362) of the 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 (PL 108-136) amended the definition of harassment as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with § 104(c)(3) [16 U.S.C. 1374 (c)(3)]. The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (PL 107-314). Military training and operational activities within the GOMEX Study Area constitute military readiness activities as that term is defined in PL 107-314 because training and operational 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 U.S.C. 1362 (18)(B)(i)(ii)].

Modeling results from the analysis predict no Level A mortalities for marine mammals from use of explosive ordnance in BOMBEX 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 BOMBEX predict that for this LOA request, one pantropical spotted dolphin and one spinner dolphin could be exposed to pressure in excess of 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 predicted.

Modeling results for use of explosive ordnance in BOMBEX predict Level B behavioral reaction without TTS exposures for 3 Atlantic spotted dolphins, 13 bottlenose dolphins, 6 Clymene dolphins, 1 melon-headed whale, 27 pantropical spotted dolphins, 2 Risso's dolphins, 1 short-finned pilot whale, 28 spinner dolphins, and 8 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 measures, the actual exposures would likely be lower than the predicted amount.

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CHAPTER 6 NUMBERS AND SPECIES TAKEN

The GOMEX Range Complex EIS/OEIS analyzed the stressors associated with proposed exercises in the GOMEX Study Area. The EIS/OEIS concluded that HE use associated with BOMBEX and the underwater detonations associated with GUNEX were the training and operational 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

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

Laist *et al.* (2001) reviewed historical, stranding, and anecdotal records on the occurrence of collisions between motorized vessels and large whales (baleen and sperm whales) to quantify the frequency of these collisions as well as the characteristics (speed, size) of vessels that may be more likely to result in mortality. After reviewing these records (including stranding records from the U.S., Italy, France, South Africa and anecdotal records from mariners around the world) 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 with approximately 15 incidents of a vessel colliding with a large whale between 1877 and 1950. Ship collisions with large whales remained infrequent until the 1950s, after which point reports became increasingly more frequent. Laist *et al.* (2001) report that both the number and speed of motorized vessels have increased over time for trans-Atlantic passenger services. 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 (such as the North Atlantic right whale) or segments of populations the impact of ship strikes may be significant.

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

Of 11 species known to be hit by ships, fin whales are struck most frequently; right whales, humpback whales, sperm whales, and gray whales are all hit commonly (Laist *et al.*, 2001). In some areas, one-third of all fin whale and right whale strandings appear to involve ship strikes. Sperm whales spend long periods (typically up to 10 min; Jacquet *et al.*, 1998) "rafting" at the surface between deep dives. This could make them exceptionally vulnerable to ship strikes. Berzin (1972) noted that there were “many” reports of sperm whales of different age classes being struck by vessels, including passenger ships and tug boats. There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (NMFS, 2006b).

In the Gulf of Mexico, sperm whales are of particular concern. Sperm whales spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives. 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.*, 2004a). In comparison with other regions of the U.S., the Gulf of Mexico is the least common area for ship strikes of large whales (Jensen and Silber, 2003). Between 1972 and 1999, eight confirmed or possible large whale ship strikes were recorded in the Gulf of Mexico, including two that collided with Navy vessels; four of these resulted in mortality of the animal (Jensen and Silber, 2003) and one resulted in extensive damage to a Navy vessel (Laist *et al.*, 2001). It is not known whether the shipstrikes involving Navy vessels resulted in the mortality of the animal (Laist *et al.*, 2001; Jensen and Silber, 2003).

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

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

Navy shipboard lookouts (also referred to as "watchstanders") are highly qualified and experienced observers of the marine environment. Their duties require that they report all objects sighted in the water to the Officer of the Deck (OOD) (e.g., trash, a periscope, marine mammals, sea turtles) and all disturbances (e.g., surface disturbance, discoloration) that may be indicative of a threat to the vessel and its crew. There are personnel serving as lookouts on station at all times (day and night) when a ship or surfaced submarine is moving through the water. Navy lookouts undergo extensive training in order to qualify as a lookout. This training includes on-the-job instruction under the supervision of an experienced lookout, followed by completion of the Personal Qualification Standard 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 on how to look for marine species, and report sightings to the OOD so that action may be taken to avoid the marine species or adjust the exercise to minimize effects to the species. Marine Species Awareness Training (MSAT) was updated in 2006, and the additional training materials are now included as required training for Navy ship and submarine lookouts. Additionally, all Commanding Officers (COs) and Executive Officers (XOs) of units involved in training exercises are required to undergo marine species awareness training. This training addresses the lookout's role in environmental protection, laws governing the protection of marine species, Navy stewardship commitments, and general observation information to aid in avoiding interactions with marine species.

West Indian manatees are particularly susceptible to vessel collisions due to their propensity for very shallow waters and their inability to move with haste (Calleson and Frohlich, 2007; Haubold *et al*., 2006; Runge *et al*., 2007; USFWS, 2001c; 2007m). Vessel collisions are the largest known source of human-caused mortality to adult West Indian manatees (USFWS, 2007m), accounting for approximately 25% of all manatee deaths recorded in Florida since 1976 (Calleson and Frohlich, 2007). The large percentage of West Indian manatees in Florida that bear scars from previous collisions indicates that sub-lethal effects of vessel traffic are also a concern. Non-lethal injuries may reduce the breeding success of wounded females and may permanently remove some animals from the breeding population (Haubold *et al*., 2006).

Based on the implementation of Navy mitigation measures and the relatively low density (180 steaming days/year) of Navy ships in the GOMEX Study Area, the likelihood that a vessel strike would occur is very low. Vessel collisions may affect baleen whales in the GOMEX Study Area, but any potential effect may be discounted due to the low occurrence of these species in the area. Vessel collisions may affect sperm whales in the GOMEX Study Area.

The probability of a West Indian manatee encountering a Navy vessel in the offshore waters of the GOMEX Study Area is extremely low based on a combination of factors. West Indian manatees are not expected to occur more than 12 nm offshore or in relatively deep waters of the GOMEX Study Area where most of the vessel movements occur. West Indian manatee occurrence becomes less common north and west of peninsular Florida (Fertl *et al*., 2005). No vessel operations occur in areas that provide foraging habitat for the West Indian manatee. In addition, the Navy has adopted mitigation measures to reduce the potential for collisions with marine mammals. These measures are described in detail in **Chapter 11**. The low probability of West Indian manatee and Navy vessel co-occurrence outside of 12 nm and the use of mitigation measures indicate that vessel collisions are extremely unlikely to occur. Therefore, vessel collisions would have no effect on West Indian manatees in the offshore waters of the GOMEX Study Area.

West Indian manatees are expected to occur in the nearshore zone and may be affected by vessel collisions associated with shallow water training in the GOMEX Study Area (i.e., MESG and CNIC harbor security group) that occurs within 12 nm of the shoreline. The boats associated with this training are small (<30 m) and have the ability to travel at high speeds. Vessels transiting to and from ports to the offshore portion of the GOMEX Study Area also pose a hazard to West Indian manatees. The risk to West Indian manatees from vessel collision increases nearer to shore (due to higher likelihood of manatee occurrence) and at higher vessel speeds (USFWS, 2001). Vessels in transit to and from ports as well as small boat use associated with MESG in the UNDET Area E3 and CNIC training in the Panama City OPAREA (Harbor Security Machine Gun Area) may affect West Indian manatees; however, the low probability of West Indian manatee and Navy vessel co-occurrence and the use of mitigation measures (**Chapter 11**) indicate that vessel collisions are unlikely to occur.

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 may be as subtle as shorter surfacings, shorter dives, fewer blows per surfacing, longer intervals between blows (breaths), ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (NRC, 2005); however, it is not known how these responses relate to significant effects (e.g., long-term effects or population consequences) (NRC, 2005). Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. The Navy enlisted the expertise of the NMFS as the cooperating agency in the preparation of this LOA; the NMFS provided expert review of the document as well as consultation pursuant to the ESA for the marine mammals with the potential to occur in the GOMEX Study Area.

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

- Evaluation of potential effects within the context of existing and current regulations, thresholds, and criteria.
- Identification of all acoustic sources that will be used during Navy training and operational activities.
- Identification of the location, season, and duration of the action to determine which marine mammal species are likely to be present.

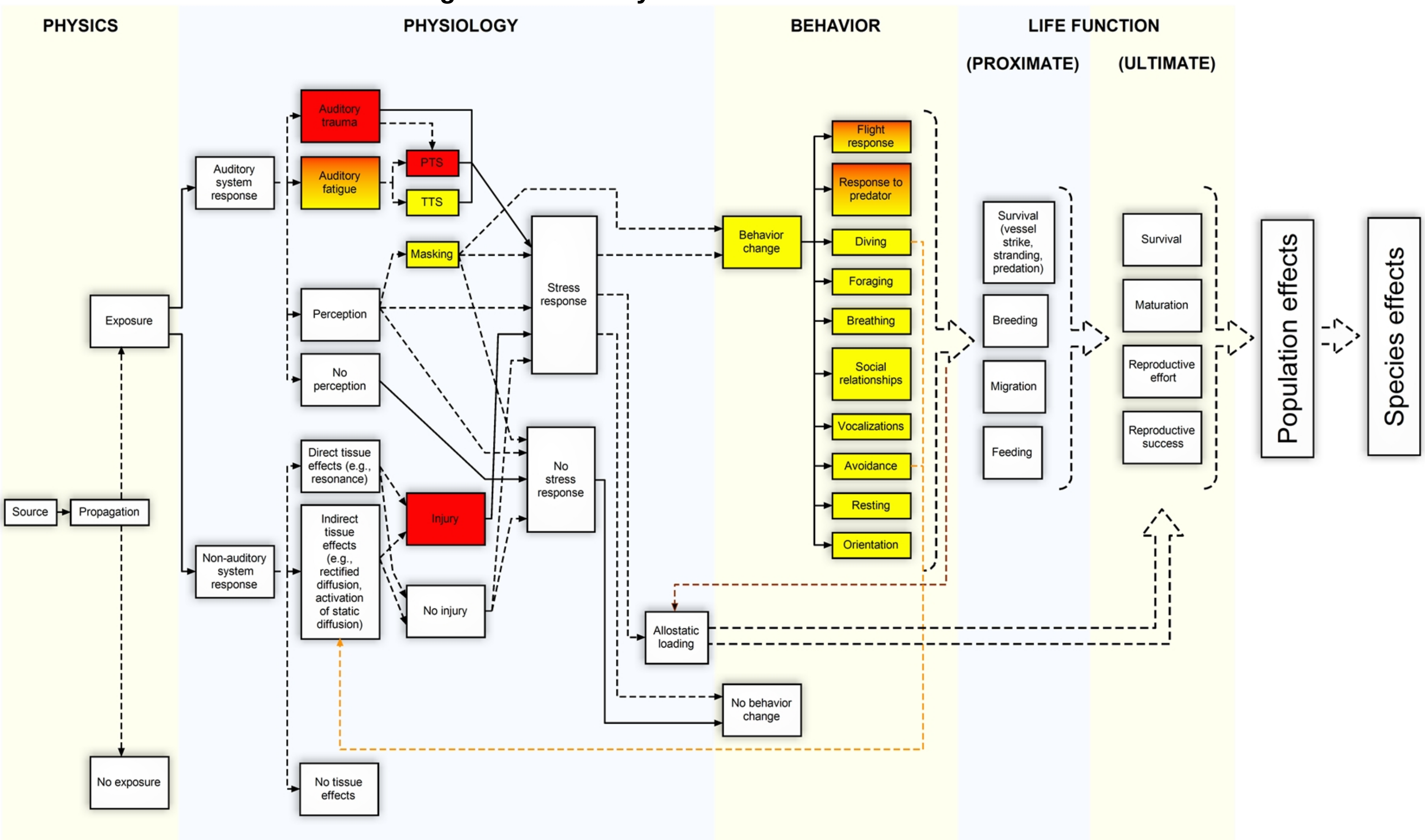
- Determination of the estimated number of marine mammals (i.e., density) of each species that will likely be present in the respective OPAREAs during the Navy training and operational activities.
- Application of the appropriate acoustic threshold criteria to the predicted sound exposures from the proposed activity. The results of this effort are then evaluated to determine whether the predicted sound exposures from the acoustic model might be considered harassment.
- Consideration of 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 4**) 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 (**Figure 4**) are colored according to how they relate to the definitions of harassment under the MMPA. Red boxes correspond to events that are injurious. By prior ruling and usage, these events would be considered as Level A harassment under the MMPA. Yellow boxes correspond to events that have the potential to qualify as Level B harassment under the MMPA. Based on prior ruling, the specific instance of TTS is considered as Level B harassment. Boxes that are shaded from red to yellow have the potential for injury and behavioral disturbance.

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

Figure 4 Analytical Framework Flow Chart



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. The assumption of a stationary animal makes the model inherently more conservative due to the fact that a stationary individual likely would accumulate energy more quickly than would an individual that is mobile and able to move away from a sound source.

6.2.2 Physiology

Potential impacts to the auditory system are assessed by considering the characteristics of the received sound (e.g., amplitude, frequency, duration) and the sensitivity of the exposed animals. Some of these assessments can be numerically based (e.g., TTS, PTS, perception). Others will be necessarily qualitative, due to lack of information, or will need to be extrapolated from other species for which information exists.

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

1. Auditory trauma represents direct mechanical injury to hearing related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma is always injurious but could be temporary and not result in PTS. Auditory trauma is always assumed to result in a stress response.
2. Auditory fatigue refers to a loss of hearing sensitivity after sound stimulation. The loss of sensitivity persists after, sometimes long after, the cessation of the sound. The mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic exhaustion of the hair cells and cochlear tissues. The features of the exposure (e.g., amplitude, frequency, duration, temporal pattern) and the individual animal's susceptibility would determine the severity of fatigue and whether the effects were temporary (TTS) or permanent (PTS). Auditory fatigue (PTS or TTS) is always assumed to result in a stress response.
3. Sounds with sufficient amplitude and duration to be detected among the background ambient noise are considered to be perceived. This category includes sounds from the threshold of audibility through the normal dynamic range of hearing (i.e., not capable of producing 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 [acoustic pressure fluctuations could cause a pre-existing gas bubble in a liquid medium to oscillate, resulting in the diffusion of dissolved gas into the bubble and a net increase in the bubble's mass and size. Rectified diffusion of gas into a pre-existing bubble occurs above a certain acoustic threshold; below this threshold, the net diffusion is out of the bubble, resulting in the dissolution of the bubble.]). 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 4** 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.

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 4** 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 4**) 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 (NRC, 2003). 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 (NRC, 2003).

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 4** 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 will 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 will be made. Based on the available literature on the bioacoustics, physiology, dive behavior, and ecology of the species, **Figure 4** will 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 depend 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 acoustic 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'Keefe 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 are BOMBEX (BOMBEX Hotbox) and GUNEX (UNDET Area E3). **Table 24** summarizes the number of events (per year by season) and specific areas where each occurs for each type of explosive ordnance used. 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 four seasons. For example, there is one BOMBEX event per year that can take place in the BOMBEX Hotbox during any season, so there are 0.25 events modeled for each season.

Table 24 Number of Explosive Events within the GOMEX Study Area

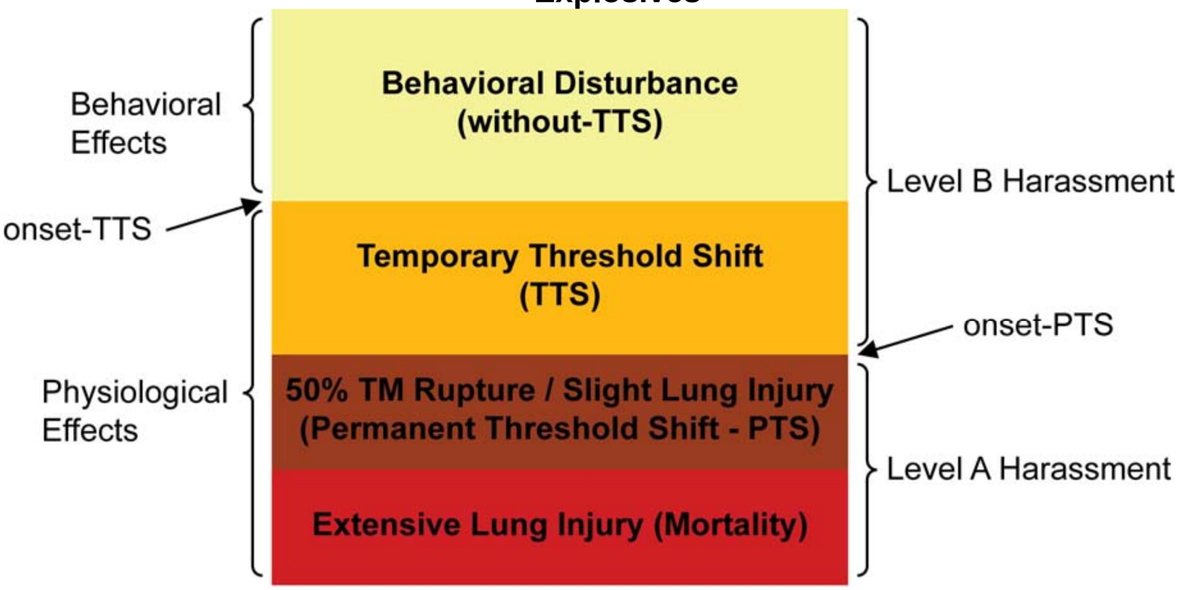
Location	Ordnance	Annual Totals
BOMBEX Hotbox	MK-83 (415.8 lbs NEW)	1*
UNDET Area E3	M3A2 anti-swimmer concussion grenade (0.5 lbs NEW)	6

**One event using MK-83 bombs consists of 4 bombs being dropped in succession. Therefore, since there is 1 event, there will be a total of 4 bombs dropped in the BOMBEX Hotbox 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 EIS (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 BOMBEX. In addition, this section reflects a revised acoustic criterion for small underwater explosions (i.e., 23 pounds per square inch [psi] for peak pressure instead of previous acoustic criterion of 12 psi for peak pressure), which is based on the final rule issued to the Air Force by NMFS (NMFS, 2005b). **Figure 5** depicts the acoustic impact framework used in this assessment.

Figure 5 Physiological and Behavioral Acoustic Effects Framework for Explosives



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

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, EFD is the time integral of the squared pressure divided by the impedance. It has International Standard (SI) units of Joules per square meter (J/m^2) (but inch-pounds per square inch [in.-lb/in.^{2}] is also used in CHURCHILL). EFD levels have units of decibels referenced to 1 square micropascal-second (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 pascal-seconds (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 one micropascal (dB re: 1 μPa).

6.3.1.1 Thresholds and Criteria for Injurious Physiological Effects

Single Explosion

For injury, the Navy uses dual criteria: eardrum rupture (i.e., tympanic-membrane [TM] rupture) and onset of slight lung injury. These criteria are considered indicative of the onset of injury. The threshold for TM rupture corresponds to a 50% 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 in.-lb/in.^{2} (about 205 dB re: 1 μPa^2-s). This recognizes that TM rupture is not necessarily a serious or life-threatening injury, but 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 (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 marine species populations were 100% small animals. The criterion with the largest potential impact range (most conservative), either TM rupture (energy threshold) or onset of slight lung injury (peak pressure threshold), will be used in the analysis to determine injurious physiological (MMPA – Level A) exposures.

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

Multiple Explosions

For this analysis, the use of multiple explosions only applies to the MK-83 bombs used in BOMBEX. Since BOMBEX events require multiple explosions, the Churchill approach had to be extended to cover multiple sound events at the same training site. For multiple exposures, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot (explosion); this is consistent with the treatment of multiple arrivals in Churchill. For positive impulse, it 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). For this assessment, there are dual criteria for TTS, an energy threshold and a peak pressure threshold. The criterion with the largest potential impact range (most conservative), either the energy threshold or peak pressure threshold, will be used in the analysis to determine non-injurious TTS (MMPA – Level B) exposures.

Single Explosion –TTS-Energy Threshold

The first threshold is a 182 dB re: 1 μPa^2-s maximum EL 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-s in any 1/3-octave band. The energy threshold usually dominates and is used in the analysis to determine potential non-injurious exposures (MMPA-Level B) 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 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 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.

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 physiological exposure. 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 BOMBEX. Because multiple explosions would occur within a discrete time period (four bombs per exercise at an interval of three to nine minutes between bombs), 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-s maximum EL in any 1/3-octave band at frequencies above 100 Hz for toothed whales/sea turtles and in any 1/3-octave band above 10 Hz for baleen whales. As stated previously for TTS, for small explosives (<1500-lb NEW), as what was modeled for this analysis, the spectrum of the shot arrival is broad, and there is essentially no difference in impact ranges for toothed whales/sea turtles or baleen whales. For BOMBEX involving MK-83 bombs, behavioral disturbance (without TTS) (177 dB re: 1 μPa^2-s) is the criterion that dominates in the analysis to determine potential behavioral exposures (MMPA-Level B) due to the use of multiple explosions.

6.3.2 Summary of Thresholds and Criteria for Impulsive Sounds

Table 25 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 BOMBEX event.

Table 25 Effects, Criteria, and Thresholds for Impulsive Sounds

Effect	Criterion	Metric	Threshold
Mortality	Onset of Extensive Lung Injury	Goertner modified positive impulse	indexed to 30.5 psi-ms (assumes 100% small animal at 26.9 lbs)
Injurious Physiological *MMPA* - Level A	50% Tympanic Membrane Rupture	Energy flux density	1.17 in.-lb/in.^{2} (about 205 dB re: 1 μPa^2-s)
Injurious Physiological *MMPA* - Level A	Onset Slight Lung Injury	Goertner modified positive impulse	indexed to 13 psi-ms (assumes 100% small animal at 26.9 lbs)
Non-injurious Physiological *MMPA* - Level B	TTS	Greatest EL in any 1/3-octave band (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures	182 dB re: 1 μPa^2-s
Non-injurious Physiological *MMPA* - Level B	TTS	Peak pressure for any single exposure	23 psi
Non-injurious Behavioral *MMPA* - Level B	Behavioral Disturbance without TTS	Greatest energy flux density level in any 1/3-octave (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures (multiple explosions only)	177 dB re: 1 μPa^2-s
MMPA - 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 for BOMBEX is presented in the following section. A more in-depth effects analysis may be found in **Appendix A**. There was no acoustic modeling conducted for GUNEX.

BOMBEX

Modeling was completed for four explosive sources (sequential detonation of four bombs per event) involved in BOMBEX with an assumed detonation depth of 1 m. The NEW used in simulations of the MK83 is 415.8 lbs.

Determining the zone of influence (ZOI) for the thresholds in terms of total 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 modeled 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 24**), provides the exposure estimates for that animal species for the given bomb source.

BOMBEX is restricted to one location (BOMBEX Hotbox). In addition to other mitigation measures (see **Chapter 11**), 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 surveyed and determined to be free of marine mammals. The exercise will be suspended if any marine mammals enter the buffer area (5,100-yard [yd] [4,663-m] radius around target). The implementation of mitigation measures like these effectively reduce exposures in the ZOI.

GUNEX

There was no acoustic modeling done for M3A2 anti-swimmer concussion grenades due to the very low NEW (0.5-lb) associated with this ordnance. In a previous Biological Opinion, the NMFS calculated the potential range within which sea turtles may be affected ('safe range') based on an analysis from Young (1991). The calculations in Young (1991) make several assumptions to ensure that there is no impact to protected species within the 'safe range'. That is, the 'safe range' as adapted by Young (1991) is designed for zero injury to species within the calculated range. The 'safe range' for marine mammals for M3A2 grenades may be calculated as the cube-root of the NEW multiplied by a specific value depending on the size of the animal. For an adult delphinid, the 'safe range' is 114 yd; for a large whale (20 ft), this safe range is 86 yd. Young (1991) indicates a detonation depth of 200 ft (61 m), but M3A2 grenades in the UNDET Area E3 will detonate at a depth of no more than 9 m. Due to the significantly shallower detonation depth of M3A2 grenades in the UNDET Area E3, the safe range for marine mammals will be less than that calculated by Young (1991). For marine mammals at or very near the surface, the 'safe range' is a 100-yd (91-m) radius from the point of detonation. This range is extremely conservative because (1) the actual distance from the point of detonation at which a marine mammal would experience harm or harassment is much less than the 'safe range' and (2) the UNDET Area E3 is very small and will be monitored visually during operations.

Table 26 Estimated ZOIs (km^2) Used in Exposure Calculations for BOMBEX

Area	Ordnance	Estimated ZOI (km^2) @ 177 dB re: 1 μPa^2-s (multiple detonations only)				Estimated ZOI (km^2) @ 205 dB re: 1 μPa^2-s or 13 psi-msec				Estimated ZOI (km^2) @ 30.5 psi-msec			
		Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
BOMBEX Hotbox	MK-83 (415.8 lbs NEW)	98.93	115.93	161.39	173.27	4.84	4.84	4.84	4.98	<0.01	<0.01	<0.01	<0.01

**ZOIs for MK-83 bombs are modeled as multiple detonations (4 bombs dropped at same location). The ZOI at 177 dB re: 1 μPa^2-s for behavioral disruption was much larger than that for TTS, and therefore was used to calculate potential Level B exposures.*

6.3.5 Summary of Potential Exposures from Explosive Ordnance Use

Explosions that occur in the GOMEX Study Area are associated with training exercises that use HE ordnance, such as BOMBEX. Explosive ordnance use is limited to specific training areas. Within the GOMEX Study Area, explosive use occurs in the BOMBEX Hotbox. Underwater detonations that occur in the GOMEX Study Area are associated with training exercises that use smaller charges (less than 5 lbs), such as GUNEX. Underwater detonation use is limited to specific training areas. Within the GOMEX Study Area, underwater detonation use occurs in the UNDET Area E3.

BOMBEX

An explosive analysis was conducted to estimate the number of marine mammals that could be exposed to impacts from explosive ordnance use associated with BOMBEX. **Table 27** provides a summary of the explosive analysis results. Exposure estimates could not be calculated for several species (blue whale, fin whale, humpback whale, North Atlantic right whale, sei whale, and minke whale) because density data could not be calculated for the GOMEX Study Area due to the limited available data for these species; however, the likelihood of exposure for species not expected to occur in the GOMEX Study Area should be even lower than for the species with occurrence frequent enough for densities to be calculated. In addition to the low likelihood of exposure, the mitigation measures presented in **Chapter 11** will be implemented prior to release of ordnance. Lookouts will monitor the area before ordnance is used. Sperm whales will have high detections rates at the surface because of their large body size and pronounced blows; however, sperm whales are long, deep divers and may be submerged, and thus not visually detectable, for over an hour. It is likely that lookouts would detect Atlantic spotted dolphins, bottlenose dolphins, Clymene dolphins, pantropical spotted dolphins, Risso's dolphins, spinner dolphins and striped dolphins due to their gregarious nature and active surface behavior. Implementation of mitigation measures will reduce the likelihood of exposure and potential effects.

Table 27 Summary of Potential Exposures (per year) from Explosive Ordnance Use Associated with BOMBEX for Marine Mammals in the GOMEX Study Area

Species/Training Operation	Potential Exposures @ 177 dB re: 1 μPa^2-s (multiple detonations only)	Potential Exposures @ 205 dB re: 1 μPa^2-s or 13 psi-ms	Potential Exposures @ 30.5 psi-ms
Sperm whale			
BOMBEX training	0	0	0
Atlantic spotted dolphin			
BOMBEX training	3	0	0
Beaked whales			
BOMBEX training	0	0	0
Bottlenose dolphin			
BOMBEX training	13	0	0
Bryde's whale			
BOMBEX training	0	0	0
Clymene dolphin			
BOMBEX training	6	0	0
False killer whale			
BOMBEX training	0	0	0
Fraser's dolphin			
BOMBEX training	0	0	0
Killer whale			
BOMBEX training	0	0	0
Kogia spp.			
BOMBEX training	0	0	0
Melon-headed whale			
BOMBEX training	1	0	0
Pantropical spotted dolphin			
BOMBEX training	27	1	0
Pygmy killer whale			
BOMBEX training	0	0	0
Risso's dolphin			
BOMBEX training	2	0	0
Rough-toothed dolphin			
BOMBEX training	0	0	0
Short-finned pilot whale			
BOMBEX training	1	0	0
Spinner dolphin			
BOMBEX training	28	1	0
Striped dolphin			
BOMBEX training	8	0	0

GUNEX

There was no acoustic modeling done for M3A2 anti-swimmer concussion grenades due to the very low NEW (0.5-lb) associated with this ordnance. These detonations occur in very shallow water areas (<30 m) and detonate at a depth of no greater than 9 m. Although the majority of marine mammal species that may occur in the western Gulf of Mexico are associated with waters over the outer continental shelf, shelf break, slope, and abyssal plain, there is still the potential for many of them to occur in UNDET Area E3. There are also several species that are known and expected to occur in waters with depths of less than 30 m.

Visual mitigation (**Chapter 11**) will help to minimize potential impacts to marine mammals in UNDET Area E3. For marine mammals at or very near the surface, the 'safe range' is a 100-yd (91-m) radius from the point of detonation. Although visual mitigation may be limited at higher vessel speeds (i.e., observers on fast-moving boats may fail to detect marine mammals within the detonation area), visual mitigation will be effective in covering the 'safe range' because this range is extremely conservative. This 'safe range' is conservative because (1) the actual distance from the point of detonation at which a marine mammal would experience harm or harassment is much less than the 'safe range' and (2) the UNDET Area E3 is very small and will be monitored visually during operations. Therefore, we do not anticipate any exposures and are not requesting takes for any species.

6.3.6 Potential Effects of Exposures to Explosives

Effects from exposure to explosives vary depending on the level of exposure. Animals exposed to levels that constitute MMPA Level B may experience a behavioral disruption from the use of explosive ordnance. Behavioral responses can include shorter surfacings, shorter dives, fewer blows per surfacing, longer intervals between blows (breaths), ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (NRC, 2005); however, it is not known how these responses relate to significant effects (e.g., long-term effects or population consequences) (NRC, 2005). In addition, animals exposed to levels that constitute MMPA Level B may experience a TTS, which may result in a slight, recoverable loss of hearing sensitivity (DoN, 2001).

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

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

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

- Most exposures are within the non-injurious TTS or behavioral effects zones (MMPA Level B harassment).
- Although the numbers presented in **Table 27** represent estimated harassment and mortality under the 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 GOMEX Study Area would result in no exposures to the following marine mammal species:

- Sperm whale
- Beaked whale
- Bryde's whale
- False killer whale
- Fraser's dolphin
- Killer whale
- *Kogia* spp.
- Pygmy killer whale
- Rough-toothed dolphin

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

- Atlantic spotted dolphin
- Bottlenose dolphin
- Clymene dolphin
- Melon-headed whale
- Pantropical spotted dolphin
- Risso's dolphin
- Short-finned pilot whale
- Spinner 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.

- Pantropical spotted dolphin
- Spinner dolphin

No exposures resulting in mortality are predicted.

CHAPTER 8 IMPACTS ON SUBSISTENCE USE

Potential impacts resulting from the proposed action would be limited to individuals of marine mammal species located in the Gulf of Mexico 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 use identified in the MMPA § 101(a)(5)(A)(i).

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CHAPTER 9 IMPACTS TO MARINE MAMMAL HABITAT AND RESTORATION LIKELIHOOD

Sources from Atlantic Fleet training and operational 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 GOMEX Study Area.

9.1 Water Quality

The GOMEX EIS/OEIS analyzed the potential effects to water quality from expendable and training items associated with the various exercises taking place. Training and operational activities would introduce constituents into the water column. Based on the analysis, these constituents would be released in quantities and at rates that would not result in a violation of any water quality standard or criteria. Quantities of constituents that have potential to be released during military training and operational activities are so negligible that they will have no short or long term impact on water quality.

Equipment used by military organizations within the GOMEX Study Area, including ships and other marine vessels, aircraft, and other equipment, are also potential sources of constituents. 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 and operational activities in the GOMEX Study Area involving the use of high explosives are potential sources of water quality constituents. 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 training and operational activities in the GOMEX Study Area emanates from multiple sources including naval ship power plants, military aircraft, surface or airborne targets, bombs, small arms, and underwater detonations. Sound produced from military sources in the GOMEX Study Area is temporary and transitory. The sounds produced during training and operational activities can be widely dispersed or concentrated in small areas for varying periods. Any anthropogenic noise attributed to training and operational activities in the GOMEX Study Area would be temporary and the affected area would be expected to immediately return to the original state when these training and operational 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, 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.

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 (i.e., water quality, sound in the water column, and prey distribution and abundance). Modifications to the water column would be short-term in nature while modifications to the seafloor may be longer-term. Potential impacts to marine mammal habitat are not anticipated to alter the function of the habitat; therefore, will have little to no impact on marine mammal species.

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CHAPTER 11 MITIGATION MEASURES

Introduction

Effective training in the GOMEX Study Area dictates that ship, submarine, and aircraft participants utilize their sensors and exercise weapons to their optimum capabilities as required by the mission. As discussed in Chapter 6, the Navy recognizes that the proposed action has the potential to impact some marine mammals in the vicinity of training, This chapter describes the Navy's overall mitigation approach as well as specific mitigation measures that would be implemented to protect marine mammals and other resources during training activities. Some of these measures are generally applicable and others are designed to apply to certain geographic areas and/or for specific types of Navy training. Due to the nature of the proposed action analyzed in this LOA, mitigation measures for many elements of the action have been established through previous environmental analyses, consultation, and/or permitting processes.

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 those measures that would be taken *in addition to* standard naval operating procedures.

Approach

Mitigation of impacts is defined in the Council of Environmental Quality (CEQ) regulations (40 CFR 1508.20) to include avoidance, minimization, rectification, reduction/elimination over time, and compensation. Given the nature of the proposed action of the preferred alternative and potential impacts analyzed here, the Navy believes that a comprehensive approach to mitigation for the GOMEX Study Area 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 where feasible. Mitigation measures discussed later in this chapter involve avoidance of sensitive areas. Planning for training and operational activities takes into consideration 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. 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 the NMFS through the regulatory process. 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. These changes may include additional mitigation or monitoring measures beyond those addressed in this LOA.

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, OODs, junior OODs (JOODs), maritime patrol aircraft aircrews, and mine warfare (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 to qualify as a watchstander 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 in the most effective means to ensure quick and effective communication within the command structure to facilitate implementation of protective measures if marine species are spotted.
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 5° steps, pausing between steps for approximately 5 s 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 mid-frequency active sonar (MFAS), pedestal mounted “Big Eye” (20x110) 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 training and operational 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 (hr) after completion of training and operational activities. Additionally, the Navy will follow internal chain of command reporting procedures as promulgated through Navy instructions and orders.

11.3 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 training and operational activities being analyzed in this LOA request.

11.3.1 Air-to-Surface At-Sea Bombing Exercises (MK-83, 415.8-pound Net Explosive Weight)

This activity occurs in the BOMBEX Hotbox of the GOMEX 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 the 150 nm from shore-based facilities (the established flight distance restriction for F/A-18 jets during unit level training events).

1. BOMBEX using explosive ordnance will only be conducted in the BOMBEX Hotbox.
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 yd 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 BOMBEX using explosive 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.

11.3.2 Surface-to-Surface Gunnery Exercises (M3A2, 0.5-pound Net Explosive Weight)

1. Anti-swimmer concussion grenades used during GUNEX will only be deployed inside UNDET Area E3.
2. Navy lookouts will conduct surveys of the area prior to the use of explosive ordnance.

3. Observers will survey the estimated range of influence, a 100-yd (91-m) radius from detonation location, for marine mammals and sea turtles from all participating vessels during the entire operation.
4. GUNEX activities using explosive ordnance will occur during daylight hours only.
5. The exercises will be conducted only if the buffer zone is visible and clear of sighted marine mammals and sea turtles.

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CHAPTER 12 MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Based on the discussion in **Chapter 8**, 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 laws and regulations that apply to the marine environment. A number of monitoring plans are currently being developed for protected marine species (primarily marine mammals and sea turtles) as part of the environmental planning and regulatory compliance process associated with a variety of training actions and range complexes. The purpose of these monitoring plans is to assess the effects of training and operational activities on marine species. The primary focus of these monitoring plans will be on effects to individuals but data may also support investigation of potential population-level trends in marine species distribution, abundance, and habitat use in various range complexes and geographic locations where Navy training occurs.

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

The primary objectives of the ICMP are:

- To monitor Navy training exercises, particularly those involving active sonar and underwater detonation, for compliance with the terms and conditions that arise from 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 and operational activities. Specific training exercise plans will be focused on short-term monitoring and mitigation for individual training and operational 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 and operational 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 and operational 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 and operational activities. Both Navy personnel (watchstanders) and independent visual observers (Navy biologists and/or contractors) will be used from a variety of platforms (both Navy and third-party), as appropriate and logistically feasible.
- Passive Acoustic Monitoring – Autonomous Acoustic Recorders (moored buoys), High Frequency Acoustic Recording Packages (HARPs), sonobuoys, passive acoustic towed arrays, shipboard passive sonar, and Navy Instrumented Acoustic Ranges can provide data on presence/absence as well as localization, identification and tracking in some cases. Passive acoustic observations are particularly important for species that are difficult to detect visually or when conditions limit the effectiveness of visual monitoring. Instrumented Navy ranges present a unique opportunity to take advantage of infrastructure that would otherwise not be available for monitoring such a large area. The Marine Mammal Monitoring on Navy Ranges (M3R) program takes advantage of this opportunity and may support long-term data collection at specific fixed sites.
- Tagging is an important tool for examining the movement patterns and diving behavior of cetaceans. Sensors can be used that measure location, swim velocity, orientation, vocalizations, as well as record received sound levels. Tagging with sophisticated digital acoustic recording tags (D-tags) may also allow direct monitoring of behaviors not readily apparent to surface observers. D-tags have recently been deployed as part of a behavioral response study (BRS-07) initiated at the Atlantic Undersea Test and Evaluation Center (AUTEC) range in the Bahamas to begin identifying behavioral mechanisms related to anthropogenic sound exposure.
- Photo identification and tagging of animals – Photo identification contributes to understanding of movement patterns and stock structure which is important to determine how potential effects may relate to individual stocks or populations.
- Oceanographic and environmental data collection – Physical and environmental data related to habitat parameters is necessary for analyzing distribution patterns, developing predictive habitat and density models, and better understanding habitat use.

Because data concerning physiological and behavioral effects, as well as long-term modifications of habitat use are extremely limited at this time, geographically-fixed longitudinal monitoring sites may be incorporated to assess potential effects to marine mammals both at the individual and population level. 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 (NEFSC) to conduct a pilot study analysis and subsequently develop a survey and monitoring plan that prescribes the recommended approach for data collection including surveys (aerial/shipboard, frequency, spatial extent, etc.), passive acoustic monitoring, photo identification and data analysis (standard line-transect, spatial modeling, etc.) necessary to establish a fine-scale seasonal baseline of protected species distribution and abundance. This baseline study will provide the foundation for establishing a monitoring program designed to provide meaningful data on potential long term effects to marine species that may be chronically exposed to training and operational activities on the USWTR. The baseline data collection portion of the program began in June 2007 at the Onslow Bay alternative site and includes coordinated aerial, shipboard, and passive acoustic surveys as well as deployment of HARPs to supplement the traditional visual surveys. A similar program is currently being initiated at the Jacksonville preferred site.

In addition to the specific monitoring initiative outlined above, the ICMP framework proposes that the Navy will continue to collaborate with and incorporate data from studies of behavioral response, abundance, distribution, habitat utilization, etc. for species of concern using a variety of methods which may include visual surveys, passive and acoustic monitoring, radar and data logging tags (to record data on acoustics, diving and foraging behavior, and movements). This work will help to build the collective knowledge base on the geographic and temporal extent of key habitats and provide baseline information to account for natural perturbations such as El Niño or La Niña events as well as establish baseline information to determine the spatial and temporal extent of reactions to Navy operations, or indirect effects from changes in prey availability and distribution. Both the Office of Naval Research (ONR) and Chief of Naval Operations (CNO) are heavily involved in supporting a variety of ongoing research efforts (see **Chapter 14**), including the recent behavioral response study (BRS-07) conducted at AUTEC during the summer of 2007.

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CHAPTER 14 RESEARCH EFFORTS

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

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

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

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

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

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

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

At present the Navy-sponsored M3R program represents the most promising effort investigating the utility of passive acoustic monitoring specifically associated with Navy instrumented training ranges. The main objective of the M3R project is to develop a toolset for passive detection, localization, and tracking of marine mammals using existing Navy undersea range infrastructure. The project is funded by the ONR and CNO (N45) as an effort to provide an effective means of studying marine mammals in natural, open ocean environments.

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

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

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CHAPTER 16 LITERATURE CITED

Adams, L.D. and P.E. Rosel. 2006. Population differentiation of the Atlantic spotted dolphin (*Stenella frontalis*) in the western North Atlantic, including the Gulf of Mexico. Marine Biology 148:671-681.

Aguilar, A. 2002. Fin whale *Balaenoptera physalus*. Pages 435-438 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Allen, M.C., A.J. Read, J. Gaudet, and L.S. Sayigh. 2001. Fine-scale habitat selection of foraging bottlenose dolphins *Tursiops truncatus* near Clearwater, Florida. Marine Ecology Progress Series 222:253-264.

Alvarez-Alemán, A., J.A. Powell, and C.A. Beck. 2007. First report of a Florida manatee documented on the North Coast of Cuba. Sirenews 47:9-10.

Anderson, R.C. 2005. Observations of cetaceans in the Maldives, 1990-2002. Journal of Cetacean Research and Management 7(2):119-135.

Au, D.W.K. and W.L. Perryman. 1985. Dolphin habitats in the eastern tropical Pacific. Fishery Bulletin 83(4):623-643.

Baird, R.W. 2002. False killer whale *Pseudorca crassidens*. Pages 411-412 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Baird, R.W., K.M. Langelier, and P.J. Stacey. 1989. First records of false killer whales, *Pseudorca crassidens*, in Canada. Canadian Field-Naturalist 103:368-371.

Banick, K. and J.L. Borger. 2005. A mass-stranding event of rough-toothed dolphins (*Steno bredanensis*) in the Florida Keys (Florida, USA): II. Release and tracking. Page 24 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Barco, S., W. McLellan, J. Allen, R. Asmutis, R. Mallon-Day, E. Meagher, D.A. Pabst, J. Robbins, R. Seton, W.M. Swingle, M. Weinrich, and P. Clapham. 2002. Population identity of humpback whales (*Megaptera novaeangliae*) in the waters of the U.S. mid-Atlantic states. Journal of Cetacean Research and Management 4(2):135-141.

Barron, G.L. and T.A. Jefferson. 1993. First records of the melon-headed whale (*Peponocephala electra*) from the Gulf of Mexico. Southwestern Naturalist 38(1):82-85.

Baumgartner, M.F., C.A. Mayo, and R.D. Kenney. 2007. Enormous carnivores, microscopic food, and a restaurant that's hard to find. Pages 138-171 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Baumgartner, M.F. 1997. The distribution of Risso's dolphin (*Grampus griseus*) with respect to the physiography of the northern Gulf of Mexico. Marine Mammal Science 13(4):614-638.

Baumgartner, M.F., K.D. Mullin, L.N. May, and T.D. Leming. 2001. Cetacean habitats in the northern Gulf of Mexico. Fishery Bulletin 99:219-239.

Baumgartner, M.F., T.V.N. Cole, P.J. Clapham, and B.R. Mate. 2003. North Atlantic right whale habitat in the lower Bay of Fundy and on the SW Scotian Shelf during 1999-2001. Marine Ecology Progress Series 264:137-154.

Beardsley, R.C., A.W. Epstein, C. Chen, K.F. Wishner, M.C. Macaulay, and R.D. Kenney. 1996. Spatial variability in zooplankton abundance near feeding right whales in the Great South Channel. Deep-Sea Research 43(7-8):1601-1625.

Beck, C. 2006. Personal communication via email between Ms. Cathy Beck, U.S. Geological Survey, Sirenia Project, Gainsville, Florida, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 6 September, 27 October.

Beck, M.W., T.D. Marsh, S.E. Reisewitz, and M.L. Bortman. 2004. New tools for marine conservation: The leasing and ownership of submerged lands. Conservation Biology 18(5):1214-1223.

Bernard, H.J. and S.B. Reilly. 1999. Pilot whales *Globicephala* Lesson, 1828. Pages 245-279 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Bérubé, M., A. Aguilar, D. Dendanto, F. Larsen, G. Notarbartolo di Sciara, R. Sears, J. Sigurjónsson, J. Urban-R., and P. J. Palsbøll. 1998. Population genetic structure of North Atlantic, Mediterranean Sea and Sea of Cortez fin whales, *Balaenoptera physalus (*Linnaeus 1758): Analysis of mitochondrial and nuclear loci. Molecular Ecology **7**:585-599.

Best, P.B. and C.H. Lockyer. 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa in the 1960s. South African Journal of Marine Science 24:111-133.

Bjørge, A. 2002. How persistent are marine mammal habitats in an ocean of variability? Pages 63-91 in Evans, P.G.H. and J.A. Raga, eds. Marine mammals: Biology and conservation. New York, New York: Kluwer Academic/Plenum Publishers.

Bolaños, J. and A. Villarroel-Marin. 2003. Three new records of cetacean species for Venezuelan waters. Caribbean Journal of Science 39(2):230-232.

Bossart, G.D., R.A. Meisner, S.A. Rommel, S. Ghim, and A.B. Johnson. 2002. Pathological features of the Florida manatee cold stress syndrome. Aquatic Mammals 29(1):9-17.

Bowen, W.D., C.A. Beck, and D.A. Austin. 2002. Pinniped ecology. Pages 911-921 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Brown, D.H., D.K. Caldwell, and M.C. Caldwell. 1966. Observations on the behavior of wild and captive false killer whales, with notes on associated behavior of other genera of captive delphinids. Los Angeles County Museum Contributions in Science 95:1-32.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: Estimating abundance of biological populations. New York, New York: Oxford University Press.

Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas, eds. 2004. Advanced distance sampling. New York, New York: Oxford University Press.

Calambokidis, J., G.H. Steiger, D.K. Ellifrit, B.L. Troutman, and C.E. Bowlby. 2004. Distribution and abundance of humpback whales (*Megaptera novaeangliae*) and other marine mammals off the northern Washington coast. Fishery Bulletin 102:563-580.

Calambokidis, J., G.H. Steiger, J.M. Straley, L.M. Herman, S. Cerchio, D.R. Salden, J. Urbán R, J.K. Jacobsen, O. von Ziegesar, K.C. Balcomb, C.M. Gabriele, M.E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladrón de Guevara P., M. Yamaguchi, F. Sato, S.A. Mizroch, L. Schlender, K.

Rasmussen, J. Barlow, and T.J. Quinn II. 2001. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science 17(4):769-794.

Caldwell, D.K. and M.C. Caldwell. 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838): Dwarf sperm whale *Kogia simus* Owen, 1866. Pages 235-260 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. London, United Kingdom: Academic Press.

Cañadas, A., R. Sagarminaga, and S. García-Tiscar. 2002. Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. Deep-Sea Research I 49:2053-2073.

CETAP (Cetacean and Turtle Assessment Program). 1982. Characterization of marine mammals and turtles in the Mid- and North Atlantic areas of the U.S. Outer Continental Shelf. Contract AA551-CT8-48. Prepared for U.S. Bureau of Land Management, Washington, D.C. by Cetacean and Turtle Assessment Program, University of Rhode Island, Graduate School of Oceanography, Kingston, Rhode Island.

Clapham, P., S. Leatherwood, I. Szczepaniak, and R.L. Brownell, Jr. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science 13(3):368-394.

Clapham, P.J. and D.K. Mattila. 1990. Humpback whale songs as indicators of migration routes. Marine Mammal Science 6(2):155-160.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy, and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. Canadian Journal of Zoology 71:440-443.

Clapham, P.J. and J.G. Mead. 1999. *Megaptera novaeangliae*. Mammalian Species 604:1-9.

Clapham, P.J., S.B. Young, and R.L. Brownell, Jr. 1999. Baleen whales: Conservation issues and the status of the most endangered populations. Mammal Review 29(1):35-60.

Clark, C.W. 1995. Annex M. Matters arising out of the discussion of blue whales: Annex M1. Application of US Navy underwater hydrophone arrays for scientific research on whales. Reports of the International Whaling Commission 45:210-212.

Clark, C.W. and G.J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics (US Navy) 52(3).

Clarke, M.R. 1996. Cephalopods as prey. III. Cetaceans. Philosophical Transactions of the Royal Society of London, Series B 351:1053-1065.

Coles, P. 2001. Identifying beaked whales at sea in North Atlantic waters. Pages 81-90 in Cresswell, G. and D. Walker, eds. A report on the whales, dolphins and seabirds of the Bay of Biscay and English Channel. Shetland Islands, United Kingdom: Organisation Cetacea (ORCA).

Collum, L.A. and T.H. Fritts. 1985. Sperm whales (*Physeter catodon*) in the Gulf of Mexico. Southwestern Naturalist 30(1):101-104.

Corkeron, P.J. and R.C. Connor. 1999. Why do baleen whales migrate? Marine Mammal Science 15(4):1228-1245.

Courbis, S.S. and G.A.J. Worthy. 2003. Opportunistic carnivory by Florida manatees (*Trichechus manatus latirostris*). Aquatic Mammals 29(1):104-107.

Croll, D.A., B. Marinovic, S. Benson, F.P. Chavez, N. Black, R. Ternullo, and B.R. Tershy. 2005. From wind to whales: Trophic links in a coastal upwelling system. Marine Ecology Progress Series 289:117-130.

Cummings, W.C. 1985. Bryde's whale *Balaenoptera edeni* Anderson, 1878. Pages 137-154 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Dahlheim, M.E. and J.E. Heyning. 1999. Killer whale *Orcinus orca* (Linnaeus, 1758). Pages 281-322 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Davis, R.W. and G.S. Fargion, eds. 1996a. Distribution and abundance of cetaceans in the north-central and western Gulf of Mexico, Final report. Volume II: Technical report. OCS Study MMS 96-0027. New Orleans, Louisiana: Minerals Management Service.

Davis, R.W. and G.S. Fargion, eds. 1996b. Distribution and abundance of cetaceans in the north-central and western Gulf of Mexico, Final report. Volume III: Appendix C, part 1 of 2. OCS Study MMS 96-0028. New Orleans, Louisiana: Minerals Management Service.

Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. Marine Mammal Science 14(3):490-507.

Davis, R.W., J.G. Ortega-Ortiz, C.A. Ribic, W.E. Evans, D.C. Biggs, P.H. Ressler, R.B. Cady, R.R. Leben, K.D. Mullin, and B. Würsig. 2002. Cetacean habitat in the northern oceanic Gulf of Mexico. Deep-Sea Research I 49:121-142.

Davis, R.W., W.E. Evans, and B. Würsig, eds. 2000. Cetaceans, sea turtles and seabirds in the northern Gulf of Mexico: Distribution, abundance and habitat associations. Volume 2: Technical report. USGS/BRD/CR-1999-0006 and OCS Study MMS 2000-003. New Orleans, Louisiana: Minerals Management Service.

Dolar, M.L.L. 2002. Fraser's dolphin *Lagenodelphis hosei*. Pages 485-487 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Donovan, G. P. 1991. A review of IWC stock boundaries. Reports of the International Whaling Commission:39-68.

DoN (Department of the Navy). 1998. Shock testing the *SEAWOLF* submarine. Final environmental impact statement. North Charleston, South Carolina: Department of the Navy, Naval Facilities Engineering Command.

DoN (Department of the Navy). 2001. Final environmental impact statement: Shock trial of the *Winston H. Churchill* (DDG 81). [CD-ROM]. February.

DoN (Department of the Navy). 2007a. Marine resources assessment for the Gulf of Mexico. Contract number N62470-02-D-9997, CTO 0030. Norfolk, Virginia: Atlantic Division, Naval Facilities Engineering Command. Prepared by Geo-Marine, Inc., Plano, Texas.

DoN (Department of the Navy). 2007b. Navy OPAREA density estimates (NODE) for the GOMEX OPAREA. Final report. Contract number N62470-02-D-9997, CTO 0046. Norfolk, Virginia: Naval Facilities Engineering Command, Atlantic. Prepared by Geo-Marine, Inc., Hampton, Virginia.

Dudzinski, K.M. 1996. Communication and behavior in the Atlantic spotted dolphins (*Stenella frontalis*): Relationships between vocal and behavioral activities. Ph.D. diss., Texas A&M University.

Ersts, P.J. and H.C. Rosenbaum. 2003. Habitat preference reflects social organization of humpback whales (*Megaptera novaeangliae*) on a wintering ground. Journal of Zoology, London 260:337-345.

Esher, R.J., C. Levenson, and T.D. Drummer. 1992. Aerial surveys of endangered and protected species in the *Empress II* ship trial operating area in the Gulf of Mexico. Final report. NRL/MR/7174-92-7002. Stennis Space Center, Mississippi: Naval Research Laboratory.

Estes, J.A., M.T. Tinker, T.M. Williams, and D.F. Doak. 1998. Killer whale predation on sea otters linking oceanic and nearshore ecosystems. Science 282:473-476.

Etnoyer, P., D. Canny, B.R. Mate, L.E. Morgan, J.G. Ortega-Ortiz, and W.J. Nichols. 2006. Sea-surface temperature gradients across blue whale and sea turtle foraging trajectories off the Baja California Peninsula, Mexico. Deep-Sea Research II 53:340-358.

Ferguson, M.C., J. Barlow, S.B. Reilly, and T. Gerrodette. 2006. Predicting Cuvier's *(Ziphius cavirostris)* and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. Journal of Cetacean Research and Management 7(3):287-299.

Fertl, D., A.J. Schiro, and D. Peake. 1997. Coordinated feeding by Clymene dolphins (*Stenella clymene*) in the Gulf of Mexico. Aquatic Mammals 23(2):111-112.

Fertl, D., A.J. Schiro, G.T. Regan, C.A. Beck, N. Adimey, L. Price-May, A. Amos, G.A.J. Worthy, and R. Crossland. 2005. Manatee occurrence in the northern Gulf of Mexico, west of Florida. Gulf and Caribbean Research 17:69-94.

Fertl, D., T.A. Jefferson, I.B. Moreno, A.N. Zerbini, and K.D. Mullin. 2003. Distribution of the Clymene dolphin *Stenella clymene*. Mammal Review 33(3):253-271.

Finneran, J.J. and C.E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes. Technical report 1913 Prepared for Chief of Naval Operations by Research and Animal Care Branch, Biosciences Division, SSC San Diego, San Diego, California.

FMRI (Florida Marine Research Institute). 2007. FWC announces annual manatee synoptic survey numbers. Press Release. 6 February. St. Petersburg, Florida: Florida Fish and Wildlife Conservation Commission.

Forcada, J. 2002. Distribution. Pages 327-333 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Ford, J.K.B. 2002. Killer whale *Orcinus orca*. Pages 669-676 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee. 1983. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. FWS/OBS-82/65. Washington, D.C.: U.S. Fish and Wildlife Service.

Fulling, G.L. and D. Fertl. 2003. *Kogia* distribution in the northern Gulf of Mexico. Pages 13-16 in Odell, D.K. and N.B. Barros, eds. Abstracts, Workshop on the Biology of Kogia held on 13 December 2003, Greensboro, North Carolina, USA.

Fulling, G.L., K.D. Mullin, and C.W. Hubard. 2003. Abundance and distribution of cetaceans in outer continental shelf waters of the U.S. Gulf of Mexico. Fishery Bulletin 101:923-932.

Gambell, R. 1985. Fin whale *Balaenoptera physalus (*Linneaus, 1758). Pages 171-192 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Gannier, A. 2002. Cetaceans of the Marquesas Islands (French Polynesia): Distribution and relative abundance as obtained from a small boat dedicated survey. Aquatic Mammals 28(2):198-210.

Gannier, A. and K.L. West. 2005. Distribution of the rough-toothed dolphin (*Steno bredanensis*) around the Windward Islands (French Polynesia). Pacific Science 59(1):17-24.

Garrison, L.P. 2007. The big picture: Modeling right whales in space and time. Pages 460-487 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Gaskin, D.E. 1982. The ecology of whales and dolphins. Portsmouth, New Hampshire: Heinemann.

Gormley, G. 1990. Orcas of the Gulf. San Francisco, California: Sierra Club Books.

Green, G.A., J.J. Brueggeman, R.A. Grotefendt, C.E. Bowlby, M.L. Bonnell, and K.C. Balcomb III. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pages 1-1 to 1-100 in Brueggeman, J.J., ed. Oregon and Washington marine mammal and seabird surveys. OCS Study MMS 91-0093. Los Angeles, California: Minerals Management Service.

Gregr, E., J. Calambokidis, L. Convey, J. Ford, I. Perry, L. Spaven, and M. Zacharias. 2005. Proposed recovery strategy for blue whales (*Balaenoptera musculus*), fin whales (*B. physalus*) and sei whales (*B. borealis*) in Pacific Canadian waters. Draft. Nanaimo, British Columbia: Fisheries and Oceans Canada.

Gregr, E.J. and A.W. Trites. 2001. Predictions of critical habitat for five whale species in the waters of coastal British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 58:1265-1285.

Griffin, R.B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Marine Mammal Science 15(1):33-51.

Griffin, R.B. and N.J. Griffin. 2003. Distribution, habitat partitioning, and abundance of Atlantic spotted dolphins, bottlenose dolphins, and loggerhead sea turtles on the eastern Gulf of Mexico continental shelf. Gulf of Mexico Science 2003(1):23-34.

Griffin, R.B. and N.J. Griffin. 2004. Temporal variation in Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphin (*Tursiops truncatus*) densities on the west Florida continental shelf. Aquatic Mammals 30(3):380-390.

Guinta, P. 2006. Whale's tail tells a tale. Accessed 16 November 2006. http://staugustine.com/stories/111606/news_4214734.shtml.

Hain, J.H.W., M.A.M. Hyman, R.D. Kenney, and H.E. Winn. 1985. The role of cetaceans in the shelf-edge region of the northeastern United States. Marine Fisheries Review 47(1):13-17.

Hain, J.H.W., M.J. Ratnaswamy, R.D. Kenney, and H.E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Reports of the International Whaling Commission 42:653-669.

Hamazaki, T. 2002. Spatiotemporal prediction models of cetacean habitats in the mid-western North Atlantic Ocean (from Cape Hatteras, North Carolina, U.S.A. to Nova Scotia, Canada). Marine Mammal Science 18(4):920-937.

Hamilton, P.K. and C.A. Mayo. 1990. Population characteristics of right whales (*Eubalaena glacialis*) observed in Cape Cod and Massachusetts Bays, 1978-1986. Reports of the International Whaling Commission (Special Issue 12):203-208.

Heithaus, M.R. and L.M. Dill. 2002. Food availability and tiger shark predation risk influence bottlenose dolphin habitat use. Ecology 83(2):480-491.

Hennessy, M.B., J.P. Heybach, J. Vernikos, and S. Levine. 1979. Plasma corticosterone concentrations sensitively reflect levels of stimulus intensity in the rat. Physiology and Behavior 22:821-825.

Herzing, D.L. 1997. The life history of free-ranging Atlantic spotted dolphins (*Stenella frontalis*): Age classes, color phases, and female reproduction. Marine Mammal Science 13(4):576-595.

Heyning, J.E. 1989. Cuvier's beaked whale - *Ziphius cavirostris* (G. Cuvier, 1823). Pages 289-308 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. San Diego, California: Academic Press.

Heyning, J.E. and J.G. Mead. 1996. Suction feeding in beaked whales: Morphological and observational evidence. Los Angeles County Museum Contributions in Science 464:1-12.

Horwood, J. 1987. The sei whale: Population biology, ecology, & management. New York, New York: Croom Helm in association with Methuen, Inc.

Horwood, J. 1990. Biology and exploitation of the minke whale. Boca Raton, Florida: CRC Press.

Hui, C.A. 1985. Undersea topography and the comparative distributions of two pelagic cetaceans. Fishery Bulletin 83(3):472-475.

IWC (International Whaling Commission). 2001. Report of the Workshop on the Comprehensive Assessment of Right Whales: A worldwide comparison. Journal of Cetacean Research and Management (Special Issue 2):1-60.

Irvine, A.B. 1983. Manatee metabolism and its influence on distribution in Florida. Biological Conservation 25:315-334.

Ivashin, M.V. and L.M. Votrogov. 1981. Minke whales, *Balaenoptera acutorostrata davidsoni*, inhabiting inshore waters of the Chukotka coast. Reports of the International Whaling Commission 31:231.

Jaquet, N. and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. Marine Ecology Progress Series 135:1-9.

Jaquet, N., D. Gendron, and A. Coakes. 2002. Movements and site fidelity of sperm whales in the Gulf of California, Mexico. Pages 78-79 in Abstracts, Sixteenth Annual Conference of the European Cetacean Society. 7-11 April 2002. Liege, Belgium.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide. Marine mammals of the world. Rome, Italy: Food and Agriculture Organization of the United Nations.

Jefferson, T.A. 1996. Estimates of abundance of cetaceans in offshore waters of the northwestern Gulf of Mexico, 1992-1993. Southwestern Naturalist 41(3):279-287.

Jefferson, T.A. 2002a. Personal communication via in-house meeting and e-mail between Dr. Thomas A. Jefferson, National Marine Fisheries Service-Southwest Fisheries Science Center, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 8 April, 27 August, 2 September, and 17 September.

Jefferson, T.A. 2006. Personal communication via email between Dr. Thomas A. Jefferson, National Marine Fisheries Service, La Jolla, California, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 25 August and 25 October.

Jefferson, T.A. 2008. Personal communication via in-house meeting between Dr. Thomas A. Jefferson, National Marine Fisheries Service-Southwest Fisheries Science Center, and Ms. Amy Whitt, Geo-Marine, Inc., Plano, Texas.

Jefferson, T.A. and A.J. Schiro. 1997. Distribution of cetaceans in the offshore Gulf of Mexico. Mammal Review 27(1):27-50.

Jefferson, T.A. and N.B. Barros. 1997. *Peponocephala electra*. Mammalian Species 553:1-6.

Jefferson, T.A. and S. Leatherwood. 1994. *Lagenodelphis hosei*. Mammalian Species 470:1-5.

Jefferson, T.A., D.K. Odell, and K.T. Prunier. 1995. Notes on the biology of the Clymene dolphin (*Stenella clymene*) in the northern Gulf of Mexico. Marine Mammal Science 11(4):564-573.

Jefferson, T.A., P.J. Stacey, and R.W. Baird. 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Review 21(4):151-180.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine mammals of the world: A comprehensive guide to their identification. San Diego, California: Academic Press.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide. Marine mammals of the world. Rome, Italy: Food and Agriculture Organization of the United Nations.

Jensen, A.S. and G.K. Silber. 2003. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25:1-37.

Jochens, A., D. Biggs, D. Engelhaupt, J. Gordon, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, J. Wormuth, and B. Würsig. 2006. Sperm whale seismic study in the Gulf of Mexico. Summary report, 2002-2004. OCS Study MMS 2006-034. New Orleans, Louisiana: Minerals Management Service.

Johnston, D.W., L.H. Thorne, and A.J. Read. 2005. Fin whales *Balaenoptera physalus* and minke whales *Balaenoptera acutorostrata* exploit a tidally driven island wake ecosystem in the Bay of Fundy. Marine Ecology Progress Series 305:287-295.

Katona, S.K. and J.A. Beard. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean. Reports of the International Whaling Commission (Special Issue 12):295-305.

Katona, S.K., J.A. Beard, P.E. Girton, and F. Wenzel. 1988. Killer whales (*Orcinus orca*) from the Bay of Fundy to the Equator, including the Gulf of Mexico. Rit Fiskideildar (Journal of the Marine Research Institute Reykjavik) XI:205-224.

Keevin, T.M. and G.L. Hempen. 1997. The environmental effects of underwater explosions with methods to mitigate impacts. St. Louis, Missouri: U.S. Army Corps of Engineers.

Keller, C.A., L.I. Ward-Geiger, W.B. Brooks, C.K. Slay, C.R. Taylor, and B.J. Zoodsma. 2006. North Atlantic right whale distribution in relation to sea-surface temperature in the southeastern United States calving grounds. Marine Mammal Science 22(2):426-445.

Kenney, R.D. and H.E. Winn. 1987. Cetacean biomass densities near submarine canyons compared to adjacent shelf/slope areas. Continental Shelf Research 7:107-114.

Kenney, R.D., G.P. Scott, T.J. Thompson, and H.E. Winn. 1997. Estimates of prey consumption and trophic impacts of cetaceans in the USA Northeast Continental Shelf ecosystem. Journal of Northwest Atlantic Fishery Science 22:155-171.

Kenney, R.D., H.E. Winn, and M.C. Macaulay. 1995. Cetaceans in the Great South Channel, 1979-1989: Right whale (*Eubalaena glacialis*). Continental Shelf Research 15:385-414.

Kenney, R.D., M.A.M. Hyman, and H.E. Winn. 1985. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States outer continental shelf. NOAA Technical Memorandum NMFS-F/NEC-41:1-99.

Kenney, R.D., P.M. Payne, D.W. Heinemann, and H.E. Winn. 1996. Shifts in northeast shelf cetacean distributions relative to trends in Gulf of Maine/Georges Bank finfish abundance. Pages 169-196 in Sherman, K., N.A. Jaworski, and T.J. Smayda, eds. The Northeast Shelf Ecosystem: Assessment, sustainability, and management. Cambridge, Massachusetts: Blackwell Science.

Ketten, D.R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NMFS-SWFSC-256:1-74.

Krahn, M.M., M.J. Ford, W.F. Perrin, P.R. Wade, R.P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples. 2004. 2004 status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-62:1-73.

Kraus, S.D., M.W. Brown, H. Caswell, C.W. Clark, M. Fujiwara, P.K. Hamilton, R.D. Kenney, A.R. Knowlton, S. Landry, C.A. Mayo, W.A. McLellan, M.J. Moore, D.P. Nowacek, D.A. Pabst, A.J. Read, and R.M. Rolland. 2005. North Atlantic right whales in crisis. Science 309:561-562.

Kraus, S.D., R.D. Kenney, A.R. Knowlton, and J.N. Ciano. 1993. Endangered right whales of the southwestern North Atlantic. OCS Study MMS 93-0024. Herndon, Virginia: Minerals Management Service.

Kruse, S., D.K. Caldwell, and M.C. Caldwell. 1999. Risso's dolphin *Grampus griseus* (G. Cuvier, 1812). Pages 183-212 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Laerm, J., F. Wenzel, J.E. Craddock, D. Weinand, J. McGurk, M.J. Harris, G.A. Early, J.G. Mead, C.W. Potter, and N.B. Barros. 1997. New prey species for northwestern Atlantic humpback whales. Marine Mammal Science 13(4):705-711.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17(1):35-75.

Leatherwood, S. and R.R. Reeves. 1983. The Sierra Club handbook of whales and dolphins. San Francisco, California: Sierra Club Books.

Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: A guide to their identification. NOAA Technical Report NMFS CIRC-396:1-176.

Leatherwood, S., T.A. Jefferson, J.C. Norris, W.E. Stevens, L.J. Hansen, and K.D. Mullin. 1993. Occurrence and sounds of Fraser's dolphins (*Lagenodelphis hosei*) in the Gulf of Mexico. Texas Journal of Science 45(4):349-354.

Lefebvre, L.W., J.P. Reid, W.J. Kenworthy, and J.A. Powell. 2000. Characterizing Manatee habitat use and seagrass grazing in Florida and Puerto Rico: Implications for conservation and management. Pacific Conservation Biology 5:289-298.

Lefebvre, L.W., M. Marmontel, J.P. Reid, G.B. Rathbun, and D.P. Domning. 2001. Status and biogeography of the West Indian manatee. Pages 425-474 in Woods, C.A. and F.E. Sergile, eds. Biogeography of the West Indies: Patterns and perspectives, 2d ed. Boca Raton, Florida: CRC Press.

Lettevall, E., C. Richter, N. Jaquet, E. Slooten, S. Dawson, H. Whitehead, J. Christal, and P. McCall Howard. 2002. Social structure and residency in aggregations of male sperm whales. Canadian Journal of Zoology 80:1189-1196.

Macaulay, M.C., K.F. Wishner, and K.L. Daly. 1995. Acoustic scattering from zooplankton and micronekton in relation to a whale feeding site near Georges Bank and Cape Cod. Continental Shelf Research 15(4/5):509-537.

MacLeod, C., W.F. Perrin, R. Pitman, J. Barlow, L. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D.L. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). Journal of Cetacean Research and Management 7(3):271-286.

MacLeod, C.D. and G. Mitchell. 2006. Key areas for beaked whales worldwide. Journal of Cetacean Research and Management 7(3):309-322.

MacLeod, C.D. and J.S. Herman. 2004. Development of tusks and associated structures in *Mesoplodon bidens* (Cetaceae, Mammalia). Mammalia 68(2-3):175-184.

MacLeod, C.D., M.B. Santos, and G.J. Pierce. 2003. Review of data on diets of beaked whales: Evidence of niche separation and geographic segregation. Journal of the Marine Biological Association of the United Kingdom 83:651-665.

MacLeod, C.D., N. Hauser, and H. Peckham. 2004. Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. Journal of the Marine Biological Association of the United Kingdom 84:469-474.

Manire, C.A. and R.S. Wells. 2005. Rough-toothed dolphin rehabilitation and post-release monitoring. Mote Marine Laboratory Technical Report No. 1047. Sarasota, Florida: Mote Marine Laboratory.

MMC (Marine Mammal Commission). 2003. Annual report to Congress 2002. Bethesda, Maryland: Marine Mammal Commission.

Mate, B. 2003. Seasonal distribution and habitat characterization of sperm whales in the Gulf of Mexico from Argos satellite-monitored radio tracking. Page 105 in Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals. 14-19 December 2003. Greensboro, North Carolina.

McAlpine, D.F. 2002. Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. Pages 1007-1009 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

McAlpine, D.F., L.D. Murison, and E.P. Hoberg. 1997. New records for the pygmy sperm whale, *Kogia breviceps* (Physeteridae) from Atlantic Canada with notes on diet and parasites. Marine Mammal Science 13(4):701-704.

McEwen, B.S. and J.C. Wingfield. 2003. The concept of allostasis in biology and medicine. Hormones and Behavior 43:2-15.

Mead, J.G. 1977. Records of sei and Bryde's whales from the Atlantic coast of the United States, the Gulf of Mexico, and the Caribbean. Reports of the International Whaling Commission (Special Issue 1):113-116.

Mead, J.G. 1989. Beaked whales of the genus-*Mesoplodon*. Pages 349-430 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. London, England: Academic Press.

Measures, L., B. Roberge, and R. Sears. 2004. Stranding of a Pygmy Sperm Whale, *Kogia breviceps,* in the Northern Gulf of St. Lawrence, Canada. Canadian Field-Naturalist 118(4):495-498.

Mellinger, D.K., C.D. Carson, and C.W. Clark. 2000. Characteristics of minke whale (*Balaenoptera acutorostrata*) pulse trains recorded near Puerto Rico. Marine Mammal Science 16(4):739-756.

Mendes, S., W. Turrell, T. Lütkebohle, and P. Thompson. 2002. Influence of the tidal cycle and a tidal intrusion front on the spatio-temporal distribution of coastal bottlenose dolphins. Marine Ecology Progress Series 239:221-229.

Mignucci-Giannoni, A.A. 1998. Zoogeography of cetaceans off Puerto Rico and the Virgin Islands. Caribbean Journal of Science 34(3-4):173-190.

Mignucci-Giannoni, A.A., S.L. Swartz, A. Martínez, C.M. Burks, and W.A. Watkins. 2003. First records of the pantropical spotted dolphin (*Stenella attenuata*) for the Puerto Rican Bank, with a review of the species in the Caribbean. Caribbean Journal of Science 39(3):381-392.

Mills, L.R. and K.R. Rademacher. 1996. Atlantic spotted dolphins (*Stenella frontalis*) in the Gulf of Mexico. Gulf of Mexico Science 1996(2):114-120.

Mitchell, E. and D.G. Chapman. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). Reports of the International Whaling Commission (Special Issue 1):117-120.

Mitchell, E. and V.M. Kozicki. 1975. Supplementary information on minke whale (*Balaenoptera acutorostrata*) from Newfoundland fishery. Journal of the Fisheries Research Board of Canada 32(7):985-994.

Mitchell, E. and R.R. Reeves. 1988. Records of killer whales in the western North Atlantic, with emphasis on eastern Canadian waters. Rit Fiskideildar (Journal of the Marine Research Institute Reykjavik) 11:161-193.

Mitchell, E.D., Jr. 1991. Winter records of the minke whale (*Balaenoptera acutorostrata acutorostrata* Lacépède 1804) in the southern North Atlantic. Reports of the International Whaling Commission 41:455-457.

MMS (Minerals Management Service). 2001. Gulf of Mexico OCS oil and gas lease sale 181: Eastern Planning Area. Final environmental impact statement. OCS EIS/EA MMS 2002-051. New Orleans, Louisiana: Minerals Management Service.

Miyazaki, N. and W.F. Perrin. 1994. Rough-toothed dolphin-*Steno bredanensis* (Lesson, 1828). Pages 1-21 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Miyazaki, N., T. Kasuya, and M. Nishiwaki. 1974. Distribution and migration of two species of *Stenella* in the Pacific coast of Japan. Scientific Reports of the Whales Research Institute 26:227-243.

Moore, J.C. 1951a. The status of the manatee in the Everglades National Park, with notes on its natural history. Journal of Mammalogy 32(1):22-36.

Moore, J.C. 1951b. The range of the Florida manatee. Quarterly Journal of the Florida Academy of Sciences 14(1):1-19.

Moore, S.E., W.A. Watkins, M.A. Daher, J.R. Davies, and M.E. Dahlheim. 2002. Blue whale habitat associations in the Northwest Pacific: Analysis of remotely-sensed data using a Geographic Information System. Oceanography 15(3):20-25.

Moreno, I.B., A.N. Zerbini, D. Danilewicz, M.C. de Oliveira Santos, P.C. Simões-Lopes, J. Lailson-Brito, Jr., and A.F. Azevedo. 2005. Distribution and habitat characteristics of dolphins of the genus *Stenella* (Cetacea: Delphinidae) in the southwest Atlantic Ocean. Marine Ecology Progress Series 300:229-240.

Mullin, K.D. and G.L. Fulling. 2003. Abundance of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998. Fishery Bulletin 101:603-613.

Mullin, K.D. and G.L. Fulling. 2004. Abundance of cetaceans in the oceanic northern Gulf of Mexico, 1996-2001. Marine Mammal Science 20(4):787-807.

Mullin, K.D. and L.J. Hansen. 1999. Marine mammals of the northern Gulf of Mexico. Pages 269-277 in Kumpf, H., K. Steidinger, and K. Sherman, eds. The Gulf of Mexico large marine ecosystem: Assessment, sustainability, and management. Malden, Massachusetts: Blackwell Science.

Mullin, K.D., T.A. Jefferson, L.J. Hansen, and W. Hoggard. 1994a. First sightings of melon-headed whales (*Peponocephala electra*) in the Gulf of Mexico. Marine Mammal Science 10(3):342-348.

Mullin, K.D., W. Hoggard, and L.J. Hansen. 2004. Abundance and seasonal occurrence of cetaceans in outer continental shelf and slope waters of the north-central and northwestern Gulf of Mexico. Gulf of Mexico Science 2004(1):62-73.

Mullin, K.D., W. Hoggard, C.L. Roden, R.R. Lohoefener, C.M. Rogers, and B. Taggart. 1994b. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. Fishery Bulletin 92:773-786.

Muñoz-Hincapié, M.F., D.M. Mora-Pinto, D.M. Palacios, E.R. Secchi, and A.A. Mignucci-Giannoni. 1998. First osteological record of the dwarf sperm whale in Colombia, with notes on the zoogeography of *Kogia* in South America. Revista Academia Colombiana de Ciencias 22(84):433-444.

Murison, L.D. and D.E. Gaskin. 1989. The distribution of right whales and zooplankton in the Bay of Fundy, Canada. Canadian Journal of Zoology 67:1411-1420.

Murphy, M.A. 1995. Occurrence and group characteristics of minke whales, *Balaenoptera acutorostrata*, in Massachusetts Bay and Cape Cod Bay. Fishery Bulletin 93:577-585.

Nemoto, T. and A. Kawamura. 1977. Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. Reports of the International Whaling Commission (Special Issue 1):80-87.

Neuhauser, H., ed. 2007. Right Whale News. 14(4).

NMFS (National Marine Fisheries Service). 1991. Recovery plan for the humpback whale (*Megaptera novaeangliae*). Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1994. Designated critical habitat; northern right whale. Federal Register 59(106):28793-28808.

NMFS (National Marine Fisheries Service). 1998a. Draft recovery plan for the fin whale *Balaenoptera physalus* and sei whale *Balaenoptera borealis*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 1998b. Recovery plan for the blue whale (*Balaenoptera musculus*). Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2001. Taking marine mammals incidental to naval activities. Federal Register 66(87):22450-22467.

NMFS (National Marine Fisheries Service). 2005a. Recovery plan for the North Atlantic right whale (*Eubalaena glacialis*). Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2005b. Taking and importing marine mammals; taking marine mammals incidental to conducting the Precision Strike Weapon (PSW) testing and training by Eglin Air Force Base in the Gulf of Mexico--Notice of issuance of an incidental harassment authorization. Federal Register 70(160):48575-48691.

NMFS (National Marine Fisheries Service). 2006a. Draft recovery plan for the sperm whale (*Physeter macrocephalus)*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2006b. Draft recovery plan for the fin whale (*Balaenoptera physalus)*. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2006c. Review of the status of the right whales in the North Atlantic and North Pacific oceans. Prepared by the National Marine Fisheries Service.

NMFS (National Marine Fisheries Service). 2007a. Endangered and threatened species; intiation of 5-year reviews for fin, sperm and southern right whales. Federal Register 72(13):2649-2650.

NMFS (National Marine Fisheries Service). 2007b. Endangered and threatened species: Initiation of a 5-year review for fin, sperm, and southern right whales. Federal Register 72(13):2649-2650.

NMFS-SWFSC (National Marine Fisheries Service-Southwest Fisheries Science Center). 2007. Final cruise instructions, NOAA Ship *McArthur II*, M2-07-08, SWFSC Cruise Number 1634: Stenella Abundance Research Project Line Transect and Ecosystem (STAR-LITE) Cruise 2007 – The project is a cetacean and ecosystem assessment survey with one vessel. La Jolla, California: National Marine Fisheries Service.

NOAA (National Oceanic and Atmospheric Administration) and FWC (Florida Fish and Wildlife Conservation Commission). 2006. NOAA and FWC confirm right whales off Florida Gulf Coast. Press Release. St. Petersburg, Florida: Florida Fish and Wildlife Conservation Commission - 28 February.

Notarbartolo-di-Sciara, G., M. Zanardelli, M. Jahoda, S. Panigada, and S. Airoldi. 2003. The fin whale *Balaenoptera physalus* (L. 1758) in the Mediterranean Sea. Mammal Review 33(2):105-150.

Nowacek, D.P., M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society B: Biological Sciences 271:227-231.

NRC (National Research Council). 2003. Ocean noise and marine mammals. Washington, D.C.: National Academies Press.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects. Washington, D.C.: National Academies Press.

Odell, D.K. and K.M. McClune. 1999. False killer whale *Pseudorca crassidens* (Owen, 1846). Pages 213-243 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

O'Keefe, D.J. and G.A. Young. 1984. Handbook on the environmental effects of underwater explosions. NSWC TR 83-240 Dahlgren, Virginia: Naval Surface Weapons Center.

Olson, P.A. and S.B. Reilly. 2002. Pilot whales *Globicephala melas* and *G. macrorhynchus*. Pages 898-903 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Ortega-Ortiz, J.G., B. Mate, and D. Engelhaupt. 2005. Habitat characterization of satellite-tracked sperm whales in the Gulf of Mexico. Page 214 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

O'Sullivan, S. and K.D. Mullin. 1997. Killer whales (*Orcinus orca*) in the northern Gulf of Mexico. Marine Mammal Science 13:141-147.

Payne, P.M. and D.W. Heinemann. 1993. The distribution of pilot whales (*Globicephala* spp.) in shelf/shelf-edge and slope waters of the Northeastern United States, 1978-1988. Reports of the International Whaling Commission (Special Issue 14):51-68.

Payne, P.M., D.N. Wiley, S.B. Young, S. Pittman, P.J. Clapham, and J.W. Jossi. 1990b. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in selected prey. Fishery Bulletin 88:687-696.

Payne, P.M., D.W. Heinemann, and L.A. Selzer. 1990a. A distributional assessment of cetaceans in shelf/shelf-edge and adjacent slope waters of the northeastern United States based on aerial and shipboard surveys, 1978-1988. Woods Hole, Massachusetts: National Marine Fisheries Service, Northeast Fisheries Science Center.

Payne, P.M., J.R. Nicolas, L. O'Brien, and K.D. Powers. 1986. The distribution of the humpback whale, *Megaptera novaeangliae*, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, *Ammodytes americanus*. Fishery Bulletin 84:271-277.

Peddemors, V.M. 1999. Delphinids of southern Africa: A review of their distribution, status and life history. Journal of Cetacean Research and Management 1(2):157-165.

Perrin, W.F. 2002. *Stenella frontalis*. Mammalian Species 702:1-6.

Perrin, W.F. and A.A. Hohn. 1994. Pantropical spotted dolphin-*Stenella attenuata*. Pages 71-98 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Perrin, W.F. and J.G. Mead. 1994. Clymene dolphin-*Stenella clymene* (Gray, 1846). Pages 161-171 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Perrin, W.F. and J.W. Gilpatrick, Jr. 1994. Spinner dolphin--*Stenella longirostris* (Gray, 1828). Pages 99-128 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Perrin, W.F., D.K. Caldwell, and M.C. Caldwell. 1994a. Atlantic spotted dolphin-*Stenella frontalis* (G. Cuvier, 1829). Pages 173-190 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Perrin, W.F., C.E. Wilson, and F.I. Archer II. 1994b. Striped dolphin--*Stenella coeruleoalba* (Meyen, 1833). Pages 129-159 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Perrin, W.F., E.D. Mitchell, J.G. Mead, D.K. Caldwell, and P.J.H. van Bree. 1981. *Stenella clymene*, a rediscovered tropical dolphin of the Atlantic. Journal of Mammalogy 62(3):583-598.

Perrin, W.F., E.D. Mitchell, J.G. Mead, D.K. Caldwell, M.C. Caldwell, P.J.H. van Bree, and W.H. Dawbin. 1987. Revision of the spotted dolphins, *Stenella* spp. Marine Mammal Science 3(2):99-170.

Perrin, W.F., M.L.L. Dolar, and D. Robineau. 1999. Spinner dolphins (*Stenella longirostris*) of the western Pacific and southeast Asia: Pelagic and shallow-water forms. Marine Mammal Science 15(4):1029-1053.

Perrin, W.F., S. Leatherwood, and A. Collett. 1994c. Fraser's dolphin-*Lagenodelphis hosei* (Fraser, 1956). Pages 225-240 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1):1-74.

Perryman, W.L. 2002. Melon-headed whale *Peponocephala electra*. Pages 733-735 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Perryman, W.L. and T.C. Foster. 1980. Preliminary report on predation by small whales, mainly the false killer whale, *Pseudorca crassidens*, on dolphins (*Stenella* spp. and *Delphinus delphis*) in the eastern tropical Pacific. NMFS-SWFSC Administrative Report LJ-80-05:1-9.

Perryman, W.L., D.W.K. Au, S. Leatherwood, and T.A. Jefferson. 1994. Melon-headed whale--*Peponocephala electra* (Gray, 1846). Pages 363-386 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Pitchford, T. 2006. Personal communication via e-mail between Mr. Tom Pitchford, Florida Marine Research Institute, St. Petersburg, Florida, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 28 August.

Pitman, R.L. 2002. Mesoplodont whales *Mesoplodon* spp. Pages 738-742 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Pitman, R.L. and P.H. Dutton. 2004. Killer whale predation on a leatherback turtle in the Northeast Pacific. Pacific Science 58(3):497-498.

Pitman, R.L. and C. Stinchcomb. 2002. Rough-toothed dolphins (*Steno bredanensis*) as predators of mahimahi (*Coryphaena hippurus*). Pacific Science 56(4):447-450.

Pivorunas, A. 1979. The feeding mechanisms of baleen whales. American Scientist 67:432-440.

Plön, S. 2004. The status and natural history of pygmy (*Kogia breviceps*) and dwarf (*K. sima*) sperm whales off southern Africa. Ph.D. diss., Rhodes University.

Plön, S. and R. Bernard. 1999. The fast lane revisited: Life history strategies of *Kogia* from southern Africa. Page 149 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 1999. Wailea, Hawaii.

Ramp, C., M. Berube, W. Hagen, and R. Sears. 2006. Survival of adult blue whales *Balaenoptera musculus* in the Gulf of St. Lawrence, Canada. Marine Ecology Progress Series 319:287-295.

Reeder, D.M. and K.M. Kramer. 2005. Stress in free-ranging mammals: Integrating physiology, ecology and natural history. Journal of Mammalogy 86(2):225-235.

Reeves, R.R., S. Leatherwood, G.S. Stone, and L.G. Eldredge. 1999. Marine mammals in the area served by the South Pacific Regional Environment Programme. Apia, Samoa: South Pacific Regional Environment Programme.

Reeves, R.R., T.D. Smith, and E.A. Josephson. 2007. Near-annihilation of a species: Right whaling in the North Atlantic. Pages 39-74 in Kraus, S.D. and R.M. Rolland, eds. The urban whale: North Atlantic right whales at the crossroads. Cambridge, Massachusetts: Harvard University Press.

Reeves, R.R., B.S. Stewart, P.J. Clapham, and J.A. Powell. 2002. National Audubon Society guide to marine mammals of the world. New York, New York: Alfred A. Knopf, Inc.

Reich, K.J. and G.A.J. Worthy. 2006. An isotopic assessment of the feeding habits of free-ranging manatees. Marine Ecology Progress Series 322:303-309.

Reid, J. 2000. Florida manatee now resident in the Bahamas. SireNews 33:6.

Reilly, S.B. and V.G. Thayer. 1990. Blue whale (*Balaenoptera musculus*) distribution in the eastern tropical Pacific. Marine Mammal Science 6(4):265-277.

Reynolds III, J.E. and D.K. Odell, eds. 1991. Marine mammal strandings in the United States: Proceedings of the Second Marine Mammal Stranding Workshop, Miami, Florida, 3-5 December 1987. NOAA Technical Report NMFS 98:1-157.

Rice, D.W. 1989. Sperm whale--*Physeter macrocephalus* (Linnaeus, 1758). Pages 177-234 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 4: River dolphins and the larger toothed whales. San Diego, California: Academic Press.

Rice, D.W. 1998. Marine mammals of the world: Systematics and distribution. Lawrence, Kansas: Society for Marine Mammalogy.

Ringelstein, J., C. Pusineri, S. Hassani, L. Meynier, R. Nicolas, and V. Ridoux. 2006. Food and feeding ecology of striped dolphin, *Stenella coeruleoalba*, in the oceanic waters of the north-east Atlantic. Journal of the Marine Biological Association of the United Kingdom 86:909-918.

Robertson, K.M. and S.J. Chivers. 1997. Prey occurrence in pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. Fishery Bulletin 95:334-348.

Roden, C.L. and K.D. Mullin. 2000. Sightings of cetaceans in the northern Caribbean Sea and adjacent waters, winter 1995. Caribbean Journal of Science 36(3-4):280-288.

Ross, G.J.B. 1984. The smaller cetaceans of the south east coast of southern Africa. Annals of the Cape Provincial Museums (Natural History) 15, Part 2:173-410.

Ross, G.J.B. and S. Leatherwood. 1994. Pygmy killer whale-*Feresa attenuata* Gray, 1874. Pages 387-404 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 5: The first book of dolphins. San Diego, California: Academic Press.

Sanders, I.M., J.C. Barrios-Santiago, and R.S. Appeldoorn. 2005. Distribution and relative abundance of humpback whales off western Puerto Rico during 1995-1997. Caribbean Journal of Science 41(1):101-107.

Santos, M.B., G.J. Pierce, A. López, R.J. Reid, V. Ridoux, and E. Mente. 2006. Pygmy sperm whales *Kogia breviceps* in the Northeast Atlantic: New information on stomach contents and strandings. Marine Mammal Science 22(3):600-616.

Santos, M.B., M.R. Clarke, and G.J. Pierce. 2001. Assessing the importance of cephalopods in the diets of marine mammals and other top predators: Problems and solutions. Fisheries Research 52(2001):121-139.

Schilling, M.R., I. Seipt, M.T. Weinrich, S.E. Frohock, A.E. Kuhlberg, and P.J. Clapham. 1992. Behavior of individually-identified sei whales *Balaenoptera borealis* during an episodic influx into the southern Gulf of Maine in 1986. Fishery Bulletin 90:749-755.

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107(6):3496-3508.

Schmidly, D.J. 1981. Marine mammals of the southeastern United States coast and the Gulf of Mexico. FWS/OBS-80/41. Washington, D.C.: U.S. Fish and Wildlife Service.

Schmidly, D.J., C.O. Martin, and G.F. Collins. 1972. First occurrence of a black right whale (*Balaena glacialis*) along the Texas coast. Southwestern naturalist 17(2):214-215.

Schoenherr, J.R. 1991. Blue whales feeding on high concentrations of euphausiids around Monterey Submarine Canyon. Canadian Journal of Zoology 69:583-594.

Sears, R., C.L.K. Burton, and G. Vikingson. 2005. Review of blue whale (*Balaenoptera musculus*) photoidentification distribution data in the North Atlantic, including the first long-range match between Iceland and Mauritania. Page 254 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Sears, R.F., F. Wenzel, and J.M. Williamson. 1987. The blue whale: a catalog of individuals from the western North Atlantic (Gulf of St. Lawrence). Mingan Island Cetacean Study, St. Lambert, Quebec, Canada 27 pp.

Sears, R., J.M. Williamson, F.W. Wenzel, M. Bérubé, D. Gendron, and P. Jones. 1990. Photographic identification of the blue whale (*Balaenoptera musculus*) in the Gulf of St. Lawrence, Canada. Reports of the International Whaling Commission (Special Issue 12):335-342.

Shane, S.H. 1990. Comparison of bottlenose dolphin behavior in Texas and Florida, with a critique of methods for studying dolphin behavior. Pages 541-558 in Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego, California: Academic Press.

Shane, S.H. 1994. Occurrence and habitat use of marine mammals at Santa Catalina Island, California from 1983-91. Bulletin of the Southern California Academy of Sciences 93:13-29.

Shane, S.H., R.S. Wells, and B. Würsig. 1986. Ecology, behavior and social organization of the bottlenose dolphin: A review. Marine Mammal Science 2(1):34-63.

Siciliano, S., M.C.O. Santos, A.F.C. Vicente, F.S. Alvarenga, E. Zampirolli, J.L. Brito, Jr., A.F. Azevedo, and J.L.A. Pizzorno. 2004. Strandings and feeding records of Bryde's whales (*Balaenoptera edeni*) in south-eastern Brazil. Journal of the Marine Biological Association of the United Kingdom 84:857-859.

Silber, G.K. and P.J. Clapham. 2001. Draft updated recovery plan for the western North Atlantic right whale, *Eubalaena glacialis*. Silver Spring, Maryland: National Marine Fisheries Service.

Slijper, E.J., W.L. van Utrecht, and C. Naaktgeboren. 1964. Remarks on the distribution and migration of whales, based on observations from Netherlands ships. Bijdragen Tot de Dierkunde 34:3-93.

Smith, T.D., J. Allen, P.J. Clapham, P.S. Hammond, S. Katona, F. Larsen, J. Lien, D. Mattila, P.J. Palsbøll, J. Sigurjónsson, P.T. Stevick, and N. Øien. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). Marine Mammal Science 15(1):1-32.

Smith, T.D., R.B. Griffin, G.T. Waring, and J.G. Casey. 1996. Multispecies approaches to management of large marine predators. Pages 467-490 in Sherman, K., N.A. Jaworski, and T.J. Smayda, eds. The Northeast Shelf Ecosystem: Assessment, sustainability, and management. Cambridge, Massachusetts: Blackwell Science.

Smultea, M.A. 1994. Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii. Canadian Journal of Zoology 72:805-811.

Stacey, P.J., S. Leatherwood, and R.W. Baird. 1994. *Pseudorca crassidens*. Mammalian Species 456:1-6.

Stern, S.J. 2002. Migration and movement patterns. Pages 742-748 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of marine mammals. San Diego, California: Academic Press.

Stevick, P.T., B.J. McConnell, and P.S. Hammond. 2002. Patterns of movement. Pages 185-216 in Hoelzel, A.R., ed. Marine mammal biology: An evolutionary approach. Oxford, United Kingdom: Blackwell Science.

Stevick, P.T., J. Allen, M. Bérubé, P.J. Clapham, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsbøll, J. Robbins, J. Sigurjónsson, T.D. Smith, N. Øien, and P.S. Hammond. 2003b. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). Journal of Zoology, London 259:231-237.

Stevick, P.T., J. Allen, M. Bérubé, P.J. Clapham, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsbøll, J. Robbins, J. Sigurjónsson, T.D. Smith, N. Øien, and P.S. Hammond. 2003a. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). Journal of Zoology, London 259:231-237.

Stewart, B.S. and S. Leatherwood. 1985. Minke whale *Balaenoptera acutorostrata* Lacepede, 1804. Pages 91-136 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Stimpert, A.K., T.V.N. Cole, R.M. Pace, III, and P.J. Clapham. 2003. Distributions of four baleen whale species in the northwest Atlantic Ocean based on large-scale aerial survey data. Page 157 in Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals. 14-19 December 2003. Greensboro, North Carolina.

Swingle, W.M., S.G. Barco, T.D. Pitchford, W.A. McLellan, and D.A. Pabst. 1993. Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9(3):309-315.

Tershy, B.R., J. Urbán-Ramírez, D. Breese, L. Rojas-Bracho, and L.T. Findley. 1993. Are fin whales resident to the Gulf of California? Revista de Investigación Científica 1:69-72.

Torres, L.G., W.A. McLellan, E. Meagher, and D.A. Pabst. 2005. Seasonal distribution and relative abundance of bottlenose dolphins, *Tursiops truncatus*, along the US mid-Atlantic Coast. Journal of Cetacean Research and Management 7(2):153-161.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19(1):3-50.

Urian, K.W., D.A. Duffield, A.J. Read, R.S. Wells, and E.D. Shell. 1996. Seasonality of reproduction in bottlenose dolphins, *Tursiops truncatus*. Journal of Mammalogy 77(2):394-403.

Urick, R.J. 1983. Principles of underwater sound. 3rd ed. Los Altos, California: Peninsula Publishing.

USCG (U.S. Coast Guard). 1999. Mandatory ship reporting systems. Federal Register 64(104):29229-29235.

USCG (U.S. Coast Guard). 2001. Mandatory ship reporting systems--Final rule. Federal Register 66(224):58066-58070.

USFWS (U.S. Fish and Wildlife Service). 1976. Determination of critical habitat for American crocodile, California condor, Indiana bat, and Florida manatee. Federal Register 41(187):41914-41916.

USFWS (U.S. Fish and Wildlife Service). 2001. Florida manatee recovery plan, (*Trichechus manatus latirostris*), third revision. Atlanta, Georgia: U.S. Fish and Wildlife Service.

USFWS (U.S. Fish and Wildlife Service). 2007. State and federal threatened, endangered, and other species of concern likely to occur in Bay County, Florida. Panama City, Flordia: United States Fish and Wildlife Service.

Van Waerebeek, K., F. Félix, B. Haase, D.M. Palacios, D.M. Mora-Pinto, and M. Muñoz-Hincapié. 1998. Inshore records of the striped dolphin, *Stenella coeruleoalba*, from the Pacific coast of South America. Reports of the International Whaling Commission 48:525-532.

Visser, I.N. 2005. First observations of feeding on thresher (*Alopias vulpinus*) and hammerhead (*Sphyrna zygaena*) sharks by killer whales (*Orcinus orca*) specialising on elasmobranch prey. Aquatic Mammals 31(1):83-88.

Visser, I.N. and F.J. Bonoccorso. 2003. New observations and a review of killer whale (*Orcinus orca*) sightings in Papua New Guinea waters. Aquatic Mammals 29(1):150-172.

Wang, M.-C., W.A. Walker, K.-T. Shao, and L.-S. Chou. 2002. Comparative analysis of the diets of pygmy sperm whales and dwarf sperm whales in Taiwanese waters. Acta Zoologica Taiwanica 13(2):53-62.

Wang, M.-C., W.A. Walker, K.-T. Shao, and L.-S. Chou. 2003. Feeding habits of the pantropical spotted dolphin, *Stenella attenuata*, off the eastern coast of Taiwan. Zoological Studies 42(2):368-378.

Waples, R. and P. Clapham, eds. 2004. Report of the working group on killer whales as a case study. Pages 62-73 in Reeves, R.R., W.F. Perrin, B.L. Taylor, C.S. Baker, and S.L. Mesnick, eds. Report of the Workshop on Shortcomings of Cetacean Taxonomy in Relation to Needs of Conservation and Management: April 30 - May 2, 2004, La Jolla, California. NOAA Technical Memorandum NMFS-SWFSC-363.

Ward, J.A. 1999. Right whale (*Balaena glacialis*) South Atlantic Bight habitat characterization and prediction using remotely sensed oceanographic data. Master's thesis, University of Rhode Island.

Ward, J.A., G.H. Mitchell, A.M. Farak, and E.P. Keane. 2005. Beaked whale habitat characterization and prediction. NUWC-NPT Technical Report 11,548. Newport, Rhode Island: Naval Undersea Warfare Center Division.

Ward-Geiger, L.I., G.K. Silber, R.D. Baumstark, and T.L. Pulfer. 2005. Characterization of ship traffic in right whale critical habitat. Coastal Management 33:263-278.

Waring, G.T. and J.T. Finn. 1995. Cetacean trophic interactions off the northeast USA inferred from spatial and temporal co-distribution patterns. Unpublished meeting document. ICES C.M. 1995/N:7. Copenhagen, Denmark: International Council for the Exploration of the Sea.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1992. Cetaceans associated with Gulf Stream features off the northeastern USA Shelf. Unpublished meeting document. ICES C.M. 1992/N:12. Copenhagen, Denmark: International Council for the Exploration of the Sea.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley, eds. 2007. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2006. NOAA Technical Memorandum NMFS-NE-201:1-378.

Waring, G.T., E. Josephson, C.P. Fairfield-Walsh, and K. Maze-Foley, eds. 2008. Final U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2007. NOAA Technical Memorandum NMFS-NE-205:1-415.

Waring, G.T., R.M. Pace, J.M. Quintal, C.P. Fairfield, and K. Maze-Foley, eds. 2004. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments -- 2003. NOAA Technical Memorandum NMFS-NE-182:1-287.

Waring, G.T., T. Hamazaki, D. Sheehan, G. Wood, and S. Baker. 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (*Physeter macrocephalus*) summer habitat in shelf-edge and deeper waters off the northeast U.S. Marine Mammal Science 17(4):703-717.

Watkins, W.A., M.A. Daher, K. Fristrup, and G. Notarbartolo di Sciara. 1994. Fishing and acoustic behavior of Fraser's dolphin (*Lagenodelphis hosei*) near Dominica, southeast Caribbean. Caribbean Journal of Science 30(1-2):76-82.

Weller, D.W., A.J. Schiro, V.G. Cockcroft, and W. Ding. 1996. First account of a humpback whale (*Megaptera novaeangliae*) in Texas waters, with a re-evaluation of historical records from the Gulf of Mexico. Marine Mammal Science 12(1):133-137.

Weller, D.W., B. Würsig, S.K. Lynn, and A.J. Schiro. 2000. Preliminary findings on the occurrence and site fidelity of photo-identified sperm whales (*Physeter macrocephalus*) in the northern Gulf of Mexico. Gulf of Mexico Science 2000(1):35-39.

Wells, R. 2007. Personal communication via email between Dr. Randall Wells, Mote Marine Laboratory, Sarasota, Florida, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 29 January.

Wells, R.S. and M.D. Scott. 1999. Bottlenose dolphin--*Tursiops truncatus* (Montagu, 1821). Pages 137-182 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 6: The second book of dolphins and the porpoises. San Diego, California: Academic Press.

Wells, R.S., C. Mainire, H. Rhinehart, D. Smith, A. Westgate, F. Townsend, T. Rowles, A. Hohn, and L. Hansen. 1999. Ranging patterns of rehabilitated rough-toothed dolphins, *Steno bredanensis*, released in the northeastern Gulf of Mexico. Page 199 in Abstracts, Thirteenth Biennial Conference on the Biology of Marine Mammals. 28 November-3 December 1999. Wailea, Hawaii.

Wells, R.S., M.D. Scott, and A.B. Irvine. 1987. The social structure of free-ranging bottlenose dolphins. Pages 247-305 in Genoways, H.H., ed. Current mammalogy. Volume 1. New York, New York: Plenum Press.

Wenzel, F., D.K. Mattila, and P.J. Clapham. 1988. *Balaenoptera musculus* in the Gulf of Maine. Marine Mammal Science 4(2):172-175.

Whitehead, H. 2003. Sperm whales: Social evolution in the ocean. Chicago, Illinois: University of Chicago Press.

Whitehead, H. and M.J. Moore. 1982. Distribution and movements of West Indian humpback whales in winter. Canadian Journal of Zoology 60:2203-2211.

Wiley, D.N., R.A. Asmutis, T.D. Pitchford, and D.P. Gannon. 1995. Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. Fishery Bulletin 93:196-205.

Willis, P.M. and R.W. Baird. 1998. Status of the dwarf sperm whale, *Kogia simus*, with special reference to Canada. Canadian Field-Naturalist 112(1):114-125.

Wingfield, J.C. 2003. Control of behavioural strategies for capricious environments. Animal Behaviour 66:807-816.

Winn, H.E., C.A. Price, and P.W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. Reports of the International Whaling Commission (Special Issue 10):129-138.

Wishner, K., E. Durbin, A. Durbin, M. Macaulay, H. Winn, and R. Kenney. 1988. Copepod patches and right whales in the Great South Channel off New England. Bulletin of Marine Science 43(3):825-844.

Wormuth, J.H., P.H. Ressler, R.B. Cady, and E.J. Harris. 2000. Zooplankton and micronekton in cyclones and anticyclones in the northeast Gulf of Mexico. Gulf of Mexico Science 2000(1):23-34.

Wright, D.G. 1982. A discussion paper on the effects of explosives on fish and marine mammals in the waters of the Northwest Territories. Canadian Technical Report of Fisheries and Aquatic Sciences 1052:1-16.

Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24(1):41-50.

Würsig, B., T.A. Jefferson, and D.J. Schmidly. 2000. The marine mammals of the Gulf of Mexico. College Station, Texas: Texas A&M University Press.

Yelverton, J.T., D.R. Richmond, E.R. Fletcher, and K.R. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Report No. AD-766 952, DNA 3114T. Prepared for the Defense Nuclear Agency, Washington, D.C.

Yochem, P.K. and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). Pages 193-240 in Ridgway, S.H. and R. Harrison, eds. Handbook of marine mammals. Volume 3: The sirenians and baleen whales. San Diego, California: Academic Press.

Yoshida, H. and H. Kato. 1999. Phylogenetic relationships of Bryde's whales in the western North Pacific and adjacent waters inferred from mitochondrial DNA sequences. Marine Mammal Science 15(4):1269-1286.

Young, G.A. 1991. Concise methods for predicting the effects of underwater explosions on marine life. NAVSWC MP 91-220. Silver Spring, Maryland: Naval Surface Warfare Center.

Zhou, K., Q. Weijuan, and L. Yuemin. 1982. *Pseudorca crassidens* (Owen) from the coastal waters of China. Investigations on Cetacea 13:263-269.

Zoodsma, B. 2006. Personal communication via email between Ms. Barb Zoodsma, National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, Florida, and Ms. Dagmar Fertl, Geo-Marine, Inc., Plano, Texas, 28 Feburary.

APPENDIX A

DRAFT TECHNICAL RISK ASSESSMENT FOR THE USE OF UNDERWATER EXPLOSIVES IN THE GULF OF MEXICO (GOMEX) STUDY AREA

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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, based upon modeling of potential acoustic effects, to marine mammals and sea turtles from underwater explosives used in the BOMBEX in the GOMEX Study Area. 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.

Figure A-1 shows the areas where explosive ordnance (BOMBEX) is used in the GOMEX Study Area under the Preferred Alternative (Alternative 2). Explosive ordnance use in the UNDET Area E3 is not addressed in this appendix because modeling is not conducted for explosives that area less than 5 lbs.

Table A-1 summarizes the number of events (per year by season) and specific areas where each occurs for each type of explosive ordnance used for the Preferred Alternative. 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. For example, there is one MK-83 BOMBEX event per year for the Preferred Alternative that can take place in the BOMBEX Hotbox during any season, so there are 0.25 events modeled for each season.

Figure A-1 Explosive Ordnance (BOMBEX) Areas in the GOMEX Study Area under the Preferred Alternative

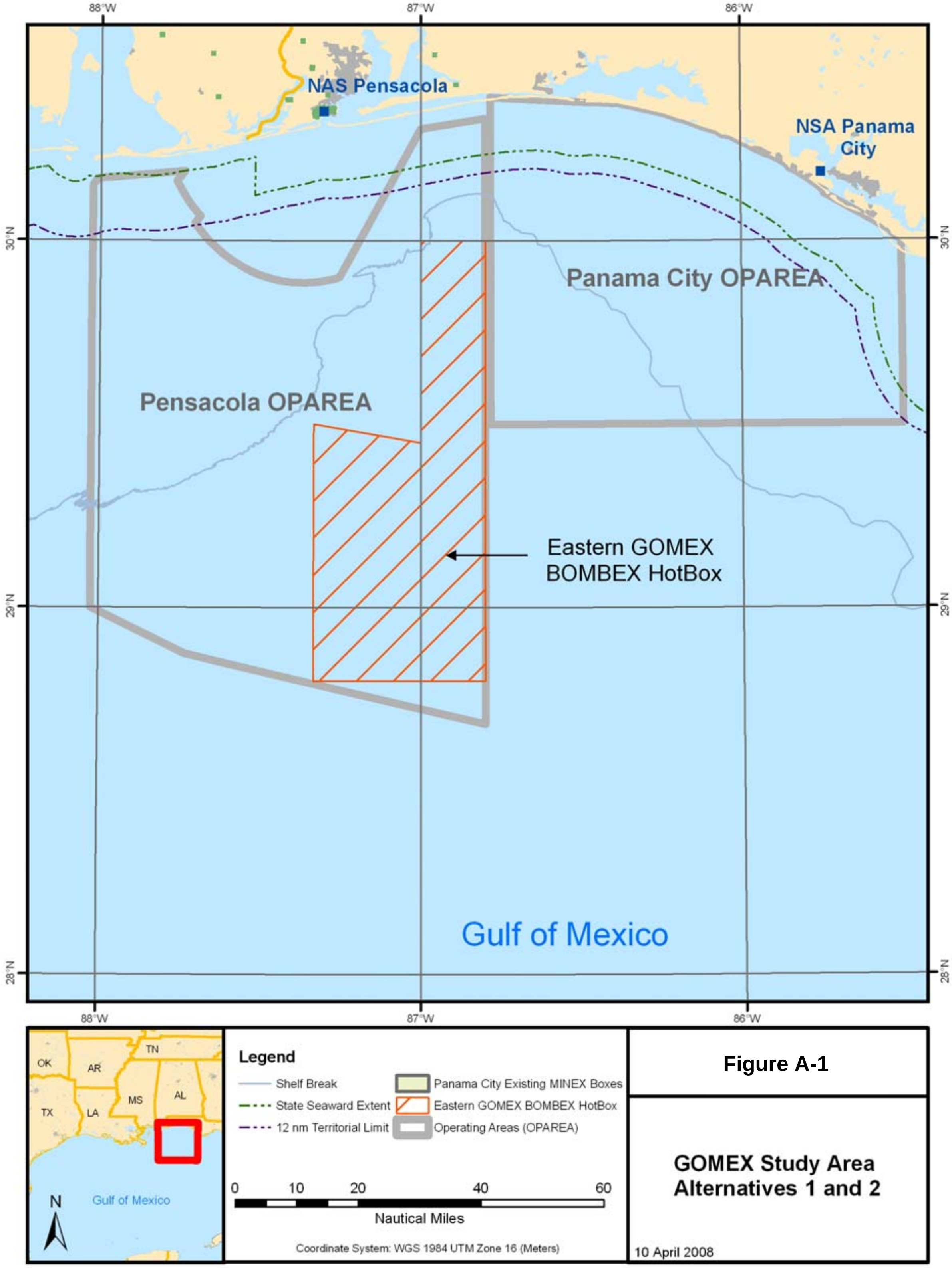


Table A-1 Number of Explosive Events within the GOMEX Study Area – Preferred Alternative

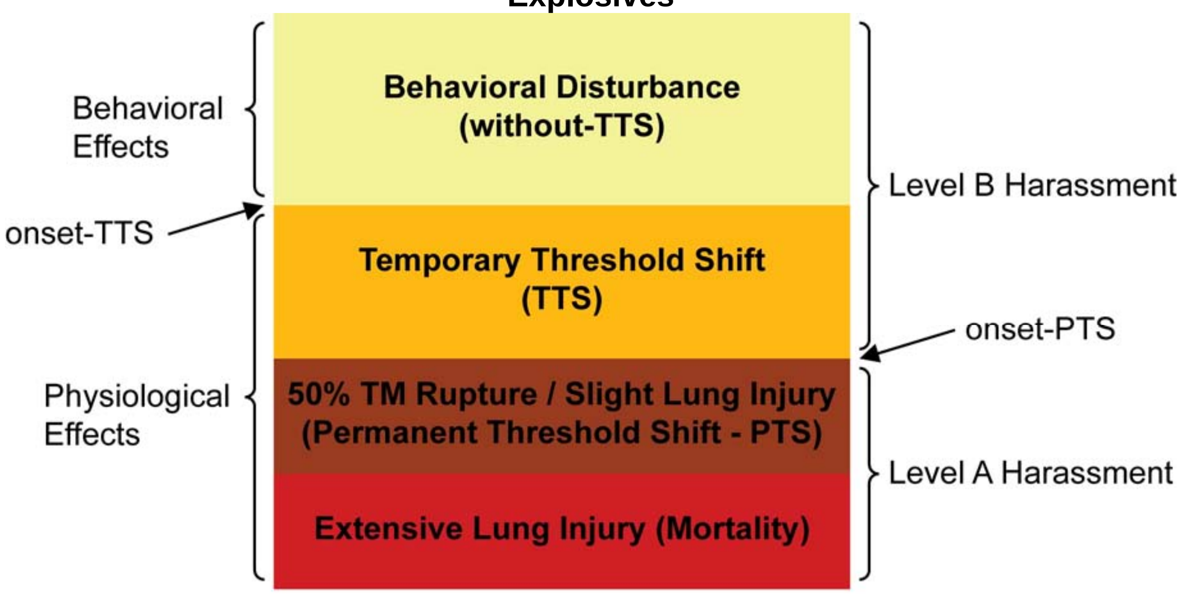
Location	Ordnance	Annual Totals
BOMBEX Hotbox	MK-83 (415.8 lbs NEW)	1*
UNDET Area E3	M3A2 anti-swimmer concussion grenade (0.5 lbs NEW)	6

** One event using the MK-83 bombs consists of 4 bombs being dropped in succession. For example, in the BOMBEX Hotbox there is 1 MK-83 event, which means that a total of 4 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 EIS (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 BOMBEX. In addition, this section reflects a revised acoustic criterion for small underwater explosions (i.e., 23 pounds per square inch [psi] for peak pressure instead of previous acoustic criterion of 12 psi for peak pressure), which is based on the final rule issued to the Air Force by NMFS (NMFS, 2005b). **Figure A-2** depicts the acoustic impact framework used in this assessment.

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



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

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, EFD is the time integral of the squared pressure divided by the impedance. It has SI units of J/m^2 (but inch-pounds per square inch [$in.\text{-}lb/in.^2$] is also used in CHURCHILL). EFD levels have units of decibels referenced to 1 micropascal squared second (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 micropascal (dB re: 1 μPa).

1.2 Thresholds and Criteria for Injurious Physiological Effects

Single Explosion

For injury, the Navy uses dual criteria: eardrum rupture (i.e., tympanic-membrane [TM] rupture) and onset of slight lung injury. These criteria are considered indicative of the onset of injury. The threshold for TM rupture corresponds to a 50% 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 $in.\text{-}lb/in.^2$ (about 205 dB re: 1 μPa^2-s). This recognizes that TM rupture is not necessarily a serious or life-threatening injury, but 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 (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 marine species populations were 100% small animals. The criterion with the largest potential impact range (most conservative), either TM rupture (energy threshold) or onset of slight lung injury (peak pressure threshold), will be used in the analysis to determine injurious physiological (MMPA – Level A) exposures.

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

Multiple Explosions

For this analysis, the use of multiple explosions only applies to the MK-83 bombs used in BOMBEX. Since BOMBEX events require multiple explosions, the Churchill approach had to be extended to cover multiple sound events at the same training site. For multiple exposures, accumulated energy over the entire training time is the natural extension for energy thresholds since energy accumulates with each subsequent shot (explosion); this is consistent with the treatment of multiple arrivals in Churchill. For positive impulse, it is consistent with Churchill to use the maximum value over all impulses received.

1.3 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). For this assessment, there are dual criteria for TTS, an energy threshold and a peak pressure threshold. The criterion with the largest potential impact range (most conservative), either the energy threshold or peak pressure threshold, will be used in the analysis to determine non-injurious TTS (MMPA – Level B) exposures.

Single Explosion –TTS-Energy Threshold

The first threshold is a 182 dB re: 1 μPa^2-s maximum energy flux density level in any 1/3-octave band at frequencies above 100 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 net explosive weight [NEW]), as what was modeled for this analysis, the spectrum of the shot arrival is broad, and there is essentially no difference in impact ranges for toothed whales/sea turtles or baleen whales.

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

1.4 Thresholds and Criteria for Behavioral Effects

Single Explosion

For a single explosion, to be consistent with Churchill, TTS is the criterion for ESA-Harassment. 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 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. 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 behavioral exposures (MMPA-Level B) due to the use of multiple explosions.

1.5 Summary of Thresholds and Criteria for Impulsive Sounds

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

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

Effect	Criterion	Metric	Threshold
Mortality	Onset of Extensive Lung Injury	Goertner modified positive impulse	indexed to 30.5 psi-ms (assumes 100% small animal at 26.9 lbs)
Injurious Physiological *MMPA* - Level A	50% Tympanic Membrane Rupture	Energy flux density	1.17 in.-lb/in.^{2} (about 205 dB re: 1 μPa^2-s)
Injurious Physiological *MMPA* - Level A	Onset Slight Lung Injury	Goertner modified positive impulse	indexed to 13 psi-ms (assumes 100% small animal at 26.9 lbs)
Non-injurious Physiological *MMPA* - Level B	TTS	Greatest EL in any 1/3-octave band (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures	182 dB re: 1 μPa^2-s
Non-injurious Physiological *MMPA* - Level B	TTS	Peak pressure for any single exposure	23 psi

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

Effect	Criterion	Metric	Threshold
Non-injurious Behavioral *MMPA* - Level B	Behavioral Disturbance without TTS	Greatest energy flux density level in any 1/3-octave (above 100 Hz for toothed whales/sea turtles and above 10 Hz for baleen whales) - for total energy over all exposures (multiple explosions only)	177 dB re: 1 μPa^2-s
MMPA - Marine Mammal Protection Act TTS - Temporary Threshold Shift			

CHAPTER 2 ACOUSTIC ANALYSIS FOR UNDERWATER EXPLOSIONS ASSOCIATED WITH BOMBEX

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 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. Under the Preferred Alternative, BOMBEX training will only take place in one location (Hotbox; **Figure A-1**).

2.1 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.

2.1.1 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.

2.1.2 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 (SSPs), and bottom type parameters including sediment characteristics, compressional and shear wave speed, density, and layer depth.

2.1.2.1 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 was identified as the BOMBEX Hotbox with given latitude and longitude location as 87.03°N, 29.29°W.

2.1.2.2 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 feet per second (ft/s) (1 meter per second [m/s]) for the model input file.

2.1.2.3 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 A-3** summarizes the data used for the BOMBEX site.

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

Site	Water Depth (m)	Bottom Sediment	Sound Speed Ratio	Density (grams per cubic centimeter [g/cm^3])
BOMBEX Hotbox	780	Silty Clay	0.994	1.421

2.1.3 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 trinitrotoluene (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 seafloor 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 (nm): 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 (nm): 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).

2.1.4 Marine Animal Data

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

2.2 Estimated Impact Areas

Table A-4 presents the BOMBEX modeling results of the impact areas for the GOMEX Range Complex.

Table A-4 Estimated ZOIs (km^2) for BOMBEX

Area	Ordnance	Estimated ZOI (km^2) @ 177 dB re: 1 μPa^2-s (multiple detonations only)				Estimated ZOI (km^2) @ 205 dB re: 1 μPa^2-s or 13 psi-msec				Estimated ZOI (km^2) @ 30.5 psi-msec			
		Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall
BOMBEX Hotbox	MK-83 (415.8 lbs NEW)	98.93	115.93	161.39	173.27	4.84	4.84	4.84	4.98	<0.01	<0.01	<0.01	<0.01

**ZOIs for MK-83 bombs are modeled as multiple detonations (4 bombs dropped at same location). The ZOI at 177 dB re: 1 μPa^2-s for behavioral disruption was much larger than that for TTS, and therefore was used to calculate potential Level B exposures.*

CHAPTER 3 LITERATURE CITED

Britt, J.R., R.J. Eubanks, and M.G. Lumsden. 1991. Underwater shock wave reflection and refraction in deep and shallow water. Volume 1: A user's manual for the REFMS code. Technical Report DNA-TR-91-15-V1. Alexandria, Virginia: Defense Nuclear Agency.

Cagniard, L. 1962. Reflection and refraction for progressive seismic waves. McGraw-Hill, New York.

DoN (Department of the Navy). 1998. Final environmental impact statement, shock testing the SEAWOLF submarine. Washington, D.C.: Naval Sea Systems Command.

DoN (Department of the Navy). 2001. Final environmental impact statement, shock trial of the Winston S. Churchill (DDG 81). Washington, D.C.: Naval Sea Systems Command.

Finneran, J.J. and C.E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes. SPAWAR Systems Center, San Diego, CA.

Goertner, J.F. 1982. Prediction of underwater explosion safe ranges for sea mammals. Report NSWC/WOL TR 82-188. Silver Spring, MD: Naval Ordnance Laboratory.

Hamilton, E. L. 1980. Geoacoustic modeling of the seafloor. Journal of the Acoustical Society of America 68(5):1313-1340.

Ketten, D.R. 1998. Marine mammal auditory systems: A summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NOAA-NMFS-SWFSC-256:1-74.

NMFS (National Marine Fisheries Service). 2001. Taking marine mammals incidental to naval activities. Federal Register 66(87):22450-22467.

NMFS (National Marine Fisheries Service). 2005b. Taking and importing marine mammals; taking marine mammals incidental to conducting the Precision Strike Weapon (PSW) testing and training by Eglin Air Force Base in the Gulf of Mexico--Notice of issuance of an incidental harassment authorization. Federal Register 70(160):48575-48691.

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107(6):3496-3508.

Urick, R.J. 1983. Principles of underwater sound. 3rd ed. Los Altos, California: Peninsula Publishing.