REVISED REQUEST FOR AN INCIDENTAL HARASSMENT AUTHORIZATION OF MARINE MAMMALS RESULTING FROM MARITIME STRIKE OPERATIONS TACTICS DEVELOPMENT AND EVALUATION

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

96 TW	96th Test Wing
AFB	Air Force Base
AGL	Above Ground Level
AGM	Air-To-Ground Missile
BA	Biological Assessment
CBU	Cluster Bomb Unit
CV	Coefficient of Variation
dB re 1 μPs^2-s	Decibel referenced to one squared microPascal-second
E	Endangered
EA	Environmental Assessment
EFD	Energy Flux Density
EFH	Essential Fish Habitat
EGTTR	Eglin Gulf Test and Training Range
EO	Executive Order
ESA	Endangered Species Act
FMC	Fishery Management Council
FMP	Fishery Management Plan
ft	Feet
GBU	Guided Bomb Unit
GMFMC	Gulf of Mexico Fishery Management Council
GOM	Gulf of Mexico
GSMFC	Gulf States Marine Fisheries Commission
HAPC	Habitat Area of Particular Concern
HEI	High Explosive Incendiary
in	Inch
in-lb/in^2	Inch-pound per square inch
J/in^2	Joules per square inch
JDAM	Joint Direct Attack Munition
JUON	Joint Urgent Operational Need
kg	Kilogram
KIAS	Knots Indicated Air Speed
km	Kilometer
km^2	Square Kilometer
lbs	Pounds
LJDAM	Laser Joint Direct Attack Munition
m	Meters
mi	Mile
min	Minute
mm	Millimeter
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NEW	Net Explosive Weight
NM	Nautical Mile
NM^2	Square Nautical Mile
NMFS	National Marine Fisheries Service
Pa-s	Pascal-second
PGU	Projectile Gun Unit
Psi-msec	Pounds per square inch-millisecond
SEFSC	Southeast Fisheries Science Center
SST	Sea Surface Temperature
T	Threatened
TA	Test Area
TD&E	Test Development and Evaluation
TTP	Tactics, Techniques, and Procedures
TTS	Temporary Threshold Shift

LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS CONT'D

USFWS	U.S. Fish and Wildlife Service
UXO	Unexploded Ordnance
ZOI	Zone of Impact

EXECUTIVE SUMMARY

With this submittal, Eglin Air Force Base requests an Incidental Harassment Authorization (IHA) for the incidental taking, but not intentional taking (in the form of noise-related and/or pressure-related impacts), of marine mammals incidental to Maritime Strike Operations Tactics Development and Evaluation testing within the Eglin Gulf Test and Training Range (EGTTR), as permitted by the Marine Mammal Protection Act (MMPA) of 1972, as amended. Maritime Strike testing is a military readiness activity. The mission may expose cetaceans within the EGTTR to noise or pressure levels currently associated with mortality, Level A harassment, and Level B harassment.

Noise and pressure metrics associated with exploding ordnance were determined to be the only activities during Maritime Strike missions with potential for significant impacts to marine species, as analyzed in the associated Environmental Assessment (U.S. Air Force, 2012; in preparation). Maritime Strike missions involve the use of multiple types of live munitions against small boat targets in the EGTTR (Gulf of Mexico). Net explosive weight of the weapons ranges from 0.02 to 945 pounds, and detonations will occur 20 feet above the water surface, at the water surface, and up 10 feet below the surface. The proposed action includes deployment of 52 live bombs/missiles and 2,500 live gunnery rounds (20 and 30 millimeter) over a timeframe of approximately two to three weeks in June 2013, with one to two missions occurring per day. The ordnance may be delivered by multiple types of aircraft including fighter jets, bombers, and unmanned aerial vehicles. The targets would consist of stationary, towed, and remotely controlled boats. Some boats would contain simulated crews made of plywood. The test location is approximately 17 miles offshore of Santa Rosa Island, in a water depth of 35 meters (115 feet).

The potential takes outlined in Section 6 represent the maximum expected number of animals that could be affected. Mitigation measures will be employed in an effort to substantially decrease the number of animals affected. Using the most applicable density estimates for each species, the zone of influence (ZOI) of each type of ordnance deployed, and the total number of planned detonations, an estimate of the potential number of animals exposed to noise and/or pressure thresholds is analyzed. Without mitigation measures in place, the total number of marine mammals potentially exposed to the positive impulse level associated with mortality (30.5 psi-msec) is less than one animal, including about 0.5 bottlenose dolphins and 0.1 Atlantic spotted dolphins. A maximum of up to approximately three marine mammals (all species combined) could potentially be exposed to injurious Level A harassment. A maximum of approximately 47 marine mammals could potentially be exposed to non-injurious (TTS) Level B harassment. Approximately 94 animals could potentially be exposed to noise corresponding to the behavioral threshold of 177 decibels (dB) EFD. It is anticipated that mitigation measures, identified in Chapter 11, will reduce the probability of all forms of take, specifically mortality, thus an IHA is being requested as opposed to a Letter of Authorization (LOA).

Marine mammal species potentially affected by Maritime Strike activities include four bottlenose dolphin stocks and one Atlantic spotted dolphin stock. The Maritime Strike test site is located in an area associated with the Northern Gulf of Mexico spotted dolphin stock, which is not considered strategic. The test site is located within a depth range corresponding to the Northern Gulf of Mexico Continental Shelf stock of bottlenose dolphins (20 to 200 meters depth), which is

not a strategic stock. However, other strategic stocks are defined in relatively close proximity and could possibly enter the test area. Three bay, sound, and estuary stocks, as well as the Northern Coastal stock (shoreline to 20 meters water depth), occur near the Maritime Strike location and are considered strategic. Individuals from the Oceanic stock, which is not considered strategic, are unlikely to enter the test area, as this stock is defined beyond the 200 meter isobath.

The information and analyses provided in this application are presented to fulfill the permit request requirements of Title I, Sections 101(a)(5)(A) and 101(a)(5)(F) of the MMPA.

1. DESCRIPTION OF ACTIVITIES

This section describes Air Force Maritime Strike mission activities conducted in the Eglin Gulf Test and Training Range (EGTTR) that could result in takes under the Marine Mammal Protection Act (MMPA) of 1972, as amended. The actions include air-to-surface test missions involving detonations above the water, at the water surface, and under water, with the potential to affect cetaceans that may be present within the action area. The mission is described in the following sections.

1.1 INTRODUCTION

The U.S. Air Force 53rd Wing seeks the ability to conduct live ordnance testing in the Gulf of Mexico (GOM) as part of the Maritime Strike Operations Tactics Development and Evaluation (TD&E) Program. The Maritime Strike program was developed in response to increasing threats at sea posed by operations conducted from small boats. There has been limited Air Force aircraft and munitions testing on engaging and defeating small boat threats. Small boats can carry a variety of weapons, can be employed in large or small numbers by many nations and groups, and may be difficult to locate, track, and engage in the marine environment. Therefore, the Air Force proposes to employ live munitions against boat targets in the GOM in order to continue development of tactics, techniques and procedures for U.S. Air Force strike aircraft to counter small maneuvering surface vessels. Maritime Strike testing is a high national defense priority, being the fourth-highest project within the U.S. Air Force (as of November 2012). In addition, the project is categorized as a Joint Urgent Operational Need (JUON). A JUON is defined as an urgent operation need identified by a combatant commander that, if not addressed immediately, will seriously endanger personnel or pose a major threat to ongoing operations.

1.2 MISSION DESCRIPTION

Maritime Strike activities involve use of multiple types of live munitions in the EGTTR against small boat targets, at all desired surface and water depth scenarios (maximum depth of 10 feet below the surface) necessary to carry out the TD&E Program. Maritime Strike operations will occur within the EGTTR, in Warning Area 151 (W-151) (Figure 1-1). The specific planned test location is approximately 17 miles offshore from Santa Rosa Island, in nearshore waters of the continental shelf. Water depth is about 35 meters (115 feet). Test events will be conducted in various sea states and weather conditions, up to a wave height of four feet.

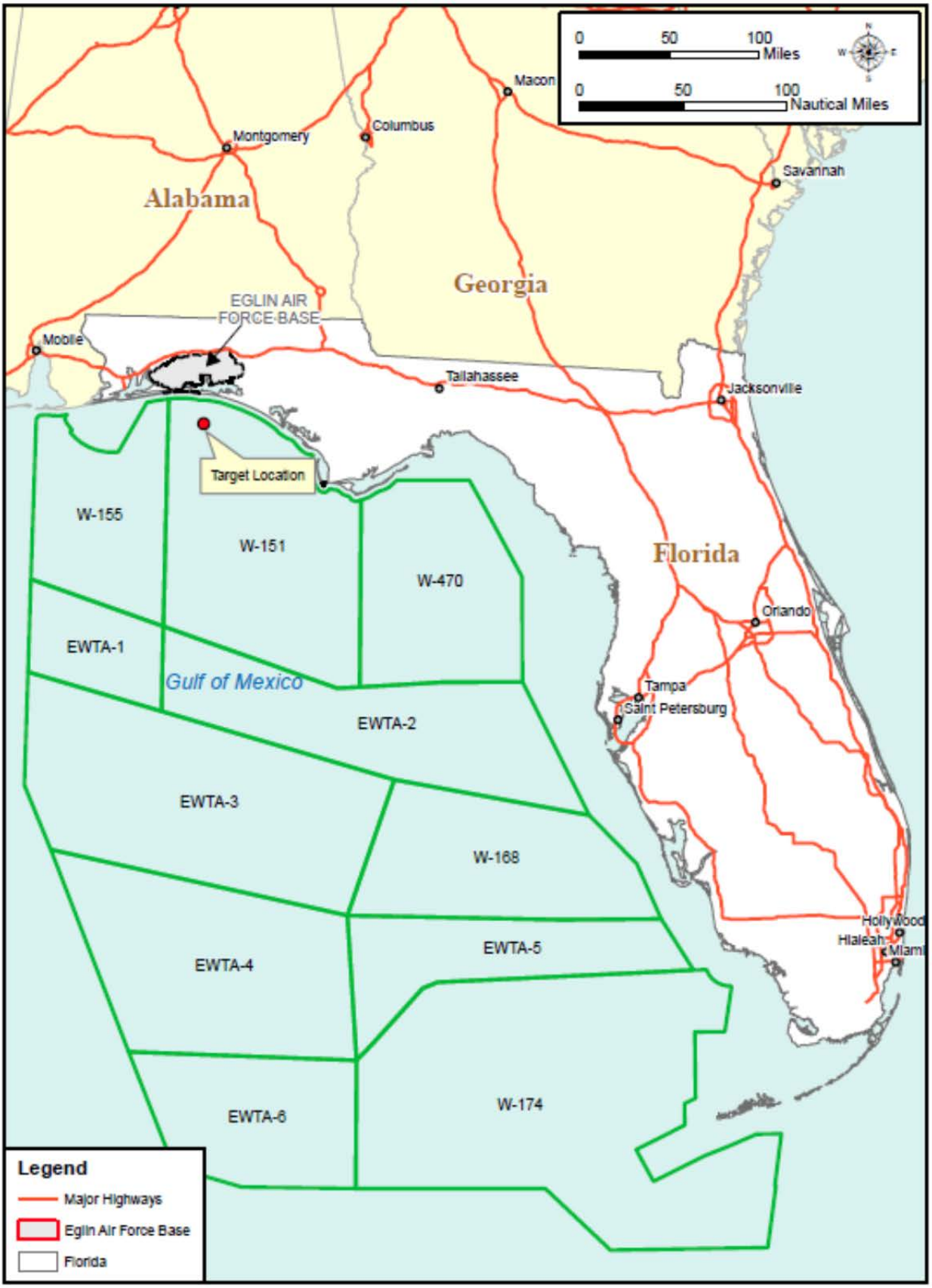

Figure 1-1. Egglin Gulf Test and Training Range (EGTTR)

Multiple munitions and aircraft will be used to meet the objectives of the Maritime Strike program (Table 1-1). Munition types include bombs, missiles, and gunnery rounds. Because the tests will focus on weapon/target interaction, no particular aircraft will be specified for a given test as long as it meets the delivery parameters. The munitions will be deployed against static, towed, and remotely controlled boat targets. Static and controlled targets consist of stripped boat hulls with plywood simulated crews and systems. Damaged boats will be recovered for data collection. Test data collection and operation of remotely controlled boats will be conducted from an instrumentation barge anchored on-site, which will also provide a platform for cameras and weapon-tracking equipment. Target boats will be positioned 300 to 600 feet from the instrument barge, depending on the munition.

Table 1-1. Live Munitions and Aircraft

Munitions	Aircraft (not associated with specific munitions)
GBU-10 laser-guided Mk-84 bomb	F-16C fighter aircraft
GBU-24 laser-guided Mk-84 bomb	F-16C+ fighter aircraft
GBU-31 Joint Direct Attack Munition, global positioning system guided Mk-84 bomb	F-15E fighter aircraft
GBU-12 laser-guided Mk-82 bomb	A-10 fighter aircraft
GBU-38 Joint Direct Attack Munition, global positioning system guided Mk-82 bomb	B-1B bomber aircraft
GBU-54 Laser Joint Direct Attack Munition, laser-guided Mk-82 bomb	B-52H bomber aircraft
CBU-103/B bomb	MQ-1/9 unmanned aerial vehicle
AGM-65E/L/K/G2 Maverick air-to-surface missile	
AGM-114 Hellfire air-to-surface missile	
M-117 bomb	
PGU-12 high explosive incendiary 30 mm rounds	
M56/PGU-28 high explosive incendiary 20mm rounds	

AGM = air-to-ground missile; CBU = Cluster Bomb Unit; GBU = Guided Bomb Unit; Mk = Mark; mm = millimeters; PGU = Projectile Gun Unit

Live testing will include three fuzing options: detonation above the water surface, at the water surface, and below the water surface (two depths). The number of each type of munition, height or depth of detonation, explosive material, and net explosive weight (NEW) of each munition is provided in Table 1-2. The quantity of live munitions tested is considered necessary to provide the intended level of tactics and weapons evaluation, including a number of replicate tests sufficient for an acceptable statistical confidence level regarding munitions capabilities.

Table 1-2. Maritime Strike Munitions

Type of Munition	Total # of Live Munitions	# of Detonations by Height/Depth	Warhead – explosive material	Net Explosive Weight per Munition
GBU-10	1	Water Surface: all	MK-84 - Tritonal	945 lbs
GBU-24	1	Water Surface: all	MK-84 - Tritonal	945 lbs
GBU-31 (JDAM)	13	Water Surface: 4	MK-84 - Tritonal	945 lbs (MK-84)
		20 feet AGL: 3		
		5 feet underwater: 3		
		10 feet underwater: 3		
GBU-12	1	Water Surface: all	MK-82 - Tritonal	192 lbs
GBU-38	13	Water Surface: 4	MK-82 – Tritonal	192 lbs (MK-82)

Type of Munition	Total # of Live Munitions	# of Detonations by Height/Depth	Warhead – explosive material	Net Explosive Weight per Munition
(JDAM)		20 feet AGL: 3 5 feet underwater: 3 10 feet underwater: 3		
GBU-54 (LJDAM)	1	Water Surface: all	MK-82 – Tritonal	192 lbs (MK-82)
AGM-65E/L/K/G2 (Maverick)	2 each (8 total)	Water Surface: all	WDU-24/B penetrating blast-fragmentation warhead	86 lbs
CBU-103	4	Water Surface: all	202 Blu-97/B Combined Effects Bomblets (0.63 lbs each)	127 lbs
AGM-114 (Hellfire)	4	Water Surface: all	High Explosive Anti-Tank (HEAT) tandem anti-armor metal augmented charge	20 lbs
M-117	6	20 feet AGL: 3 Water Surface: 3	750 lb blast/fragmentation bomb, used the same way as MK-82 - Tritonal	386 lbs (Tritonal)
PGU-12 HEI 30 mm	1,000	Water Surface: all	30 x 173 mm caliber with aluminized RDX explosive. Designed for GAU-8/A Gun System	0.1 lbs
M56/PGU-28 HEI 20 mm	1,500	Water Surface: all	20 x 120 mm caliber with aluminized Comp A-4 HEI. Designed for M61 and M197 Gun System	0.02 lbs (Comp A-4 HEI)

AGL = above ground level; AGM = air-to-ground missile; CBU = Cluster Bomb Unit; GBU = Guided Bomb Unit; JDAM = Joint Direct Attack Munition; LJDAM = Laser Joint Direct Attack Munition; mm = millimeters; lbs = pounds; PGU = Projectile Gun Unit; HEI = high explosive incendiary

A human safety zone will be established around the test area prior to each live mission, and will be enforced by a large number of safety boats (approximately 20 to 25). The size of this zone will vary, depending upon the particular munition used in a given test. A composite safety footprint was developed, which incorporates all munitions being deployed and averages them out. The composite safety footprint consisted of approximately a 19 mile-wide diameter (9.5 mile-wide radius from the detonation point). Non-participating vessels (such as recreational and commercial fishermen) will be excluded from entering the safety footprint while it is active, which is expected to be up to four hours per mission on test days. The Eglin Safety Office will position the safety support vessels around the safety footprint to ensure commercial and recreational boats do not accidentally enter the area. Before delivering the ordnance, mission aircraft may make a dry run over the target area to ensure that it is clear of non-participating vessels, although this action would not necessarily be performed for all tests.

In addition, measures designed to avoid or minimize impacts to protected marine species have been developed in cooperation with NOAA Fisheries. A separate zone around the target will be established for marine species protection, based on the distance to which energy- and pressure-related impact zones could extend for the various types of ordnance listed in Table 1-2. This zone will not necessarily be the same size as the human safety zone. Trained marine species observers will be aboard at least two of the safety boats and will survey the species protection zone before each test. In addition, mission-related personnel will be within the test area performing various tasks and will observe for protected marine species as feasible throughout

test preparation. Crews on the remaining safety boats will also opportunistically scan for and radio information regarding the presence of marine mammals near the perimeter, although this will not be their primary task.

At least two ordnance delivery aircraft will participate in each live weapon release mission. Prior to the test, Air Force pilots aboard mission aircraft may make a dry run over the target area to ensure it is clear of non-participating vessels before ordnance is deployed. Due to the limited flyover duration and potentially high speed and altitude, pilots will not survey for marine species.

In addition to surveys conducted from boats, one to three video cameras will be positioned on an instrumentation barge anchored on-site. The camera(s) will be used to monitor for the presence of protected species. A marine species observer will be located in the Eglin control tower, along with mission personnel, to view the video feed before and during test activities. Missions would not proceed until the target area is clear. A detailed description of mitigation measures is provided in Chapter 11.

After each test, floating targets would be inspected to identify and render safe any unexploded ordnance (UXO), including fuzes or intact munitions. The Eglin Air Force Explosive Ordnance Disposal team would be on hand for each test. UXO that cannot be removed would be detonated in place, which could result in sinking of the target vessel. Once the area has been cleared for re-entry, test personnel would retrieve target debris and marine species observers will survey the area for any evidence of adverse impacts to protected species.

2. DURATION AND LOCATION OF THE ACTIVITIES

Maritime Strike missions are scheduled to occur over an approximate two- to three-week period in June 2013. Missions would occur on weekdays during daytime hours only, with one or two missions occurring per day. All activities would take place within the EGTTR, which is defined as the airspace over the GOM controlled by Eglin AFB, beginning at a point three NM from shore. The EGTTR is subdivided into blocks consisting of Warning Areas W-155, W-151, W-470, W-168, and W-174, as well as Eglin Water Test Areas 1 through 6 (Figure 2-1). Warning Area W-155, which is controlled by the Navy, is used occasionally to support Eglin missions. Over 102,000 square nautical miles (NM^2) of GOM surface waters exist under the EGTTR air space. However, activities described in this document will occur only in W-151, and specifically in sub-area W-151A (Figure 2-1). Descriptive information for all of W-151 and for W-151A is provided below.

W-151

The inshore and offshore boundaries of W-151 are roughly parallel to the shoreline contour. The shoreward boundary is 3 NM from shore, while the seaward boundary extends approximately 85 to 100 NM offshore, depending on the specific location. W-151 covers a surface area of approximately 10,247 NM^2 (35,145 square kilometers [km^2]), and includes water depths ranging from about 20 to 700 meters. This range of depth includes continental shelf and slope waters. Approximately half of W-151 lies over the shelf.

W-151A

W-151A extends approximately 60 NM offshore and has a surface area of 2,565 NM^2 (8,797 km^2). Water depths range from about 30 to 350 meters and include continental shelf and

slope zones. However, most of W-151A occurs over the continental shelf, in water depths less than 250 meters. Maritime Strike operations will occur in the shallower, northern inshore portion of the sub-area, in a water depth of about 35 meters (115 feet).

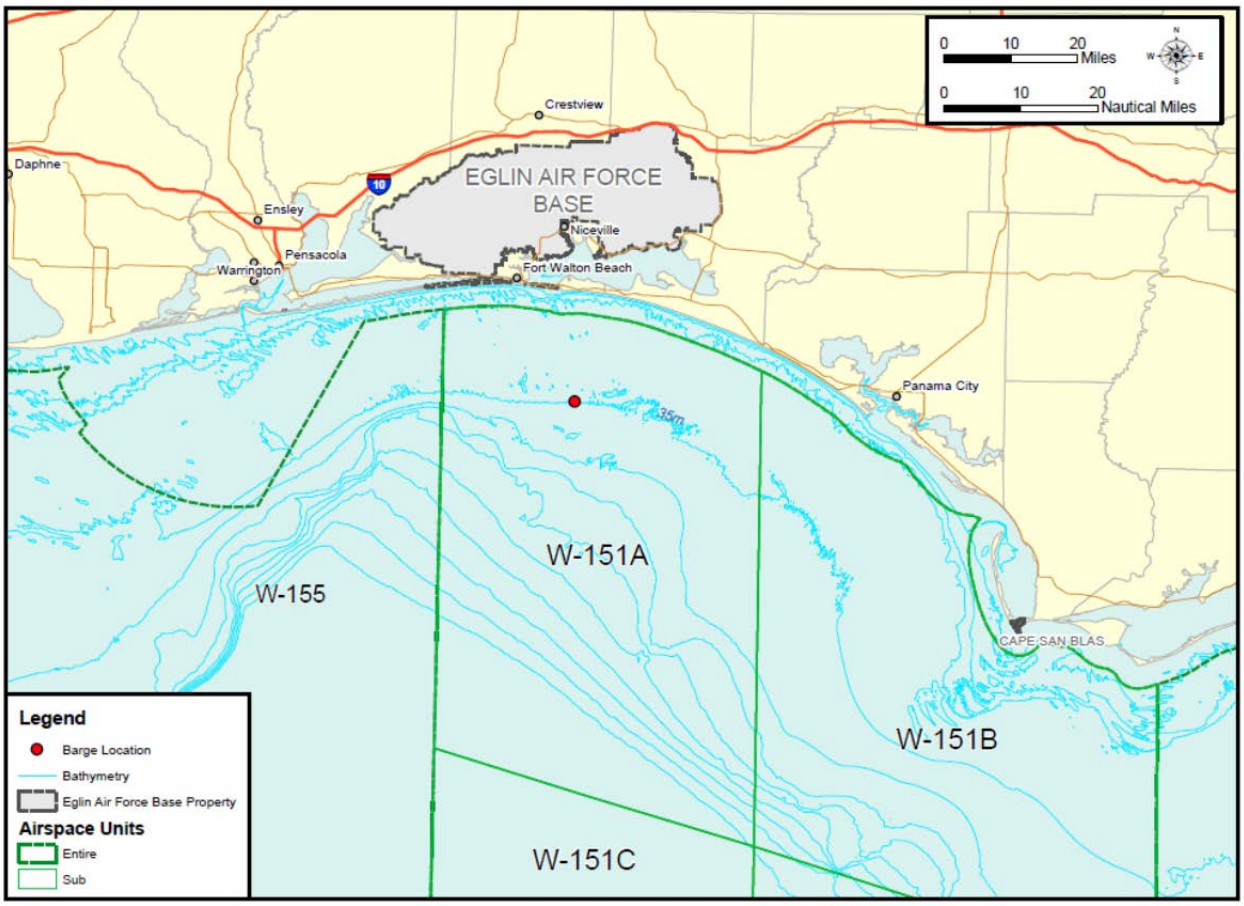

Figure 2-1. Maritime Strike Test Location in W-151A

3. MARINE MAMMAL SPECIES AND NUMBERS

Marine mammals that potentially occur within the northeastern GOM include numerous species of cetaceans and one sirenian, the Florida manatee (*Trichechus manatus latirostris*). Manatees primarily inhabit coastal and inshore waters, and are rarely sighted offshore. Maritime Strike missions will be conducted approximately 17 miles off the coast. Therefore manatee occurrence is considered unlikely, and further discussion of marine mammal species is limited to cetaceans.

Up to 28 cetacean species occur in the northern GOM. However, species with likely occurrence in the test area, and therefore evaluated in this document, are limited to the bottlenose dolphin (*Tursiops truncatus*) and Atlantic spotted dolphin (*Stenella frontalis*). These two species are frequently sighted in the northern Gulf over the continental shelf, in a water depth range that encompasses the Maritime Strike test location (Garrison, 2008; DON, 2007; Davis et al., 2000). Dwarf sperm whales (*Kogia sima*) and pygmy sperm whales (*Kogia breviceps*) are occasionally sighted over the shelf, but are not considered regular inhabitants (Davis et al., 2000). The remaining cetacean species are primarily considered to occur at and beyond the shelf break (water depth of approximately 200 meters), and are therefore not included.

Bottlenose and spotted dolphin density estimates used in this document were obtained from two sources. Bottlenose dolphin estimates were obtained from a habitat modeling project conducted for portions of the EGTTR, including the Maritime Strike project area, as described in Garrison (2008). As part of the modeling effort, personnel from NOAA Fisheries' Southeast Fisheries Science Center (SEFSC) conducted line transect aerial surveys of the continental shelf and coastal waters of the eastern GOM during winter (February 2007; water temperatures of 12-15°Celsius) and summer (July/August 2007; water temperatures >26°Celsius). The surveys covered nearshore and continental shelf waters (to a maximum depth of 200 meters), with the majority of effort concentrated in waters from the shoreline to 20 meters depth. Marine species encounter rates during the surveys were corrected for sighting probability and the probability that animals were available on the surface to be seen. The survey data were combined with remotely sensed environmental data/habitat parameters (water depth, sea surface temperature [SST], and chlorophyll-*a* concentration) to develop habitat models. The technical approach, described as Generalized Regression and Spatial Prediction, spatially projects the species-habitat relationship based on distribution of environmental factors, resulting in predicted densities for un-sampled locations and times. The spatial density model can therefore be used to predict relative density in unobserved areas and at different times of year based upon the monthly composite SST and chlorophyll datasets derived from satellite data. Similarly, the spatial density model can be used to predict relative density for any sub-region within the surveyed area.

Garrison (2008) produced bottlenose dolphin density estimates at various spatial scales within the EGTTR. At the largest scale, density data were aggregated into four principal strata categories: North-Inshore, North-Offshore, South-Inshore, and South-Offshore. Densities for these strata were provided in the published survey report. Unpublished densities were also provided for smaller blocks (sub-areas) corresponding to airspace units, and a number of these sub-areas were combined to form larger zones. Densities in these smaller areas were provided to Eglin AFB in Excel© spreadsheets by the report author.

For both large areas and sub-areas, regions occurring entirely within waters deeper than 200 meters were excluded from predictions, and those straddling the 200 meter isobath were clipped to remove deep water areas. In addition, because of limited survey effort, density estimates beyond 150 meters water depth are considered invalid. The environmental conditions encountered during the survey periods (February and July/August) do not necessarily reflect the range of conditions potentially encountered throughout the year. In particular, the transition seasons of spring (April-May) and fall (October-November) have a very different range of water temperatures. Accordingly, for predictions outside of the survey period or spatial range, it is necessary to evaluate the statistical variance in predicted values when attempting to apply the model. The coefficient of variation (CV) of the predicted quantity is used to measure the validity of model predictions. According to Garrison (2008), the best predictions have CV values of approximately 0.2. When CVs approach 0.7, and particularly when they exceed 1.0, the resulting model predictions are extremely uncertain and are considered invalid.

Based upon the preceding discussion, the bottlenose dolphin density estimate used in this document is the median density corresponding to sub-area 137 (Figure 3-1). The planned Maritime Strike test location lies within this sub-area. Within this block, Garrison (2008) provided densities based upon one year (2007) and five-year monthly averages for SST and chlorophyll. The five year average is considered preferable. Only densities with a CV rounded

to 0.7 or lower (i.e., 0.64 and below) were considered. The CV for June in this particular block is 0.62.

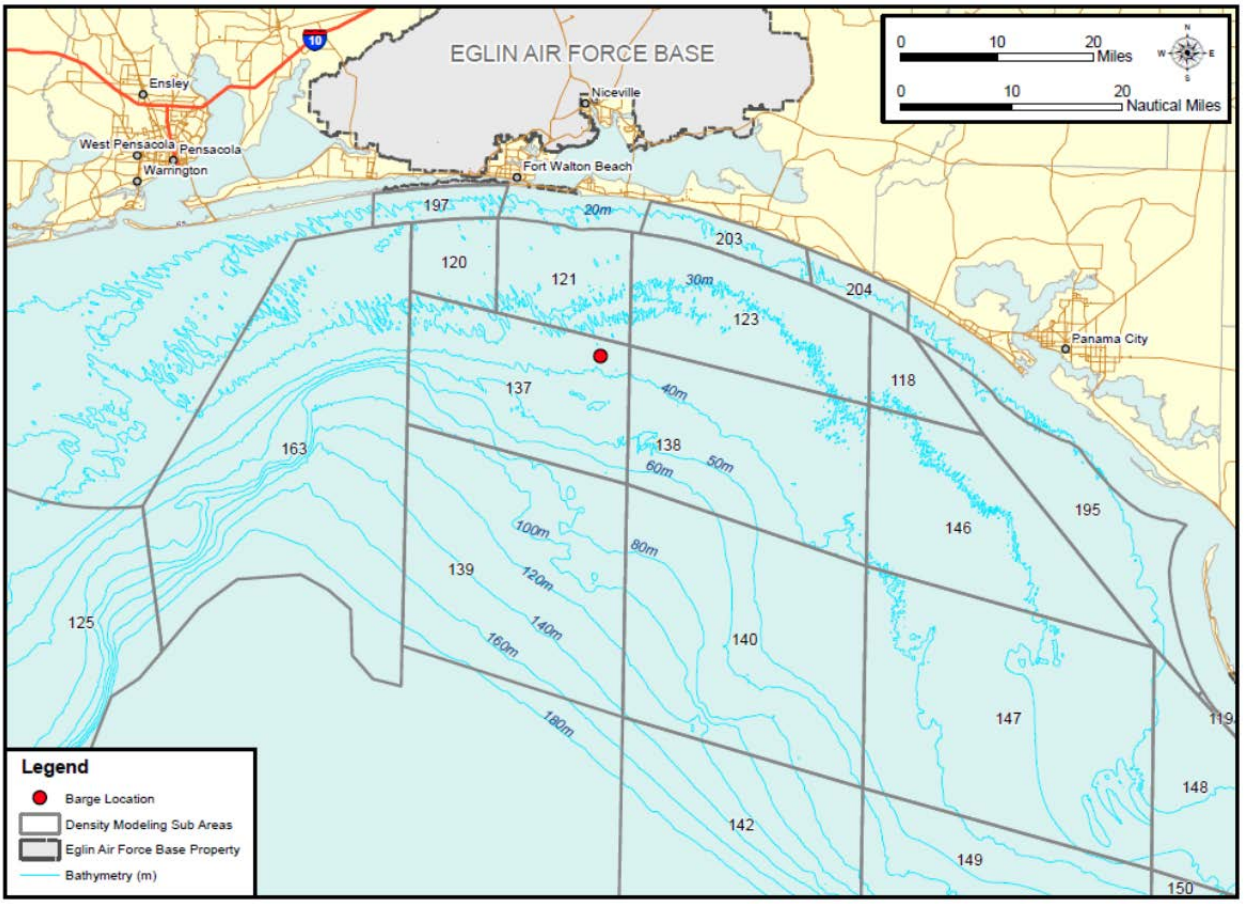

Figure 3-1. Sub-Areas Included in Garrison (2008)

Atlantic spotted dolphin density was derived from Fulling et al. (2003), which describes the results of mammal surveys conducted in association with fall ichthyoplankton surveys from 1998 to 2001. The surveys were conducted by SEFSC personnel from the U.S.-Mexico border to southern Florida, in water depths of 20 to 200 meters. Using the software program DISTANCE©, density estimates were generated for East and West regions, with Mobile Bay as the dividing point. The East region is used in this document. Densities were provided for Atlantic spotted dolphins and unidentified *T. truncatus*/*S. frontalis* (among other species). The unidentified *T. truncatus*/*S. frontalis* category is treated as a separate species group with a unique density. Density estimates from Fulling et al. (2003) were not adjusted for sighting probability (perception bias) or surface availability (availability bias) [g(0) = 1] in the original survey report, likely resulting in underestimation of true density. Perception bias refers to the failure of observers to detect animals, although they are present in the survey area and available to be seen. Availability bias refers to animals that are in the survey area, but are not able to be seen because they are submerged when observers are present. Perception bias and availability bias result in the underestimation of abundance and density numbers (negative bias).

Fulling et al. (2003) did not collect data to correct density for perception and availability bias. However, in order to address this negative bias, Eglin AFB has adjusted density estimates based

on information provided in available literature. There are no published g(0) correction factors for Atlantic spotted dolphins. However, Barlow (2006) estimated g(0) for numerous marine mammal species near the Hawaiian Islands, including offshore pantropical spotted dolphins (*Stenella attenuata*). Separate estimates for this species were provided for group sizes of 1 to 20 animals [g(0) = 0.76], and greater than 20 animals [g(0) = 1.00]. Although Fulling et al. (2003) sighted some spotted dolphin groups of more than 20 individuals, the 0.76 value is used as a more conservative approach. Barlow (2006) provides the following equation for calculating density:

$$\text{Density (\# animals/km}^2) = \frac{(n)\,(S)\,(f_0)}{(2L)\,(g_0)}$$

Where n = number of animal group sightings on effort
S = mean group size
f(0) = sighting probability density at zero perpendicular distance (influenced by species detectability and sighting cues such as body size, blows, and number of animals in a group)
L = transect length completed (km)
g(0) = probability of seeing a group directly on a trackline (influenced by perception bias and availability bias)

Because (n), (S), and (f_0) cannot be directly incorporated as independent values due to lack of the original information, we substitute the variable $X_{species}$ which incorporates all three values, such that $X_{species} = (n)(S)(f_0)$ for a given species. This changes the density equation to:

$$D = \frac{X_{species}}{(2L)\,(g_0)}$$

Using the minimum density estimates provided in Fulling et al. (2003) for Atlantic spotted dolphins and solving for $X_{SpottedDolphin}$:

$$0.201 = \frac{X_{Spotted\ Dolphin}}{(2)\,(816)\,(1.0)}$$

$X_{SpottedDolphin} = 328.032.$

Placing this value of $X_{SpottedDolphin}$ and the revised g(0) estimate (0.76) in the original equation results in the following adjusted density estimate for Atlantic spotted dolphin:

$$D_{Adjusted} = \frac{328.032}{(2)(816)(0.76)}$$

$D_{Adjusted} = 0.265$

Using the same method, adjusted density for the unidentified *T. truncatus*/*S. frontalis* species group is 0.009 animals/km^2. There are no variances attached to either of these recalculated density values, so overall confidence in these values is unknown.

Table 3-1 shows the densities for each species and species group used in this document to calculate potential takes.

Table 3-1. Marine Mammal Density Estimates

Species	Density (animals/km^2)
Bottlenose dolphin[1]	0.455
Atlantic spotted dolphin[2]	0.265
Unidentified bottlenose dolphin/Atlantic spotted dolphin[2]	0.009

[1]Source: Garrison, 2008; adjusted for observer and availability bias by the author
[2]Source: Fulling et al., 2003; adjusted for negative bias based on information provided by Barlow (2003; 2006)

4. AFFECTED SPECIES STATUS AND DISTRIBUTION

Information on each dolphin species, including general descriptions, status, and occurrence, is provided below. Descriptions include Potential Biological Removal (PBR). PBR is defined as the maximum number of animals that may be removed, not including natural mortalities, from a stock while allowing that stock to reach or maintain its optimal sustainable population. In addition, the NMFS has identified certain cetacean stocks as strategic. A "strategic stock" is a marine mammal stock considered likely to be listed under the Endangered Species Act of 1973 (ESA), currently listed under the ESA, currently listed as depleted under the MMPA, or for which the level of non-natural mortality or serious injury (e.g. from commercial fishing) exceeds the PBR level.

Distribution of cetaceans in the Gulf is influenced by hydrographic and bathymetric features. The dominant hydrographic feature in the Gulf is the Loop Current that, though generally south of the continental slope, can generate anti-cyclonic (clockwise circulating) and cyclonic (counterclockwise) eddies that move onto or influence the slope and shelf regions. Davis et al. (2000) noted during 1997-98 surveys of the northern Gulf of Mexico that cetaceans were concentrated along the continental slope and in or near cyclonic eddies. Cetaceans may also be associated with seafloor features such as the DeSoto Canyon, Florida Escarpment, Mississippi Canyon, and Mississippi River Delta. These and other bathymetric features are shown on Figure 4-1.

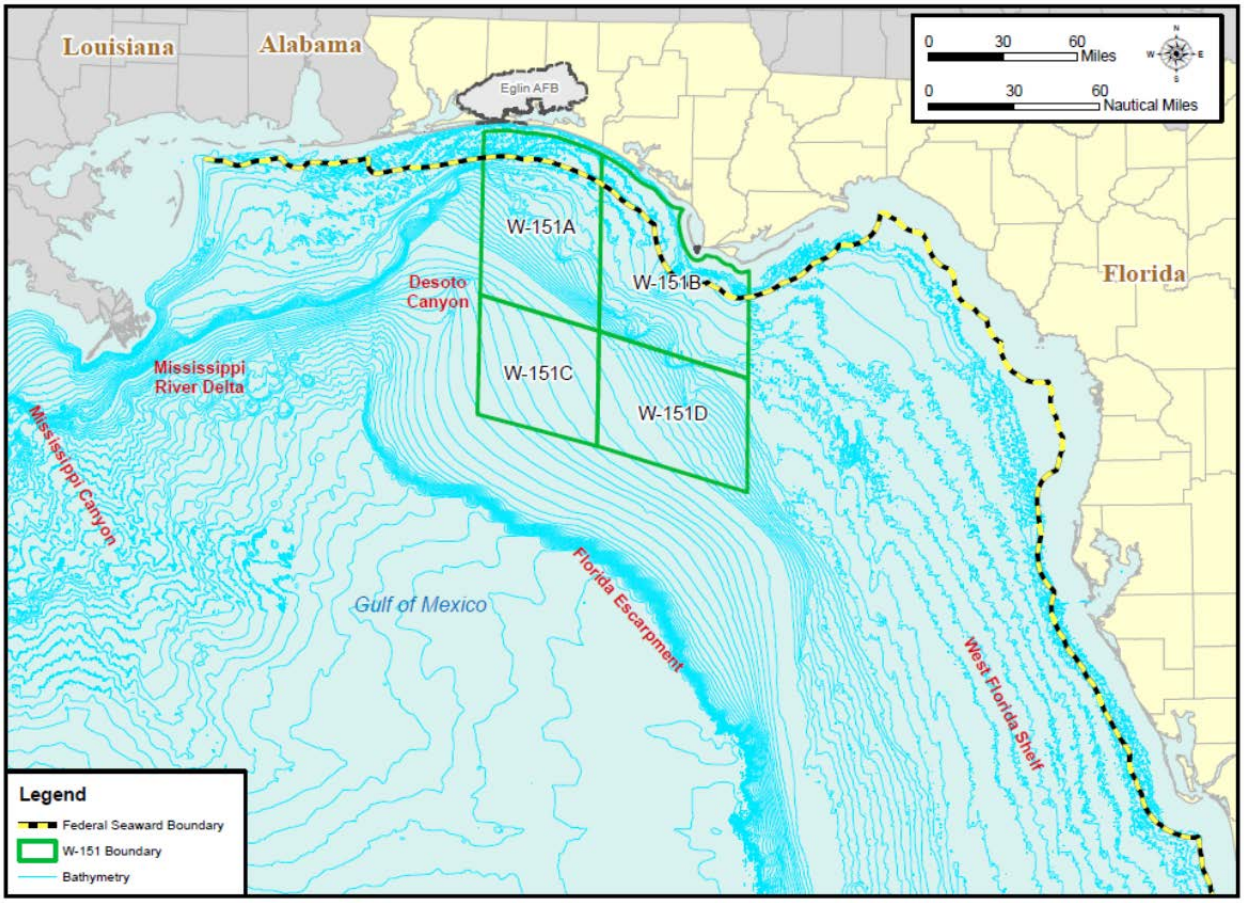

Figure 4-1. Topographical Features of the Gulf of Mexico in Relation to W-151

4.1 Atlantic bottlenose dolphin (*Tursiops truncatus*)

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

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

Status **–**In the northern GOM, there are coastal stocks; a continental shelf stock; an oceanic stock; and 32 bay, sound, and estuarine stocks (Waring et al., 2006). Sellas et al. (2005) reported the first evidence that the coastal stock off west central Florida is genetically separated from the adjacent inshore areas. Table 4-1 summarizes information on bottlenose dolphin stocks that occur in the north-central Gulf of Mexico, although not all these stocks have an equal probability of occurrence in the Maritime Strike test area. More detailed descriptions follow the table. Descriptions were obtained from stock assessment reports available on the NMFS website.

Table 4-1. Bottlenose Dolphin Stocks in the North-Central Gulf of Mexico

Stock		Distribution	Strategic Stock	Estimated Abundance	PBR
Bay, Sound, & Estuarine Stocks:	Choctawhatchee Bay	Areas of contiguous, enclosed, or semi-enclosed water bodies	Yes	179 resident, 53 transient	1.7
	Pensacola/East Bay		Yes	33	U
	St. Andrew Bay		Yes	124	U
Gulf of Mexico Northern Coastal		Waters from shore to the 20-meter (66-foot) isobath, from the Mississippi River delta to the Florida Big Bend region	Yes	2,473	20
Northern Gulf of Mexico Continental Shelf		Waters between the 20- and 200-meter (66- and 656-foot) isobaths, from Texas to Key West	No	17,777	U
Northern Gulf of Mexico Oceanic		Waters from the 200-meter (656-foot) isobath to the seaward extent of the U.S. Exclusive Economic Zone	No	5,806	42

PBR = Potential Biological Removal; U = undetermined

Genetic, photo-identification, and tagging data support the concept of relatively discrete bay, sound, and estuarine stocks. The NMFS has provisionally identified 32 such stocks which inhabit areas of contiguous, enclosed, or semi-enclosed water bodies adjacent to the northern GOM. The stocks are based on a description of dolphin communities in some areas of the Gulf coast. A community is generally defined as resident dolphins that regularly share a large portion

of their range; exhibit similar distinct genetic profiles; and interact with each other to a much greater extent than with dolphins in adjacent waters. Although the shoreward boundary of W-151 is beyond these environments, individuals from these stocks could potentially enter the study area. Movement between various communities has been documented (Waring et al., 2009), and Fazioli et al. (2006) reported that dolphins found within bays, sounds, and estuaries on the west central Florida coast move into the nearby Gulf waters used by coastal stocks. Maritime Strike activities will occur seaward of the area considered to be occupied by the Choctawhatchee Bay stock. The best abundance estimate for this stock, as provided in the Stock Assessment Report, is 179 resident dolphins, with an additional 232 transient dolphins. Stocks immediately to the west and east of Choctawhatchee Bay include Pensacola/East Bay and St. Andrew Bay stocks. PBR for the Choctawhatchee Bay stock is 1.7 individuals. NMFS considers all 32 stocks to be strategic.

Three coastal stocks have been identified in the northern GOM, occupying waters from the shore to the 20-meter (66-foot) isobath: Eastern Coastal, Northern Coastal, and Western Coastal stocks. The Western Coastal stock inhabits nearshore waters from the Texas/Mexico border to the Mississippi River Delta. The Northern Coastal stock's range is considered to be from the Mississippi River Delta to the Big Bend region of Florida (approximately 84°W). The Eastern Coastal stock is defined from 84°W to Key West, Florida. Of the coastal stocks, the Northern Coastal is geographically most closely associated with the Maritime Strike mission area. PBR is 20 individuals. Prior to 2012, this stock was not considered strategic. However, the Draft 2012 Stock Assessment Report identifies an ongoing Unusual Mortality Event of unprecedented size and duration (since February 2012) that has resulted in NMFS' reclassification of this stock as strategic.

The Northern GOM Continental Shelf stock is defined as bottlenose dolphins inhabiting the waters from the Texas/Mexico border to Key West, Florida, between the 20- and 200-meter (66- and 656-foot) isobaths. The continental shelf stock probably consists of a mixture of coastal and offshore ecotypes. PBR is undetermined, and the stock is not considered strategic.

The Oceanic stock is provisionally defined as bottlenose dolphins inhabiting waters from the 200-meter (656-foot) isobath to the seaward extent of the U.S. Exclusive Economic Zone. This stock is believed to consist of the offshore form of bottlenose dolphins. The continental shelf stock may overlap with the oceanic stock in some areas and may be genetically indistinguishable. PBR is 42 individuals, and the stock is not considered strategic.

Diving Behavior – Dive durations as long as 15 minutes are recorded for trained individuals (Ridgway et al., 1969). Typical dives, however, are more shallow and of a much shorter duration. Mean dive durations of Atlantic bottlenose dolphins typically range from 20 to 40 seconds at shallow depths (Mate et al., 1995) and can last longer than 5 minutes during deep offshore dives (Klatsky et al., 2005). Offshore bottlenose dolphins regularly dive to 450 meters (1,476 feet) and possibly as deep as 700 meters (2,297 feet) (Klatsky et al., 2005).

Acoustics and Hearing – Sounds emitted by bottlenose dolphins have been classified into two broad categories: pulsed sounds (including clicks and burst-pulses) and narrow-band continuous sounds (whistles), which usually are frequency modulated. Clicks and whistles have a dominant frequency range of 110 to 130 kiloHertz (kHz) and a source level of 218 to 228 decibels referenced to one micropascal-meter (dB re 1 μPa-m peak-to-peak) (Au, 1993) and 3.4 to

14.5 kHz and 125 to 173 dB re 1 μPa-m peak-to-peak, respectively (Ketten, 1998). Whistles are primarily associated with communication and can serve to identify specific individuals (i.e., signature whistles) (Caldwell and Caldwell, 1965; Janik et al., 2006). Up to 52 percent of whistles produced by bottlenose dolphin groups with mother-calf pairs can be classified as signature whistles (Cook et al., 2004). Sound production is also influenced by group type (single or multiple individuals), habitat, and behavior (Nowacek, 2005). Bray calls (low-frequency vocalizations; majority of energy below 4 kHz), for example, are used when capturing fishes in some regions (Janik, 2000). Additionally, whistle production has been observed to increase while feeding (Acevedo-Gutiérrez and Stienessen, 2004; Cook et al., 2004). Furthermore, both whistles and clicks have been demonstrated to vary geographically in terms of overall vocal activity, group size, and specific context (e.g., feeding, milling, traveling, and socializing) (Jones and Sayigh, 2002; Zaretsky et al., 2005; Baron, 2006).

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

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

Distribution –Bottlenose dolphins are distributed worldwide in tropical and temperate waters. The species occurs in all three major oceans and many seas. In the western North Atlantic, bottlenose dolphins occur as far north as Nova Scotia but are most common in coastal waters from New England to Florida, the Gulf of Mexico, the Caribbean, and southward to Venezuela and Brazil (Würsig et al., 2000). Bottlenose dolphins occur seasonally in estuaries and coastal embayments as far north as Delaware Bay (Kenney, 1990) and in waters over the outer continental shelf and inner slope, as far north as Georges Bank (CETAP, 1982; Kenney, 1990).

The bottlenose dolphin is by far the most widespread and common cetacean in coastal waters of the GOM (Würsig et al., 2000). Bottlenose dolphins are frequently sighted near the Mississippi

River Delta (Baumgartner et al., 2001) and have even been known to travel several kilometers up the Mississippi River.

Gulf of Mexico

Bottlenose dolphins are abundant in continental shelf waters throughout the northern GOM (Fulling et al., 2003; Waring et al. (2006), including the outer continental shelf, upper slope, nearshore waters, the DeSoto Canyon region, the West Florida Shelf, and the Florida Escarpment. Mullin and Fulling (2004) noted that in oceanic waters, bottlenose dolphins are encountered primarily in upper continental slope waters (less than 1,000 meters in bottom depth) and that highest densities are in the northeastern Gulf. Significant occurrence is expected near all bays in the northern Gulf.

The results of a recent survey effort of nearshore and continental shelf waters of the eastern GOM (Garrison, 2008) identified four areas where bottlenose dolphins were clustered in winter: nearshore waters off Louisiana, the Florida Panhandle, north of Tampa Bay, and southwestern Florida. Dolphins were also common over the entire shelf. In summer, the number of group sightings was comparatively lower than in winter (162 versus 281), and bottlenose dolphins were more evenly distributed throughout coastal and shelf waters.

4.2 Atlantic spotted dolphin (*Stenella frontalis*)

Description – The Atlantic spotted dolphin has features that resemble the bottlenose dolphin. In body shape, it is typically somewhat larger than the inshore bottlenose dolphin ecotype, with a moderately long, thick beak. The dorsal fin is tall and falcate and there is generally a prominent spinal blaze. Adults are up to 2.3 meters (7.5 feet) long and can weigh as much as 143 kilograms (315 pounds) (Jefferson et al., 1993). Atlantic spotted dolphins are born spotless and develop spots as they age (Perrin et al., 1994; Herzing, 1997). Some individuals become so heavily spotted that the dark cape and spinal blaze are difficult to see (Herzing, 1997).

There is marked regional variation in adult body size of the Atlantic spotted dolphin (Perrin et al., 1987). In addition, there are two forms: a robust, heavily spotted form that inhabits the continental shelf, usually found within 250 to 350 km (135 to 189 NM) of the coast, and a smaller, less-spotted form that inhabits offshore waters (Perrin et al., 1994). The largest body size occurs in waters over the continental shelf of North America (East Coast and Gulf of Mexico) and Central America (Perrin, 2002). The smaller, offshore form is not known to occur in the GOM.

Status – The most recent abundance estimate, as provided in the 2012 Draft Stock Assessment Report, is 37,611 individuals in the northern GOM (outer continental shelf and oceanic waters). The northern GOM population is considered genetically differentiated from the western North Atlantic populations. PBR for this species is undetermined. This is not considered a strategic stock

Diving Behavior – Information on diving depth for this species is available from a satellite-tagged individual in the Gulf of Mexico (Davis et al., 1996a). This individual made short, shallow dives to less than 10 meters (33 feet) and as deep as 60 meters (197 feet), while in waters over the continental shelf on 76 percent of dives.

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

Hearing ability for the Atlantic spotted dolphin is unknown. However, odontocetes are generally adapted to hear high-frequencies (Ketten, 1997).

Distribution – Atlantic spotted dolphins are distributed in warm-temperate and tropical Atlantic waters from northern New England to Venezuela, including the GOM and the Caribbean Sea (Perrin et al., 1987). Atlantic spotted dolphins may occur in both continental shelf and offshore waters (Perrin et al., 1994). In oceanic waters, this species usually occurs near the shelf break and upper continental slope waters (Davis et al., 1998; Mullin and Hansen, 1999).

Gulf of Mexico

Atlantic spotted dolphins in the northern GOM are abundant in continental shelf waters (Fulling et al., 2003; Waring et al., 2006). In the GOM, Atlantic spotted dolphins are most abundant east of Mobile Bay (Fulling et al., 2003). On the West Florida shelf, spotted dolphins are more common in deeper waters than bottlenose dolphins (Griffin and Griffin, 2003); Griffin and Griffin (2004) reported higher densities of spotted dolphins in this area during November through May.

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

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

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

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

5. TAKE AUTHORIZATION REQUESTED

The Marine Mammal Protection Act (MMPA) established, with limited exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction. The act further regulates "takes" of marine mammals in the high seas by vessels or persons under U.S. jurisdiction. The term *take*, as defined in Section 3 (16 United States Code [USC] 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 for two levels thereof, Level A (potential injury) and Level B (potential disturbance).

The National Defense Authorization Act of fiscal year 2004 (Public Law 108-136) amended the definition of harassment for military readiness activities. Military readiness activities, as defined in Public Law 107-314, Section 315(f), includes all training and operations related to combat, and the adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat. This definition, therefore, includes Maritime Strike activities occurring in the EGTTR mission area. The amended definition of harassment for military readiness activities 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"), or

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

Section 101(a)(5) of the MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of marine mammals by U.S. citizens who engage in a specified activity (exclusive of commercial fishing) within a specified geographic region. These incidental takes may be allowed if the National Marine Fisheries Service (NMFS) determines the taking will have a negligible impact on the species or stock and the taking will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses.

Pursuant to Section 101(a)(5), an Incidental Harassment Authorization (IHA) for the incidental taking (but not intentional taking) of marine mammals is requested for Maritime Strike TD&E test activities within the EGTTR. Take is requested for harassment only, including Level A and Level B (physiological and behavioral) harassment. Taking into consideration the mitigation measures identified in Chapter 11, no takes in the form of mortality are anticipated or requested. The subsequent analyses in this request will identify the applicable types of take.

6. NUMBERS AND SPECIES TAKEN

Cetaceans spend their entire lives in the water and are entirely submerged below the surface most of the time (greater than 90 percent for most species). When at the surface, unless engaging in behaviors such as jumping, spyhopping, etc., the body is almost entirely below the water's surface, with only the blowhole exposed to allow breathing. This can make cetaceans difficult to locate visually and also exposes them to underwater noise, both natural and anthropogenic, essentially 100 percent of the time because their ears are nearly always below the water's surface. Marine mammals may be potentially injured or harassed due to noise or pressure waves from detonation of live ordnance during Maritime Strike tests. The potential numbers and species taken are assessed in this section. Appendix A includes a description of the acoustic modeling methodology used to estimate exposures as well as model results. Typical mission scenarios are described in Section 1. Three key sources of information are necessary for estimating potential noise effects on marine mammals: 1) the zone of influence, which is the distance from the explosion to which a particular energy or pressure threshold extends; 2) the density of animals potentially occurring within the zone of influence; and 3) the number of events.

Zone of Influence

The Zone of Influence (ZOI) is defined as the area or volume of ocean in which marine mammals could potentially be exposed to various noise thresholds associated with exploding ordnance. Marine mammals may be affected by certain energy and pressure levels resulting from the detonations. Criteria and thresholds generally used for impact assessment in this document were originally developed for the shock trials of the *USS SEAWOLF* and *USS Winston S. Churchill* (DDG-81). An exception, explained later in this section, is the modification of the Level B harassment pressure metric associated with temporary threshold shift from 12 pounds per square inch (psi) to 23 psi. These thresholds are currently accepted and used by the NMFS for all similar underwater noise impact analyses.

Criteria for assessing potential impacts may include 1) mortality, 2) injury (hearing-related and non-hearing related) and 3) harassment (temporary loss of some hearing ability and behavioral reactions). Due to low mortality estimates (about 0.5 bottlenose dolphins and 0.1 Atlantic spotted dolphins) and the implementation of required mitigation measures, mortality resulting from these tests is considered highly unlikely. The paragraphs below provide a general discussion of the various metrics, criteria, and thresholds used for impact assessment.

Metrics

Standard impulsive and acoustic metrics were used for the analysis of underwater energy and pressure waves in this document. Four metrics are particularly important for this risk assessment.

- *Peak Pressure*: This is the maximum positive pressure, or peak amplitude of impulsive sources, for an arrival. Units are in psi.
- *Positive Impulse*: This is the time integral of the pressure over the initial positive phase of an arrival. This metric represents a time-averaged pressure disturbance from an

explosive source. Units are typically Pascal-second (Pa-s) or pounds per square inch per millisecond (psi-msec). The latter is used in this document. There is no decibel analog for impulse.

- *Energy flux density (EFD)*: For plane waves, which is assumed for acoustic energy produced by the actions described in this document, EFD is the time integral of the squared pressure divided by the impedance. EFD levels have units of Joules per square meter (J/m^2), inch-pounds per square inch ($in\text{-}lb/in^2$), or decibels referenced to one squared microPascal-second (dB re 1 μPa^2-s) (with the usual convention that the reference impedance is the same as the impedance at the field point). The latter unit is used in this document.
- *1/3-Octave EFD*: This is the EFD in a 1/3-octave frequency band. A 1/3-octave band has upper and lower frequency limits with a ratio of $2^{1/3}$. Therefore, the band width is approximately 25 percent above and below center frequency. The 1/3 octave selected is the hearing range at which the subject animals' hearing is believed to be most sensitive.

Criteria and Thresholds: Mortality

Lethal impacts, as evaluated in this document, are associated with exposure to a certain level of positive impulse pressure, expressed as psi-msec. The criterion for marine mammal mortality used in the *Churchill* document is "onset of severe lung injury." The threshold is stated in terms of the Goertner (1982) modified positive impulse with value indexed to 30.5 psi-msec. The Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way. Because animals of greater mass can withstand greater pressure shock waves, this threshold was conservatively based on the mass of a dolphin calf. This threshold is further conservative in that, although it corresponds to only a one percent chance of mortal injury, any animal experiencing onset of severe lung injury is considered to be lethally taken.

Criteria and Thresholds: Injury (Level A Harassment)

Non-lethal injurious impacts are currently defined with dual criteria: 1) eardrum (i.e., tympanic-membrane [TM]) rupture, and 2) the onset of slight lung injury. These criteria are considered indicative of the onset of injury. The more conservative (i.e., most impactive) of the two thresholds are typically used for impact analysis as a conservation measure. The threshold for TM rupture is considered to correspond to a 50 percent rupture rate (i.e., 50 percent of animals exposed to the threshold are expected to suffer TM rupture). This threshold is considered to be an EFD value of 1.17 $in\text{-}lb/in^2$, which corresponds to approximately 205 dB re 1 μPa^2-s (the term "sound exposure level" is increasingly used synonymously with EFD). TM rupture is not necessarily considered a life-threatening injury, but is a useful index of possible injury that is well-correlated with measures of permanent hearing impairment (e.g., Ketten [1998] indicates a 30 percent incidence of permanent threshold shift (PTS) at this threshold).

The onset of slight lung injury is the second criterion considered indicative of non-lethal injury. A cetacean would be expected to recover from this type of injury. The criterion is associated with a positive impulse level which is given in terms of the Goertner (1982) modified positive impulse metric indexed to 13 psi-msec. The 13 psi-msec threshold corresponds to slight lung injury in a dolphin calf. The impact range for similar injury in an adult dolphin or larger

cetacean would be less. However, as a conservative measure, the 13 psi-msec threshold is endorsed by NMFS for use in estimating impacts to all cetaceans.

Criteria and Thresholds: Non-Injurious Impacts (Level B Harassment)

Public Law 108-136 (2004) amended the definition of Level B harassment under the MMPA for military readiness activities. For such activities, Level B harassment is defined as "any act that 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." Thus, Level B harassment is limited to non-injurious impacts. Unlike Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may be considered Level B harassment.

The physiological effect associated with non-injurious Level B harassment is TTS, which is defined as a temporary, recoverable loss of hearing sensitivity at a particular frequency or frequency range. Similar to Level A harassment, TTS is currently defined with dual criteria. The first criterion is an EFD of 182 dB re 1 μPa^2-s in any 1/3-octave band at frequencies above 100 Hz for toothed whales and above 10 Hz for baleen whales. The second criterion is stated in terms of peak pressure at 23 psi. This threshold is derived from the CHURCHILL document and was subsequently adopted by NMFS in its Final Rule on the unintentional taking of marine animals incidental to the shock testing (NMFS, 2001). The original criteria incorporated 12 psi. The current criteria and threshold for peak pressure over all exposures was updated from 12 psi to 23 psi for explosives less than 907 kg (2,000 lb) based on an Incidental Harassment Authorization issued to the Air Force for a similar action (NOAA, 2006). Peak pressure and energy scale at different rates with charge weight, so that ranges based on the peak-pressure threshold are much greater than those for the energy metric when charge weights are small, even when source and animal are away from the surface. In order to more accurately estimate TTS for smaller detonations while preserving the safety feature provided by the peak pressure threshold, the threshold is appropriately scaled for small shot detonations. This scaling is based on the similitude formulas (e.g., Urick, 1983) used in virtually all compliance documents for short ranges. Further, the peak pressure threshold for TTS due to explosives offers a safety margin for source or animal near the ocean surface. The more conservative (i.e., larger) range of the two criteria is used to estimate impacts to marine mammals in this document.

Behavioral reactions may occur at noise levels below those considered to cause TTS in marine mammals, particularly in cases of multiple detonations. Behavioral effects may include decreased ability to feed, communicate, migrate, or reproduce, among others. Such effects are known as sub-TTS Level B harassment. Behavioral effects are currently considered to occur at an EFD level of 177 dB re 1 μPa^2-s. Although dual criteria have been developed for Level A and Level B (physiological) harassment, at the time of this writing a dual criterion has not been adopted by NMFS for non-TTS behavioral responses by marine mammals due to lack of empirical information and data. Therefore, while it would generally be expected that the threshold for behavioral modification would be lower than that causing TTS, since there is no psi-related behavioral metric, the impact area for physiological effects used for take estimates may in some cases be greater than that associated with behavioral effects.

Table 6-1 provides a summary of the thresholds and criteria discussed above and used in this document to estimate potential noise impacts to marine mammals.

Table 6-1. Criteria and Thresholds Used for Impact Analyses

Mortality	Level A Harassment		Level B Harassment		
30.5 psi-msec	205 dB re 1 μPa^2-s EFD*	13 psi-msec	182 dB re 1 μPa^2-s EFD*	23 psi peak pressure	177 dB re 1 μPa^2-s EFD*
Onset of severe lung injury	TM rupture in 50% of exposed animals	Onset of slight lung injury	TTS	TTS	Behavioral response

*In greatest 1/3-octave band above 10 Hz or 100 Hz

Marine Mammal Density

Density estimates for marine mammals occurring in the EGTTR are provided in Table 3-1. As discussed in Chapter 3, densities were derived from the results of published documents authored by NMFS personnel. Density is nearly always reported for an area (e.g., animals per square kilometer). Analyses of survey results may include correction factors for negative bias, such as the Garrison (2008) report for bottlenose dolphins. Even though Fulling et al. (2003) did not provide a correction for Atlantic spotted dolphins or unidentified bottlenose/spotted dolphins, Eglin AFB adjusted those densities based on information provided in other published literature (Barlow 2003; 2006). Although the study area appears to represent only the surface of the water (two-dimensional), density actually implicitly includes animals anywhere within the water column under that surface area. Density estimates usually assume that animals are uniformly distributed within the prescribed area, even though this is likely rarely true. Marine mammals are often clumped in areas of greater importance, for example, in areas of high productivity, lower predation, safe calving, etc. Density can occasionally be calculated for smaller areas, but usually there are insufficient data to calculate density for such areas. Therefore, assuming an even distribution within the prescribed area is the typical approach.

In addition, assuming that marine mammals are distributed evenly within the water column does not accurately reflect behavior. Databases of behavioral and physiological parameters obtained through tagging and other technologies have demonstrated that marine animals use the water column in various ways. Some species conduct regular deep dives while others engage in much shallower dives, regardless of bottom depth. Assuming that all species are evenly distributed from surface to bottom is almost never appropriate and can present a distorted view of marine mammal distribution in any region. Therefore, a depth distribution adjustment is applied to marine mammal densities in this document (Table 6-2). By combining marine mammal density with depth distribution information, a three-dimensional density estimate is possible. These estimates allow more accurate modeling of potential marine mammal exposures from specific noise sources.

Table 6-2. Depth Distribution for marine Mammals in the Maritime Strike Test Area

Species	Depth Distribution	Reference
Bottlenose dolphin	Daytime: 96% at <50 m, 4% at >50 m; Nightime: 51% at <50 m, 8% at 50-100 m, 19% at 101-250 m, 13% at 251-450 m, and 9% at >450 m.	Klatsky et al. (2007)
Atlantic spotted dolphin	76% at <10 m, 20% at 10-20 m, and 4% at 21-60 m.	Davis et al. (1996)

m = meters

Number of Events

The number of events for Maritime Strike activities generally corresponds to the number of live ordnance expenditures, as shown in Table 1-2. However, it should be noted that the number of bursts modeled for the CBU-103 cluster bomb is 202, which is the number of individual bomblets per bomb. Also, the 20 mm and 30 mm gunnery rounds were modeled as one burst each.

Exposure Estimates

Refer to Appendix A for a description of the acoustic modeling methodology used in this analysis. Table 6-3 provides the maximum estimated summer range, or radius, from the detonation point to which the various thresholds extend. This range is then used to calculate the total area of the ZOI. The calculated ZOIs are combined with the density estimates listed in Table 3-1 (adjusted for depth distribution) and the number of live munitions to provide an estimate of the number of marine mammals potentially exposed to the various impact thresholds (Table 6-4). For metrics with two criteria (e.g., 205 dB EFD and 13 psi-msec for Level A harassment), the criteria that yielded higher exposure estimates are presented and used for impact calculations. Appendix A contains model results for all criteria. The impact estimates shown in Table 6-4 do not account for required mitigation measures, which are expected to reduce the likelihood and extent of impacts. These measures are described in Chapter 11.

Table 6-3. Summer Threshold Radii (in meters) for Maritime Strike Ordnance

Munition	Height / Depth of Detonation	Mortality	Level A Harassment		Level B Harassment		
		30.5 psi-msec	205 dB EFD*	13 psi-msec	182 dB EFD*	23 psi	177 dB EFD*
GBU-10	Water Surface	202	275	362	1023	1280	1361
GBU-24	Water Surface	202	275	362	1023	1280	1361
GBU-31 (JDAM)	Water Surface	202	275	362	1023	1280	1361
	20 feet AGL	0	0	0	0	0	0
	5 feet underwater	385	468	700	2084	1281	2775
	10 feet underwater	457	591	836	2428	1280	3526
GBU-12	Water Surface	114	161	243	744	752	1020
GBU-38 (JDAM)	Water Surface	114	161	243	744	752	1020
	20 feet AGL	0	0	0	0	0	0
	5 feet underwater	239	280	445	1411	752	2070
	10 feet underwater	279	345	532	1545	752	2336
GBU-54 (LJDAM)	Water Surface	114	161	243	744	752	1020
AGM-65E/L/K/G2 (Maverick)	Water Surface	84	124	187	618	575	846
CBU-103	Water Surface	9	231	21	947	111	1335
AGM-114 (Hellfire)	Water Surface	46	70	105	425	353	618
M-117	20 feet AGL	0	0	0	0	0	0
	Water Surface	147	203	293	847	950	1125
PGU-13 HEI 30 mm	Water Surface	0	6	7	31	60	55
M56/PGU-28 HEI 20 mm	Water Surface	0	0	0	16	37	27

*In greatest 1/3-octave band above 10 Hz or 100 Hz

Table 6-4. Number of Marine Mammals Potentially Affected by Maritime Strike Test Missions

Species	Mortality	Level A Harassment	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Bottlenose dolphin	0.524	2.008	30.187	61.069
Atlantic spotted dolphin	0.145	1.050	16.565	31.345
Unidentified bottlenose dolphin/Atlantic spotted dolphin	0.010	0.040	0.597	1.208
TOTAL	**0.679**	**3.098**	**47.349**	**93.622**

The table indicates the potential for lethality, injury, and non-injurious harassment (including behavioral harassment) to marine mammals in the absence of mitigation measures. The numbers represent total impacts for all detonations combined. Mortality was calculated as approximately one-half an animal for bottlenose dolphins and about 0.1 animals for spotted dolphins. It is expected that, with implementation of the management practices outlined in Chapter 11, potential impacts would be mitigated to the point that there would be no mortality takes.

7. IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

Based on the low mortality exposure estimates calculated by the acoustic model combined with the implementation of mitigation measures identified in Chapter 11, zero marine mammals are expected to be affected by pressure levels associated with mortality. Therefore, Eglin AFB is requesting an IHA, as opposed to an LOA.

A maximum of up to approximately three marine mammals could potentially be exposed to injurious Level A harassment (approximately two bottlenose dolphins and one spotted dolphin). Level A harassment could result from exposure of marine mammals to 205 dB EFD energy

levels or to 13 psi-msec positive impulse. Since the threshold with the higher exposure numbers was used to determine takes, impacts are associated with the 205 dB EFD energy threshold, which corresponds to a 50 percent TM rupture rate.

A maximum of approximately 47 marine mammals could potentially be exposed to non-injurious (TTS) Level B harassment. TTS results from fatigue or damage to hair cells or supporting structures and may cause disruption in the processing of acoustic cues. However, hearing sensitivity is recovered within a relatively short time. As with takes for Level A harassment, the energy-related metric (182 dB EFD) results in higher exposure estimates.

Approximately 94 animals could potentially be exposed to noise corresponding to the behavioral threshold of 177 dB EFD during Maritime Strike missions. Behavioral harassment occurs at distances beyond the range of structural damage and hearing threshold shift. Possible behavioral responses to a detonation include panic, startle, departure from an area, and disruption of activities such as feeding or breeding.

None of the estimates above take into account the mitigation measures outlined in Chapter 11, which may reduce the number of exposures.

Atlantic spotted dolphins potentially affected by Maritime Strike test activities are part of the Northern Gulf of Mexico stock, which is considered to occur over the continental shelf from 10 to 200 meters depth, and onto the continental slope. This stock is not considered strategic. Four bottlenose dolphin stocks occur in the north-central GOM and could theoretically be affected by test activities. The Choctawhatchee Bay stock occurs north of the test site and is considered strategic. It is not probable that large numbers of dolphins from this stock would be affected, given that Maritime Strike activities will occur about 17 miles seaward of Choctawhatchee Bay. However, individuals may move into deeper water at times, and therefore potentially occur in the test area. In addition, individuals from other adjacent bay, sound, and estuarine stocks, such as the Pensacola/East Bay and St. Andrew Bay stocks (also considered strategic), could potentially transit through the area. Bottlenose dolphins affected by test activities are most likely to be associated with the Northern Coastal stock (shoreline to 20 meter depth; considered strategic) and Northern GOM Continental Shelf stock (20 meter to 200 meter depth; not considered strategic). Individuals from the Oceanic stock, which is not strategic, are unlikely to be affected because of their provisional distribution beyond the 200 meter isobath.

8. IMPACT ON SUBSISTENCE USE

Potential impacts resulting from the proposed activities will be limited to individuals of marine mammal species located in the Gulf of Mexico that have no subsistence requirements. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

9. IMPACTS TO MARINE MAMMAL HABITAT AND THE LIKELIHOOD OF RESTORATION

The primary sources of marine mammal habitat impact are noise and pressure waves resulting from live Maritime Strike missions. However, neither the noise nor overpressure constitutes a long-term physical alteration of the water column or bottom topography. In addition, they are not expected to affect prey availability, are of limited duration, and are intermittent in time.

Surface vessels associated with the missions are present in limited duration and are intermittent as well. Therefore, it is not anticipated that marine mammals will stop utilizing the waters of W-151, either temporarily or permanently, as a result of noise associated with mission activities.

Other factors related to Maritime Strike activities that could potentially affect marine mammal habitat include the introduction of metals and chemical materials into the water column via spent munitions and explosive byproducts. The effects of each were analyzed in the Maritime Strike Environmental Assessment (EA) (U.S. Air Force, 2012, in preparation) and were determined to be insignificant. The analysis in the EA is summarized in the following paragraphs.

Metals typically used to construct bombs, missiles, and gunnery rounds include copper, aluminum, steel, and lead, among others. Aluminum is also present in some explosive materials. These materials would settle to the seafloor after munitions are detonated. Metal ions would slowly leach into the substrate and the water column, causing elevated concentrations in a small area around munitions fragments. Some of the metals, such as aluminum, occur naturally in the ocean at varying concentrations and would not necessarily impact the substrate or water column. Other metals, such as lead, could cause toxicity in microbial communities in the substrate. However, such effects would be localized to a very small distance around munitions fragments and would not significantly affect the overall habitat quality of sediments in the northeastern Gulf. In addition, metal fragments would corrode, degrade, and become encrusted over time.

Chemical materials include explosive byproducts and also fuel, oil, and other fluids associated with remotely controlled target boats. Explosive byproducts would be introduced into the water column through detonation of live munitions. Explosive materials include 2,4,6-trinitrotoluene (TNT) and RDX, among others. Various byproducts are produced during and immediately after detonation of TNT and RDX. During the very brief time that a detonation is in progress, intermediate products may include carbon ions, nitrogen ions, oxygen ions, water, hydrogen cyanide, carbon monoxide, nitrogen gas, nitrous oxide, cyanic acid, and carbon dioxide (Becker, 1995). However, reactions quickly occur between the intermediates, and the final products consist mainly of water, carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen gas, although small amounts of other compounds are typically produced as well.

Chemicals introduced to the water column would be quickly dispersed by waves, currents, and tidal action, and eventually become uniformly distributed. A portion of the carbon compounds such as CO and CO_2 would likely become integrated into the carbonate system (alkalinity and pH buffering capacity of seawater). Some of the nitrogen and carbon compounds, including petroleum products, would be metabolized or assimilated by phytoplankton and bacteria. Most of the gas products that do not react with the water or become assimilated by organisms would be released to the atmosphere. Due to dilution, mixing, and transformation, none of these chemicals are expected to have significant impacts on the marine environment.

Explosive material that is not consumed in a detonation could sink to the substrate and bind to sediments. However, the quantity of such materials is expected to be inconsequential. Research has shown that if munitions function properly, nearly full combustion of the explosive materials will occur, and only extremely small amounts of raw material will remain. In addition, any remaining materials will be naturally degraded. TNT decomposes when exposed to sunlight (ultraviolet radiation), and is also degraded by microbial activity (Becker, 1995). Several types

of microorganisms have been shown to metabolize TNT. Similarly, RDX is decomposed by hydrolysis, ultraviolet radiation exposure, and biodegradation.

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

Based on the discussions in Section 9, marine mammal habitat will not be lost or modified.

11. MEANS OF AFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS

The potential takes discussed in Section 6 represent the maximum expected number of animals that could be exposed to particular noise and pressure thresholds. The impact estimates do not take into account measures that will be employed to minimize impacts to marine species (these measures will help ensure human safety of test participants and non-participants as well). Mitigation measures consist of visual monitoring to detect the presence of marine mammals and marine mammal indicators (large schools of fish and flocks of birds). Monitoring procedures are described in the following subsections.

Visual Monitoring

Visual monitoring will be required during Maritime Strike missions from surface vessels and high-definition video cameras. A large number of safety boats (approximately 20 to 25) will be stationed around the test site to clear non-participating vessels from the area. Based on the composite footprint, safety boats will be located approximately 15,289 meters (9.5 miles) from the detonation point. Actual distance will vary based on the size of the munition being deployed, but as a comparison tool, this distance is used for the mitigation plan. Trained marine species observers will be aboard at least two of these boats and will conduct protected species surveys before each test. The survey boats will be dedicated solely to observing for marine species while the remaining safety boats clear the area of non-authorized vessels. The area to be surveyed will encompass the largest applicable ZOI, which in almost all cases is the Level B behavioral harassment range, based on the particular ordnance involved in a given test. Based on acoustic modeling results for the summer season, the largest possible distance from the target to be surveyed is 3,526 meters (2.2 miles). This distance corresponds to the 177 dB EFD behavioral harassment threshold for 945 pound NEW munitions detonated at 10 feet underwater. The smallest distance to be surveyed is 37 meters (0.02 miles), which is the 23 psi Level B range for 20 mm gunnery rounds. The survey pattern will depend upon the size of the ZOI and may include line transects or circular routes. Because of human safety issues, observers will be required to leave the test area 30 minutes in advance of live weapon deployment and move to a position on the safety zone periphery, approximately 9.5 miles from the detonation point. Observers will continue to scan for marine mammals from the periphery, but effectiveness will be limited as the boat will remain at a designated station.

Mission-related personnel will be within the test area (on boats and the instrumentation barge) on each day of testing well in advance of weapon deployment, typically near sunrise. Target strikes are planned to occur within 300 to 600 feet of the barge. They will perform a variety of tasks including target preparation, equipment checks, etc., and will opportunistically observe for marine mammals and indicators as feasible throughout test preparation. However, such

observations are considered incidental and would only occur as time and schedule permits. Any sightings would be relayed to the control tower, as described in the detailed mitigation procedures below.

In addition to vessel-based monitoring, one to three video cameras will be positioned on an instrumentation barge anchored on-site, as described in Section 2.1.1, to allow for real-time monitoring for the duration of the mission. The camera configuration and actual number of cameras used would depend on the specific test being conducted. In addition to monitoring the area for test-specific issues, the camera(s) will also be used to monitor for the presence of protected species. A marine species observer would be located in the Eglin control tower, along with mission personnel, to view the video feed before and during test activities. The distance to which objects can be detected at the water surface by use of the cameras is considered generally comparable to that of the human eye. The barge will be located about 100 to 200 meters from the target. The marine mammal mortality threshold distance extends from 0 to 457 meters (depending on ordnance), and the Level A distance extends from 0 to 836 meters. Given these distances, observers could reasonably be expected to view a substantial portion of the mortality zone in front of the camera, although a small portion would be behind or to the side of the camera view. Some portion of the Level A harassment zone could also be viewed, although it would be less than that of the mortality zone (a large percentage would be behind or to the side of the camera view). Representative screen shots from three different cameras are shown in Figures 11-1 through 11-3.

Figure 11-1. Representative Screen Shot, Camera 1

Figure 11-2. Representative Screen Shot, Camera 2

Figure 11-3. Representative Screen Shot, Camera 3

At least two ordnance delivery aircraft will participate in each live weapon release mission, in addition to an E-9A surveillance plane. Prior to the test, Air Force pilots aboard mission aircraft may make a dry run over the target area to ensure it is clear of non-participating vessels before ordnance is deployed. Observation effectiveness may vary among aircraft types. Jets will fly at a minimum speed of 300 knots indicated air speed (approximately 345 miles per hour, depending on atmospheric conditions) and at a minimum altitude of 1,000 feet (305 meters). Due to the limited flyover duration and potentially high speed and altitude, observation for marine species would probably be only marginally effective at best, and pilots would, therefore, not participate in species surveys. The turboprop-driven E-9A aircraft is well suited to locating vessels on the

ocean surface through use of radar. However, the radar is not effective for detecting small marine species, and the aircraft configuration is not conducive to visually searching the ocean surface. Therefore, the E-9A would not participate in marine species surveys.

Environmental Considerations

Weather that supports the ability to observe marine mammals is required to effectively implement the surveys. Wind speed and the resulting surface conditions of the GOM are critical factors affecting observation effectiveness. Higher winds typically increase wave height and create "white cap" conditions, both of which limit an observer's ability to locate marine species at or near the surface. Maritime Strike missions will be delayed or rescheduled if the sea state is greater than number 4 of Table 11-1 at the time of the test. The lead scientist at the test site will make the final determination of whether conditions are conducive for sighting protected species or not. In addition, the test event will occur no earlier than two hours after sunrise and no later than two hours prior to sunset to ensure adequate daylight for pre- and post-mission monitoring

Table 11-1. Sea State Scale for Maritime Strike Surveys

Sea State Number	Sea Conditions
0	Flat calm, no waves or ripples.
1	Light air, winds 1-2 knots; wave height to 1 foot; ripples without crests.
2	Light breeze, winds 3-6 knots; wave height 1-2 feet; small wavelets, crests not breaking.
3	Gentle breeze, winds 7-10 knots; wave height 2-3.5 feet; large wavelets, scattered whitecaps.
4	Moderate breeze, winds 11-16 knots; wave height 3.5-6 feet; breaking crests, numerous whitecaps.

Survey Team

The survey team will consist of a combination of Air Force and civil service/civilian personnel. Vessel-based and video monitoring will be conducted during all test missions (maximum of two missions per day). The Eglin Range Safety Officer, in cooperation with the Santa Rosa Island Tower Control, will coordinate and manage all species observation efforts. Marine mammal sightings and other applicable information will be communicated to tower control. The safety officer and tower control will also be in continual contact with the test director throughout the mission and will coordinate information regarding range clearing. Final decisions regarding mission execution, including possible test delay or relocation based on marine mammal sightings, will be the responsibility of the safety officer, with concurrence from the test director. Lines of communication for marine mammal surveys are shown in Figure 11-4. Responsibilities of each survey component are described in the following paragraphs.

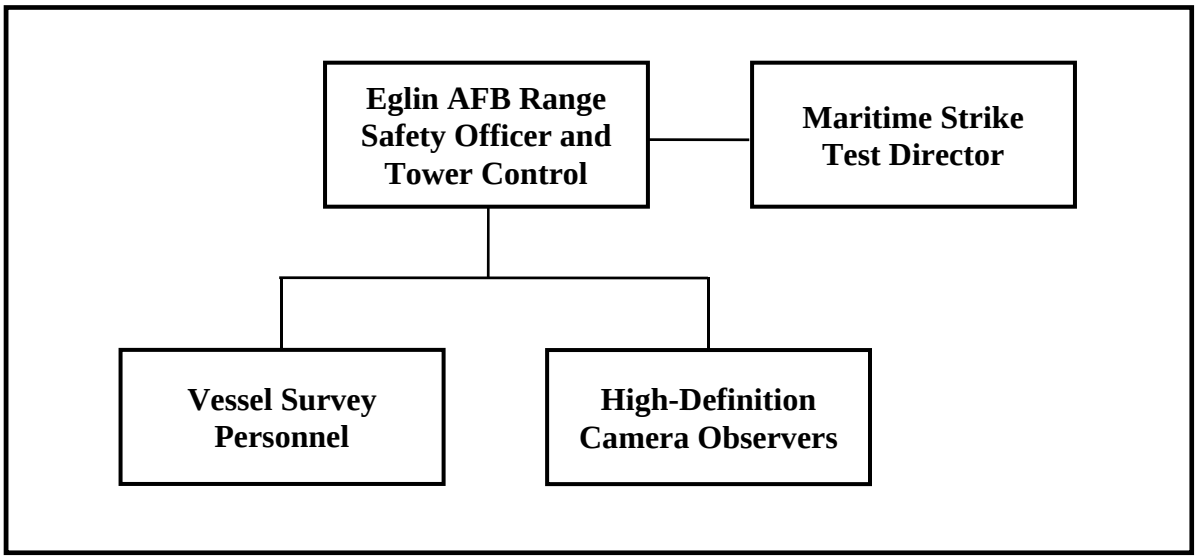

Figure 11-4. Marine Species Observer Lines of Communication

Surface Vessel Survey Team

Marine species and species indicator monitoring would be conducted from at least two surface vessels. Marine mammal indicators include large schools of fish (which could indicate the potential for marine mammals to enter the ZOI) and large, active groups of birds (which could indicate a large school of fish is present). Monitoring activities will be conducted from the highest point feasible on the vessels. Vessel-based observers will be familiar with marine life in the area and will be equipped with binoculars. If the entire ZOI cannot be adequately observed from a stationary point, the surface vessels will conduct line transects or move in other applicable patterns to provide sufficient coverage.

High-Definition Video Camera Controller

Maritime Strike test missions will be monitored from the instrumentation barge via live high-definition video feed. Video monitoring would, in addition to facilitating assessment of the test mission, make possible remote viewing of the area for determination of environmental conditions and the presence of marine species. Although not part of the surface vessel survey team, the video controller will report any marine mammal sightings to the Range Safety Officer/tower control. The entire ZOI will not be visible through the video feed for all tests.

Lines of Communication

The vessel monitoring teams and the video camera controller will have open lines of communication to facilitate real-time reporting of marine mammals and other relevant information, such as safety concerns. Direct radio communication between all surface vessel and barge personnel and the Range Safety Officer/tower control will be maintained throughout the test. Survey results from the surface vessels and video feed will be relayed to the Tower and

safety officer. The safety officer and test director will collaborate regarding range clearance, with the safety officer having final authority for mission go/no go decisions.

Detailed Mitigation Plan

The largest ZOI will be monitored for the presence of marine mammals and mammal indicators. Maritime Strike mitigations will be regulated by Air Force safety parameters. Although unexpected, any mission may be delayed or cancelled due to technical issues. Should a technical delay occur, all mitigation procedures would continue until either the test takes place or is canceled. To ensure the safety of survey personnel, the team will depart the test area approximately 30 minutes before live ordnance delivery. In some cases, two missions could occur in one day. If there is more than 1 hour between missions, pre-mission surveys would be reinitiated until 30 minutes prior to the second event. Stepwise mitigation procedures for the Maritime Strike mission are outlined below.

Pre-mission Monitoring: The purposes of pre-mission monitoring are to 1) evaluate the test site for environmental suitability of the mission, and 2) verify that the ZOI is free of visually detectable marine mammals, as well as potential indictors of these species. On the morning of the test, the test director and safety officer will confirm that there are no issues that would preclude mission execution and that weather is adequate to support mitigation measures.

(a) Two Hours Prior to Mission

Mission-related surface vessels will be on site at least two hours prior to the test mission. Observers on board at least one vessel will assess the overall suitability of the test site based on environmental conditions (sea state) and presence/absence of marine mammal indicators. This information will be relayed to the safety officer.

(b) One and One-Half Hours Prior to Mission

Vessel-based surveys and video camera surveillance will begin one and one-half hours prior to live weapon deployment. Surface vessel observers will survey the ZOI and relay all marine species and indicator sightings, including the time of sighting and direction of travel, if known, to the safety officer. Surveys will continue for approximately one hour. During this time, mission personnel in the test area will also observe for marine species as feasible. If marine mammals or indicators are observed within the ZOI, the test range will be declared “fouled,” a term that signifies to mission personnel that conditions are such that a live ordnance drop cannot occur (e.g., protected species or civilian vessels are in the test area). If no marine mammals or indicators are observed, the range will be declared “green.”

(c) One-Half Hour Prior to Mission

At approximately 30 minutes prior to live weapon deployment, marine species observers will be instructed to leave the test site and remain outside the safety zone, which on average will be 9.5 miles from the detonation point, (the actual size is determined by weapon NEW and method of delivery) during conduct of the mission. The survey team will continue to monitor for protected species while leaving the area. Once the survey vessels have arrived at the perimeter of the safety zone (approximately 30 minutes after being instructed to leave, depending on actual travel

time) the mission will be allowed to proceed. Protected species monitoring will continue from the periphery of the safety zone while the mission is in progress. The other safety boat crews would also be instructed to observe for marine species. Challenges from monitoring at this point include the potentially far distance from the target (on average 9.5 miles) and the requirement for the safety boats to remain on station. These observations are therefore considered supplemental to the dedicated protected species surveys and would not be relied upon as the primary monitoring method. After the survey vessels leave the area, marine species monitoring of the immediate test site will continue on the tower through the video feed received from the high definition cameras on the instrumentation barge.

(d) Execution of Mission

Immediately prior to live weapon drop, the test director and safety officer will communicate to confirm the results of marine mammal surveys and the appropriateness of proceeding with the mission. The safety officer will have final authority to proceed with, postpone, move, or cancel the mission. The mission would be postponed or moved if:

1. Any marine mammal is visually detected within the ZOI. Postponement would continue until the animal(s) that caused the postponement is confirmed to be outside of the ZOI due to the animal swimming out of the range.
2. Large schools of fish or large flocks of birds feeding at the surface are observed within the ZOI. Postponement would continue until these potential indicators are confirmed to be outside the ZOI.

In the event of a postponement, pre-mission monitoring would continue as long as weather and daylight hours allow.

Post-mission monitoring: Post-mission monitoring is designed to determine the effectiveness of pre-mission mitigation by reporting sightings of any dead or injured marine mammals. Post-detonation monitoring surveys will be conducted by the same observers that conducted pre-mission surveys, and will commence as soon as EOD personnel declare the test area safe. Vessels will move into the ZOI from outside the safety zone and monitor for at least 30 minutes, concentrating on the area down-current of the test site. The monitoring team will document any marine mammals that were killed or injured as a result of the test and, if practicable, recover and examine any dead animals. The species, number, location, and behavior of any animals observed will be documented and reported to the Eglin Natural Resources Section. If a second mission is conducted on the same day, the post-mission monitoring may also be considered part of pre-mission monitoring for the second event. In this case, pre-mission monitoring would continue until 30 minutes prior to weapon delivery.

The NMFS maintains stranding networks along U.S. coasts to collect and circulate information about marine mammal standings. Local coordinators may report stranding data to state and regional coordinators. Any observed dead or injured marine mammal would be reported to the appropriate coordinator.

12. MINIMIZATION OF ADVERSE EFFECTS ON SUBSISTENCE USE

Based on the discussion in Section 8, there are no impacts on the availability of species or stocks for subsistence use.

13. MONITORING AND REPORTING MEASURES

For Maritime Strike missions, prospective mission sites will be monitored for marine mammal presence prior to commencement of activities. Vessel-based monitoring will continue up to 30 minutes before live ordnance delivery. In addition, there will be 20-25 boats stationed around the periphery (approximately 9.5 miles from the detonation point) that continue to monitor for protected species that may enter the safety footprint. Furthermore, after the survey vessels have exited the safety footprint, a trained marine species observer located in the observation tower will continue monitoring the immediate test area through live video feed for the duration of the mission. Post-mission surveys will be carried out in all cases. If any marine mammals are detected during pre-mission surveys (up to 30 minutes prior to launch) or the live video feed received from cameras on the barge, activities will be immediately halted until the area is clear of all marine mammals. Refer to Chapter 11 for a more detailed explanation of monitoring requirements.

In addition to monitoring for marine species before and after missions, the following monitoring and reporting measures will be required.

- The Eglin Natural Resources Section will track use of the EGTTR and protected species observation results through the use of mission report forms.
- A summary annual report of marine mammal observations and mission activities will be submitted to the NMFS Southeast Regional Office and the NMFS Office of Protected Resources either at the time of a request for renewal of the IHA, or 90 days after the expiration of the current permit if a new permit is not requested. This annual report must include the following information:
    - Date and time of each exercise;
    - A complete description of the pre-exercise and post-exercise activities related to mitigating and monitoring the effects of mission activities on marine mammal populations;
    - Results of the monitoring program, including numbers by species/stock of any marine mammals noted injured or killed as a result of the missions, and number of marine mammals (by species if possible) that may have been harassed due to presence within the activity zone; and
- If any dead or injured marine mammals are observed or detected prior to mission activities, or injured or killed during mission activities, a report must be made to NMFS by the following business day.
- Any unauthorized takes of marine mammals (i.e., mortality) must be immediately reported to NMFS and to the respective stranding network representative.

14. RESEARCH

Although Eglin AFB does not currently conduct independent research efforts, Eglin's Natural Resources Section participates in marine animal tagging and monitoring programs lead by other agencies. Additionally, the Natural Resources Section has also supported participation in annual surveys of marine mammals in the GOM with NMFS. From 1999 to 2002, Eglin, through a contract representative, participated in summer cetacean monitoring and research efforts. The contractor participated in visual surveys in 1999 for cetaceans in the GOM, photographic identification of sperm whales in the northeastern Gulf in 2001, and as a visual observer during the 2000 Sperm Whale Pilot Study and the 2002 sperm whale Satellite-tag (S-tag) cruise. In addition, Eglin's Natural Resources Section has obtained Department of Defense funding for two marine mammal habitat modeling projects. The latest such project (Garrison, 2008) included funding for and extensive involvement of NMFS personnel so that the most recent aerial survey data could be utilized for habitat modeling and protected species density estimates in the northeastern GOM.

Eglin conducts other research efforts which utilize marine mammal stranding information as a potential means of ascertaining the effectiveness of mitigation techniques. Stranding data is collected and maintained for the Florida panhandle area as well as Gulf-wide. This task is undertaken through the establishment and maintenance of contacts with local, state, and regional stranding networks. Eglin AFB assists with stranding data collection by maintaining its own team of permitted stranding personnel. In addition to simply collecting stranding data, various analyses are performed. Stranding events are tracked by year, season, and NMFS statistical zone, both Gulf-wide and on the coastline in proximity to Eglin AFB. Stranding data may be analyzed in relation to records of EGTTR mission activity in each water range, and possible correlations examined. In addition to being used as a possible measure of the effectiveness of mitigations, stranding data can yield insight into the species composition of cetaceans in the region.

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16. REFERENCES

Acevedo-Gutiérrez, A. and S.C. Stienessen, 2004. Bottlenose dolphins (*Tursiops truncatus*) increase number of whistles when feeding. *Aquatic Mammals* 30(3):357-362.

Au, W.W.L. 1993. The sonar of dolphins. New York, New York: Springer-Verlag.

Au, W.W.L. and D.L. Herzing. 2003, Echolocation signals of wild Atlantic spotted dolphin (*Stenella frontalis*). *Journal of the Acoustical Society of America 113*(1):598-604.

Barlow, Jay. 2006. Preliminary Estimates of the Abundance of Cetaceans Along the U.S. West Coast: 1991-2001. Southwest Fisheries Science Center Administrative report LJ-03-03. February 2003.

Barlow, Jay. 2003. Cetacean Abundance in Hawaiian Waters Estimated from a Summer/Fall Survey in 2002. Marine Mammal Science, 22(2); 446-464. April 2006.

Baron, S. 2006. Personal communication via email between Dr. Susan Baron, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida, and Dr. Amy R. Schlock, Geo-Marine, Inc., Hampton, Virginia, 31 August.

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

Caldwell, M.C. and D.K. Caldwell, 1965. Individualized whistle contours in bottlenosed dolphins (*Tursiops truncatus). Nature* 207:434-435.

Cetacean and Turtle Assessment Program (CETAP), 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.

Cook, M.L.H., L.S. Sayigh, J.E. Blum, and R.S. Wells, 2004. Signature-whistle production in undisturbed free-ranging bottlenose dolphins (*Tursiops truncatus). Proceedings of the Royal Society B: Biological Sciences* 271:1043-1049.

Curry, B.E. and J. Smith. 1997. Phylogeographic structure of the bottlenose dolphin (*Tursiops truncatus*): Stock identification and implications for management. Pages 227-247 in Dizon, A.E., S.J. Chivers, and W.F. Perrin, eds. *Molecular genetics of marine mammals*. Lawrence, Kansas: Society for Marine Mammalogy.

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 II: Technical Report. Prepared by Texas A&M University at Galveston and the National Marine Fisheries Service. U.S. Department of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans LA. OCS Study MMS 2000-003. 346 pp.

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., B. Würsig, G.S. Fargion, T.A. Jefferson, and C. C. Schroeder, 1996a. Overview of the Gulf of Mexico. Pages 9-54 in Davis, R.W. and G.S. Fargion, eds. Distribution and abundance of cetaceans in the north-central and western Gulf of Mexico, final report. Volume 2: Technical report. OCS Study MMS 96-0027. New Orleans: Minerals Management Service.

Davis, R.W., G.A.J. Worthy, B. Wursig and S.K. Lynn. 1996a. Diving behavior and at-sea movements of an Atlantic spotted dolphin the Gulf of Mexico. Marine Mammal Science 12(4): 569-581.

Department of the Navy (DON), U.S. Fleet Forces Command, 2007. Marine Resources Assessment for the Gulf of Mexico. Final Report. February 2007.

Duffield, D. A., S. H. Ridgway, and L. H. Cornell, 1983. Hematology distinguishes coastal and offshore forms of dolphins (*Tursiops*). *Canadian Journal of Zoology*, Vol 61, pp 930–933.

Fazioli, K.L., S. Hofmann, and R.S. Wells. 2006. Use of Gulf of Mexico coastal waters by distinct assemblages of bottlenose dolphins (*Tursiops truncatus)*. *Aquatic Mammals* 32(2):212-222.

Finneran, J.J. and D.S. Houser. 2006. Comparison of in-air evoked potential and underwater behavioral hearing thresholds in four bottlenose dolphins (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 119(5): 3181-3192.

Finneran, J.J., D.A. Carder, and S.H. Ridgway, 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*), belugas, (*Delphinapterus leucas*), and California sea lions (*Zalophus californianus*). Environmental Consequences of Underwater Sound (ECOUS) Symposium, San Antonio, Texas. 12-16 May 2003.

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

Garrison, L. 2008. Protected Species Habitat Modeling in the Eglin Gulf Test and Training Range. Department of Defense Legacy Resource management Program, Project Number 05-270. Prepared by Dr. Lance Garrison, Southeast Fisheries Science Center, National Marine Fisheries Service.

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* 21(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.

Hersh, S.L. and D.A. Duffield. 1990. Distinction between northwest Atlantic offshore and coastal bottlenose dolphins based on hemoglobin profile and morphometry. Pages 129-139 in Leatherwood, S. and R.R. Reeves, eds. The bottlenose dolphin. San Diego, California: Academic Press.

Herzing, D.L. 1996. Vocalizations and associated underwater behavior of free-ranging Atlantic spotted dolphins, *Stenella frontalis* and bottlenose dolphins, *Tursiops truncatus*. *Aquatic Mammals* 22(2):61-79.

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.

Hoelzel, A.R., C.W. Potter, and P.B. Best, 1998. Genetic differentiation between parapatric 'nearshore' and 'offshore' populations of the bottlenose dolphin. *Proceedings of the Royal Society B: Biological Sciences* 265:1177-1183.

Janik, V.M. 2000. Food-related bray calls in wild bottlenose dolphins *(Tursiops truncatus). Proceedings of the Royal Society B: Biological Sciences* 267:923-927.

Janik, V.M., L.S. Sayigh, and R.S. Wells. 2006. Signature whistle shape conveys identity information to bottlenose dolphins. *Proceedings of the National Academy of Sciences of the United States of America* 103(21):8293-8297.

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.

Jones, G.J. and L.S. Sayigh. 2002. Geographic variation in rates of vocal production of free-ranging bottlenose dolphins. *Marine Mammal Science* 18(2):374-393.

Kenney, R.D. 1990. Bottlenose dolphins off the northeastern United States. Pages 369-386 in S. Leatherwood and R.R. Reeves, eds. The bottlenose dolphin. San Diego: Academic Press.

Ketten, D.R. 1998. Marine mammal auditory systems: *A summary of audiometric and anatomical data and its implications for underwater acoustic impacts.* NOAA-TM-NMFSSWFSC-256, Department of Commerce.

Ketten, D.R., 1997. Structure and Function in Whale Ears. *Bioacoustics* vol. 8, no. 1, pp. 103-136.

Kingston, S.E. and P.E. Rosel, 2004. Genetic differentiation among recently diverged *delphinid* taxa determined using AFLP markers. *Journal of Heredity* 95(1):1-10.

Klatsky, LJ, RS Wells and JC Sweeney. 2007. Offshore bottlenose dolphins (*Tursiops truncatus*): Movement and dive behavior near the Bermuda Pedestal. *Journal of Mammalogy* 88(1):59-66.

Klatsky, L., R. Wells, and J. Sweeney, 2005. Bermuda's deep diving dolphins - Movements and dive behavior of offshore bottlenose dolphins in the Northwest Atlantic Ocean near Bermuda. Page 152 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Lammers, M.O., W.W.L. Au, and D.L. Herzing, 2003. The broadband social acoustic signaling behavior of spinner and spotted dolphins. *Journal of the Acoustical Society of America* 114(3):1629-1639.

Mate, B. R., K. A. Rossbach, S. L. Nieukirk, R. S. Wells, A. B. Irvine, M. D. Scott, and A. J. Read, 1995. Satellite-monitored movements and dive behavior of a bottlenose dolphin (*Tursiops truncatus*) in Tampa Bay, Florida. *Marine Mammal Science*, Vol 11, No 4, pp 452–463.

Mead, J.G. and C.W. Potter. 1995. Recognizing two populations of the bottlenose dolphin (*Tursiops truncatus*) off the Atlantic Coast of North America: Morphologic and ecologic considerations. IBI Reports 5:31-44.

Mooney, T.A. 2006. Personal communication via email between Dr. Aran Mooney, University of Hawaii, Marine Mammal Research Program, Kane'ohe, Hawaii, and Dr. Amy R. Scholik, Geo-Marine., Inc., Hampton, Virginia, 29 August.

Mooney, T.A., P.E. Nachtigall, W.W.L. Au, M. Breese, and S. Vlachos. 2005. Bottlenose dolphin: Effects of noise duration, intensity, and frequency. Page 197 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

Moore, S. E. and J. E. Clark, 1998. Summary of Marine Mammal Occurrence and Population Estimates in U.S. Coastal Waters Subject to Military Aircraft Overflights. Prepared for U.S. Air Force Research Laboratory, Wright-Patterson AFB, OH.

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, 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. Cambridge, England: Blackwell Science.

Nachtigall, P.E., D.W. Lemonds, and H.L. Roiblat, 2000. Psychoacoustic studies of dolphin and whale hearing, in *Hearing by Whales and Dolphins*, Au, W.W.L., A.N. Popper, and R.R. Fay, eds. Springer-Verlag: New York. pp 330-363.

Nachtigall, P.E., J.L. Pawloski, and W.W.L. Au, 2003. Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenose dolphin (*Tursiops truncatus*). *Journal of the Acoustical Society of America* 113:3425-3429.

Nowacek, D.P. 2005. Acoustic ecology of foraging bottlenose dolphins (*Tursiops truncatus*), habitat specific use of three sound types. *Marine Mammal Science* 21(4):587-602.

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

Perrin, W.F., D.K. Caldwell, and M.C. Caldwell. 1994. 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., 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.

Ridgway, S. H., B. L. Scronce, and J. Kanwisher, 1969. Respiration and deep diving in the bottlenose porpoise. *Science*, Vol 166, pp 1651–1654.

Ridgway, S.H. 2000. The auditory central nervous system. Pages 273-293 in Au, W.W.L., A.N. Popper, and R.R. Fay, eds. Hearing by whales and dolphins. New York, New York: Springer-Verlag.

Ridgway, S.H., D.A. Carder, R.R. Smith, T. Kamolnick, C.E. Schlundt, and W.R. Elsberry, 1997. Behavioral responses and temporary shift in masked hearing threshold of bottlenose dolphins, *Tursiops truncatus*, to 1-second tones of 141 to 201 dB re 1 µPa. Technical Report 1751, Revision 1. San Diego: Naval Sea Systems Command.

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

Sellas, A.B., R.S. Wells, and P.E. Rosel. 2005. Mitochondrial and nuclear DNA analyses reveal fine scale geographic structure in bottlenose dolphins (*Tursiops truncatus*) in the Gulf of Mexico. *Conservation Genetics* 6:715-728.

Turl, C.W. 1993. Low-frequency sound detection by a bottlenose dolphin. *Journal of the Acoustical Society of America* 94(5): 3006-3008.

U.S. Air Force. 2012. Fact Sheet for the E-9A. Information accessed on the internet at http://www.af.mil/information/factsheets/factsheet.asp?id=13080. Information accessed on September 28, 2012.

Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. Rosel, eds., 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2009. NOAA Technical Memorandum NMFS-NE-213. U.S. Department Of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center. Woods Hole, MA. December.

Waring, G.T., E. Josephson, C.P. Fairfield-Walsh, and K. Maze-Foley, eds., 2006. *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2005.* NOAA Technical Memorandum NMFS-NE-194:1-346.

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.

Zaretsky, S.C., A. Martinez, L.P. Garrison, and E.O. Keith. 2005. Differences in acoustic signals from marine mammals in the western North Atlantic and northern Gulf of Mexico. Page 314 in Abstracts, Sixteenth Biennial Conference on the Biology of Marine Mammals. 12-16 December 2005. San Diego, California.

APPENDIX A:

ACOUSTIC MODELING METHODOLOGY

ACOUSTIC MODELING METHODOLOGY

A.1 SUMMARY DESCRIPTION OF MODELING METHODOLOGY

Marine mammal exposure estimates are derived from the results of acoustic modeling performed by a contracted company with expertise in underwater acoustics. The modeling process and methodology are discussed in the following sections, which include a description of the acoustic sources being modeled, characterization and descriptions of important environmental components incorporated into the model, methodologies and calculations used to model impacts on marine animals, and a description of determining harassment estimates and model results.

A.2 EXPLOSIVE ACOUSTIC SOURCES

A.2.1 Acoustic Characteristics of Explosive Sources

The acoustic sources employed for Maritime Strike Operations are categorized as broadband explosives. Broadband explosives produce significant acoustic energy across several frequency decades of bandwidth. Propagation loss is sufficiently sensitive to frequency as to require model estimates at several frequencies over such a wide band.

Explosives are impulsive sources that produce a shock wave that dictates additional pressure-related metrics (peak pressure and positive impulse). A list of the proposed munitions to be used in Maritime Strike Operations is provided in Table 1-2.

Explosives detonated underwater introduce loud, impulsive, broadband sounds into the marine environment. Three source parameters influence the effect of an explosive: the weight of the explosive material, the type of explosive material, and the detonation depth. The net explosive weight (NEW) measurement accounts for the first two parameters. The NEW of an explosive is the weight of TNT required to produce an equivalent explosive power.

The detonation depth of an explosive is particularly important due to a propagation effect known as surface-image interference. For sources located near the sea surface, a distinct interference pattern arises from the coherent sum of the two paths that differ only by a single reflection from the pressure-release surface. As the source depth and/or the source frequency decreases, these two paths increasingly and destructively interfere with each other, reaching total cancellation at the surface (barring surface-reflection scattering loss).

A.2.2 Animal Harassment Effects of Explosive Sources

The harassment exposures expected to result from these sources are computed on a per in-water explosive basis; to estimate the number of harassment exposures for multiple explosives, consider the following: Let A represent the impact area (that is, the area in which the chosen metric exceeds the threshold) for a single explosive. The cumulative effect of a series of explosives is then dictated by the spacing of the explosives relative to the movement of the marine wildlife. If the detonations are spaced widely in time or space, allowing for sufficient animal movements as to ensure a different population of animals is considered for each

detonation and N corresponds to the number of explosives being detonated, calculating the cumulative impact area ($A_{Cumulative}$) of N explosives can be represented as, $A_{Cumulative} = N \times A$, regardless of the metric. This leads to a worst case estimate of harassments and is the method used in this analysis.

At the other extreme is the case where the detonations occur at essentially the same time and location (but not close enough to require the source emissions to be coherently summed). In this case, the pressure metrics (peak pressure and positive impulse) are constant regardless of the number of detonations spaced closely in time, while the energy metrics increase at a rate of $N^{1/2}$ (under spherical spreading loss only) or less.

The firing sequence for some of the proposed munitions (CBU-103) consists of a number of rapid bursts, often lasting a second or less. Due to the tight spacing in time, each burst can be treated as a single detonation. For the energy metrics the impact area of a burst is computed using a source energy spectrum that is the source spectrum for a single detonation scaled by the number of rounds in a burst. For the pressure metrics, the impact area for a burst is the same as the impact area of a single round. For all metrics, the cumulative impact area of an event consisting of N bursts is merely the product of the impact area of a single burst and the number of bursts, as would be the case if the bursts are sufficiently spaced in time or location as to insure that each burst is affecting a different set of marine wildlife.

Explosives are modeled as detonating at depths ranging from the water surface to 10 feet below the surface, as provided by Government-Furnished Information. Impacts from above surface detonations were considered negligible and not modeled.

For sources that are detonated at shallow depths, it is frequently the case that the explosion may breach the surface with some of the acoustic energy escaping the water column. The source levels have not been adjusted for possible venting nor does the subsequent analysis attempt to take this into account.

A.3 ENVIRONMENTAL CHARACTERIZATION

A.3.1 Important Environmental Parameters for Estimating Animal Harassment

Propagation loss ultimately determines the extent of the Zone of Influence (ZOI) for a particular source activity. In turn, propagation loss as a function of range depends on a number of environmental parameters including:

- water depth
- sound speed variability throughout the water column
- bottom geo-acoustic properties, and
- surface roughness, as determined by wind speed

Since the U.S. Navy has conducted extensive testing and training activities in the marine environment, such as Anti-Submarine Warfare, over the last four to five decades, they have invested heavily in measuring and modeling environmental parameters that contribute to

propagation loss. The result of this effort is the following collection of global databases containing these environmental parameters, which are accepted as standards for Navy and other Department of Defense modeling efforts. **Table A-1** contains the version of the databases used in the modeling for this analysis.

Table 0-1. Navy Standard Databases Used in Modeling

Parameter	Database	Version
Water Depth	Digital Bathymetry Data Base Variable Resolution	DBDBV 6.0
Ocean Sediment	Re-packed Bottom Sediment Type	BST 2.0
Wind Speed	Surface Marine Gridded Climatology Database	SMGC 2.0
Temperature/Salinity Profiles	Generalized Digital Environment Model	GDEM 3.0

The sound speed profile directs the sound propagation in the water column. The spatial variability of the sound speed field is generally small over operating areas of typical size. The presence of a strong oceanographic front is a noteworthy exception to this rule. To a lesser extent, variability in the depth and strength of a surface duct can be of some importance. If the sound speed minimum occurs within the water column, more sound energy can travel further without suffering as much loss (ducted propagation). But if the sound speed minimum occurs at the surface or bottom, the propagating sound interacts more with these boundaries and may become attenuated more quickly. In the mid-latitudes, seasonal variation often provides the most significant variation in the sound speed field. For this reason, both summer and winter profiles are modeled to demonstrate the extent of the difference.

Losses of propagating sound energy occur at the boundaries. The water-sediment boundary defined by the bathymetry can vary by a large amount. In a deep water environment, the interaction with the bottom may matter very little. In a shallow water environment the opposite is true and the properties of the sediment become very important. The sound propagates through the sediment, as well as being reflected by the interface. Soft (low density) sediment behaves more like water for lower frequencies and the sound has relatively more transmission and relatively less reflection than a hard (high density) bottom or thin sediment.

The roughness of the boundary at the water surface depends on the wind speed. Average wind speed can vary seasonally, but could also be the result of local weather. A rough surface scatters the sound energy and increases the transmission loss. Boundary losses affect higher frequency sound energy much more than lower frequencies.

A.3.2 Characterizing the Acoustic Marine Environment

The environment for modeling impact value is characterized by a frequency-dependent bottom definition, range-dependent bathymetry and sound velocity profiles (SVP), and seasonally varying wind speeds and SVPs. The bathymetry database is on a grid of variable resolution.

The sound velocity profile database has a fixed spatial resolution storing temperature and salinity as a function of time and location. The low frequency bottom loss is characterized by standard definition of geo-acoustic parameters for the given sediment type of sand. The high frequency bottom loss class is fixed to match expected loss for the sediment type. The area of interest can be characterized by the appropriate sound speed profiles, set of low frequency bottom loss

parameters, high frequency bottom loss class, and High Frequency Environmental Acoustics (HFEVA) very-high frequency sediment type for modeled frequencies in excess of 10 kilohertz (kHz).

Generally seasonal variation is sampled by looking at summer and winter cases. However, given current plans to conduct Maritime Strike activities in the June 2013 timeframe, ordnance usage was assigned to the summer season only rather than equally divided between summer and winter seasons.

Impact volumes in the operating area were then computed using propagation loss estimates and the explosives model derived for the representative environment.

A.3.3 Description of the Maritime Strike Operations Study Area Environment

The Maritime Strike Operations Study Area is located off the coast of Florida in the Gulf of Mexico. It is an area that slopes from shallow waters near the coast to deeper waters offshore. The bottom is characterized as sandy sediment according to the Bottom Sediments Type Database. Environmental values were extracted from unclassified Navy standard databases in a radius of 50 km around the center point at

N 30° 08.5' W 86° 28'

The Navy standard database for bathymetry has a resolution of 0.05 minutes in the Gulf of Mexico; see **Figure A-1**. Mean and median depths from DBDBV in the extracted area are 47 and 112 meters, respectively.

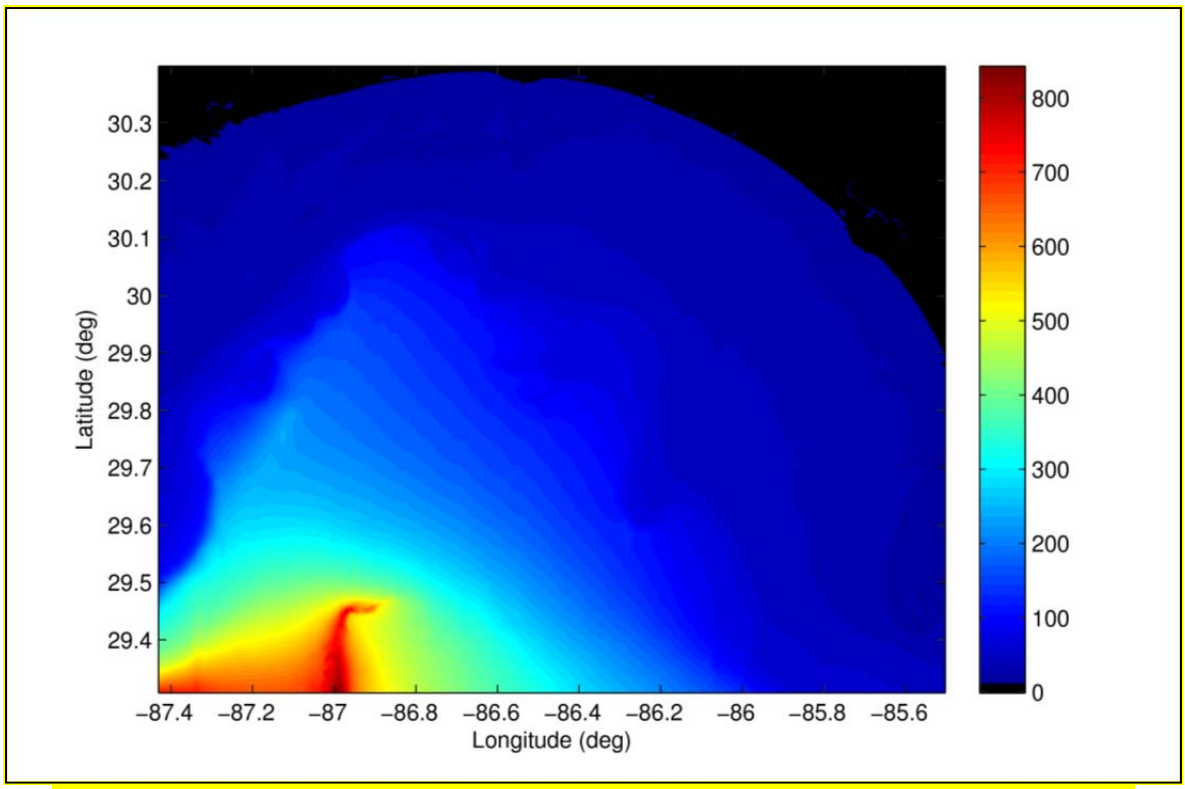

Figure A-1. Bathymetry (in meters) for Maritime Strike Operations Study Area Representative Environment

The seasonal variability in wind speed was modeled as 8.6 knots in the summer and 13.02 knots in the winter.

Example input of range-dependent bathymetry is depicted in **Figure A-2** for the due-north bearing.

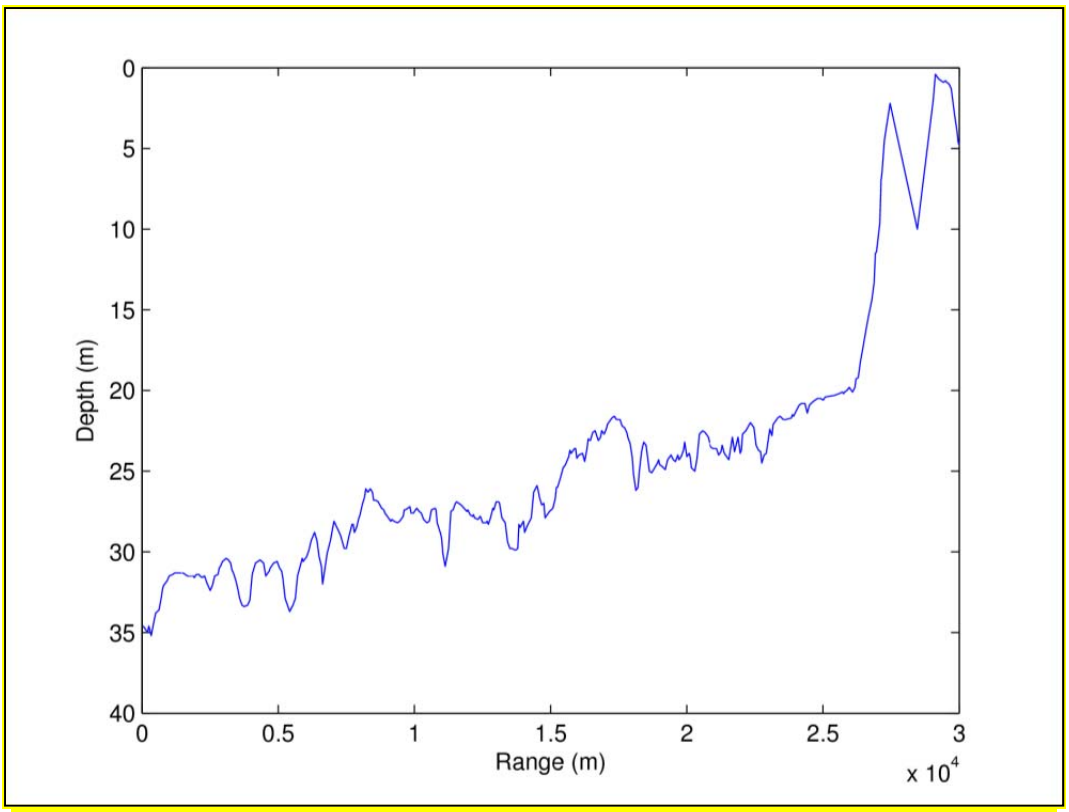

Figure A-2. Bathymetry Due-North of Maritime Strike Operations Study Area Center Point

A.4 MODELING IMPACT ON MARINE ANIMALS

Many underwater actions include the potential to injure or harass marine animals in the neighboring waters through noise emissions. The number of animals exposed to potential harassment in any such action is dictated by the propagation field and the characteristics of the noise source.

Estimating the number of animals that may be injured or otherwise harassed in a particular environment entails the following steps.

- For the relevant environmental acoustic parameters, transmission loss (TL) estimates are computed, sampling the water column over the appropriate depth and range intervals. TL calculations are also made over disjoint one-third octave bands for a wide range of frequencies with dependence in range, depth, and azimuth for bathymetry and sound speed. TL computations were sampled with 20 degree spacing in azimuth.

- The accumulated energy within the waters where the source detonates is sampled over a volumetric grid. At each grid point, the received energy from each source emission is modeled as the effective energy source level reduced by the appropriate propagation loss from the location of the source at the time of the emission to that

grid point and summed. For the peak pressure or positive impulse, the appropriate metric is similarly modeled for each emission. The maximum value of that metric over all frequencies and emissions is stored at each grid point.

- The impact volume for a given threshold is estimated by summing the incremental volumes represented by each grid point sampled in range and depth for which the appropriate metric exceeds that threshold, and accumulated over all modeled bearings. Histograms representing impact volumes as a function of (possibly depth-dependent) thresholds are stored in a spreadsheet for dynamic changes of thresholds.

- Finally, the number of harassments is estimated as the inner-product of the animal density depth profile and the impact volume and scaled by user-specifiable surface animal densities.

The following sub-section describes in detail the process of computing impact volumes.

A.4.1 Calculating Transmission Loss

Transmission loss (TL) was pre-computed for both seasons for thirty non-overlapping frequency bands. The bands had one-third octave spacing around center frequencies from 50 Hz to approximately 40.637 kHz. The TL was then modeled using the Navy Standard GRAB V3 propagation loss model (Keenan, 2000) with CASS v4.3, and the results were interpolated onto a variable range grid with logarithmic spacing. The increased spatial resolution near the source provided greater fidelity for estimates.

TL was calculated from the source depth to an array of output depths. The output depths were the mid-points of depth intervals matching GDEM's depth sampling. For water depths from surface to 10 m depth, the depth interval was 2 m. Between 10 m and 100 m water depth, the depth interval was 5 m. For waters greater than 100 m, the depth interval was 10 m. For the Maritime Strike study area environment, there were thirty depths (1, 3, 5, 7, 9, 12.5, 17.5, 22.5, 27.5, 32.5, 37.5, 42.5, 47.5, 52.5, 57.5, 62.5, 67.5, 72.5, 77.5, 82.5, 87.5, 92.5, 97.5, 105, 115, 125, 135, 145, 155, 160, all in meters) representing depth-interval midpoints. The output depths represent possible locations of the animals and are used with the animal depth distribution to better estimate animal impact. The depth grid is used to make the surface-image interference correction and to capture the depth-dependence of the positive impulse threshold.

An important propagation consideration at low frequencies is the effect of surface-image interference. As either source or target approach the surface, pairs of paths that differ by a single surface reflection set up an interference pattern that ultimately causes the two paths to cancel each other when the source or target is at the surface. A fully coherent summation of the eigenrays produces such a result but also introduces extreme fluctuations that would have to be highly sampled in range and depth, and then smoothed to give meaningful results, and would be inappropriate in representing a broad one-third octave band of the spectrum. An alternative approach is to implement what is sometimes called a semi-coherent summation. A semi-coherent sum attempts to capture significant effects of surface-image interference (namely the reduction of the field due to destructive interference of reflected paths as the source or target

approach the surface) without having to deal with the more rapid fluctuations associated with a fully coherent sum. The semi-coherent sum is formed by a random phase addition of paths that have already been multiplied by the expression:

$$\sin^2\left(\frac{4\pi f z_s z_a}{c^2 t}\right)$$

where f is the frequency, z_s is the source depth, z_a is the animal depth, c is the sound speed and t is the travel time from source to animal along the propagation path. For small arguments of the sine function this expression varies directly as the frequency and the two depths. It is this relationship that causes the propagation field to go to zero as the depths approach the surface or the frequency approaches zero.

A.4.2 Computing Impact Volumes

The next two sections provide a detailed description of the approach taken to compute impact volumes for explosives. The impact volume associated with a particular activity is defined as the volume of water in which some acoustic metric exceeds a specified threshold. The product of this impact volume with a volumetric animal density yields the expected value of the number of animals exposed to that acoustic metric at a level that exceeds the threshold. The acoustic metric can either be an energy term (energy flux density, either in a limited frequency band or across the full band) or a pressure term (such as peak pressure or positive impulse). The thresholds associated with each of these metrics define the levels at which half of the animals exposed will experience some degree of harassment (ranging from behavioral change to mortality).

Impact volume is particularly relevant when trying to estimate the effect of repeated source emissions separated in either time or space. Impact range, which is defined as the maximum range at which a particular threshold is exceeded for a single source emission, defines the range to which marine mammal activity is monitored in order to meet mitigation requirements.

The effective energy source level is modeled directly for the sources to be used for Maritime Strike activities at a specific location in the Gulf. The energy source level is comparable to the model used for other explosives (Arons [1954], Weston [1960], McGrath [1971], Urick [1983], Christian and Gaspin [1974]). The energy source level over a one-third octave band with a center frequency of f for a source with a net explosive weight of w pounds is given by:

$$\mathrm{ESL} = 10 \log_{10} (0.26 f) + 10 \log_{10} (2 p_{max}^2 / [1/\theta^2 + 4\pi^2 f^2]) + 197 \ \mathrm{dB}$$

where the peak pressure for the shock wave at one meter is defined as

$$p_{max} = 21600 \, (w^{1/3} / 3.28)^{1.13} \ \mathrm{psi} \qquad \text{(A-1)}$$

and the time constant is defined as:

$$\theta = [(0.058) (w^{1/3}) (3.28 / w^{1/3})^{0.22}] / 1000 \ \mathrm{sec} \qquad \text{(A-2)}$$

For each season and explosive source, the amount of energy in the water column is calculated. The propagation loss for each frequency, expressed as a pressure term, modulates the sound energy found at each point on the grid of depth (uniform spacing) and range (logarithmic spacing). If a threshold is exceeded at a point, the impact volume at an annular sector is added to the total impact volume. The impact volume at a point is calculated exactly using the depth interval, the range interval of the point, and the slice of a sphere centered where the range is zero.

A.4.3 Effects of Metrics on Impact Volumes

The impact of explosive sources on marine wildlife is measured by three different metrics, each with its own thresholds. The energy metric, the peak pressure metric, and the "modified" positive impulse metric are discussed in this section. The energy metric, using the peak one-third-octave level, is accumulated after the explosive detonation. The other two metrics, peak pressure and positive impulse, are not accumulated but rather the maximum levels are taken.

Energy Metric

The energy flux density is sampled at several frequencies in one-third-octave bands and only the peak one-third-octave level is accumulated over time. In the case of Level A calculations, the Total Energy is considered.

Peak Pressure Metric

The peak pressure metric is a simple, straightforward calculation at each range/animal depth combination. First, the transmission pressure ratio, modified by the source level in a one-third-octave band, is summed across frequency. This averaged transmission ratio is normalized by the total broadband source level. Peak pressure at that range/animal depth combination is then simply the product of:

- the square root of the normalized transmission ratio of the peak arrival,
- the peak pressure at a range of one meter (given by equation A-1), and
- the similitude correction (given by $r^{-0.13}$, where r is the slant range).

If the peak pressure for a given grid point is greater than the specified threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

"Modified" Positive Impulse Metric

The modeling of positive impulse follows the work of Goertner (Goertner, 1982). The Goertner model defines a "partial" impulse as

$$\int_0^{T_{min}} p(t)\, dt$$

where $p(t)$ is the pressure wave from the explosive as a function of time t, defined so that $p(t) = 0$ for $t < 0$. This similitude pressure wave is modeled as

$$p(t) = p_{max}\, e^{-t/\theta}$$

where p_{max} is the peak pressure at one meter (see, equation A-1), and θ is the time constant defined in equation A-2.

The upper limit of the "partial" impulse integral is

$$T_{min} = \min \{T_{cut}, T_{osc}\}$$

where T_{cut} is the time to cutoff and T_{osc} is a function of the animal lung oscillation period. When the upper limit is T_{cut}, the integral is the definition of positive impulse. When the upper limit is defined by T_{osc}, the integral is smaller than the positive impulse and thus is just a "partial" impulse. Switching the integral limit from T_{cut} to T_{osc} accounts for the diminished impact of the positive impulse upon the animals lungs that compress with increasing depth and leads to what is sometimes call a "modified" positive impulse metric.

The time to cutoff is modeled as the difference in travel time between the direct path and the surface-reflected path in an isovelocity environment. At a range of r, the time to cutoff for a source depth z_s and an animal depth z_a is

$$T_{cut} = 1/c\ \{\ [r^2 + (z_a + z_s)^2]^{1/2} - [r^2 + (z_a - z_s)^2]^{1/2}\ \}$$

where c is the speed of sound.

The animal lung oscillation period is a function of animal mass M and depth z_a and is modeled as

$$T_{osc} = 1.17\, M^{1/3}\, (1 + z_a/33)^{-5/6}$$

where M is the animal mass (in kg) and z_a is the animal depth (in feet).

The modified positive impulse threshold is unique among the various injury and harassment metrics in that it is a function of depth and the animal weight. So instead of the user specifying the threshold, it is computed as $K\,(M/42)^{1/3}\,(1 + z_a/33)^{1/2}$. The coefficient K depends upon the level of exposure. For the onset of slight lung injury, K is 19.7; for the onset of extensive lung hemorrhaging (1% mortality), K is 47.

Although the thresholds are a function of depth and animal weight, sometimes they are summarized as their value at the sea surface for a typical dolphin calf (with an average mass of 12.2 kg). For the onset of slight lung injury, the threshold at the surface is approximately 13 psi-msec; for the onset of extensive lung hemorrhaging (1% mortality), the threshold at the surface is approximately 31 psi-msec.

As with peak pressure, the "modified" positive impulse at each grid point is compared to the derived threshold. If the impulse is greater than that threshold, then the incremental volume for the grid point is added to the impact volume for that depth layer.

A.5 ESTIMATING ANIMAL HARASSMENT

A.5.1 Distribution of Animals in the Environment

Species densities are usually reported by marine biologists as animals per square kilometer. This gives an estimate of the number of animals below the surface in a certain area, but does not provide any information about their distribution in depth. The impact volume vector specifies the volume of water ensonified above the specified threshold in each depth interval. A corresponding animal density for each of those depth intervals is required to compute the expected value of the number of exposures. The two-dimensional area densities do not contain this information, so three-dimensional densities must be constructed by using animal depth distributions to extrapolate the density at each depth.

The following bottlenose dolphin (summer profile) example demonstrates the method used to account for three-dimensional analysis by merging the depth distributions with user-specifiable surface densities. Bottlenose dolphins are distributed with:

- 19.2% in 0-10 m,
- 76.8% in 10-50 m,
- 1.7% in 50-100 m, and
- 2.3% in 100-165 m.

The impact volume vector is sampled at 30 depths over the maximally 165-m water column. Since this is a finer resolution than the depth distribution, densities are apportioned uniformly over depth intervals. For example, 19.2% of bottlenose dolphins are in the 0-10 meter interval, so approximately:

- 3.84% are in 0-2 meters,
- 3.84% are in 2-4 meters,
- 3.84% are in 4-6 meters,
- 3.84% are in 6-8 meters, and
- 3.84% are in 8-10 meters.

Similarly, 76.8% are in the 10-50 m interval, so approximately:

- 9.60% are in 10 - 15 meters,
- 9.60% are in 15 - 20 meters,
- 9.60% are in 20 - 25 meters,
- etc

A.5.2 Harassment Estimates

Impact volumes for all depth intervals are scaled by their respective depth densities, divided by their depth interval widths, summed over the entire water column and finally converted to square kilometers to create impact areas. The spreadsheet allows a user-specifiable surface density in animals per square kilometer, so the product of these quantities yields expected number of animals in ensonified water where they could experience harassment.

Since the impact volume vector is the volume of water at or above a given threshold per unit operation (e.g. per detonation, or clusters of munitions explosions), the final harassment count for each animal is the unit operation harassment count multiplied by the number of units deployed.

The detonations of explosive sources are generally widely spaced in time and/or space. This implies that the impact volume for multiple firings can be easily derived by scaling the impact volume for a single detonation. Thus the typical impact volume vector for an explosive source is presented on a per-detonation basis.

The following tables (Tables A-2 through A-4) show exposure estimates from each munition/detonation scenario at the various threshold levels being analyzed for all protected species in which takes are being requested. The total exposure estimates from all Maritime Strike activities are summed in the bottom rows for each species. It should be noted that, in some cases where there are dual criteria, the pressure metric (positive impulse) may have a larger impact range, but the energy metric results in a greater exposure number. This may be observed by comparing the exposure estimates in Tables A-2 through A-4 with the impact ranges in Table 6-3, and is most pronounced for Level A harassment thresholds. This phenomenon is due to the fact that positive impulse is a depth-dependent threshold. The 13 psi-msec threshold occurs near the surface, and the maximum range is likely based on the shallow threshold. However, exposure estimates are based on volumetric integration with animal depth profile. The animal depth distribution profile may also lead to other results that may not be immediately intuitive, such as a particular species having a higher mortality exposure estimate compared to other species, but a lower harassment exposure estimate.

Table A-2. Bottlenose Dolphin Exposure Estimates from Maritime Strike Operations TD&E Activities

Ordnance	NEW (lbs)	Burst Size	Depth (ft)	Level B			Level A		Mortality
				Behavioral	TTS		PTS	Injury	
				177 dB SEL	182 dB SEL	23 psi	205 dB SEL	13 psi ms	30.5 psi ms
GBU-10	945	1	Surface	0.750	0.430	0.625	0.043	0.010	0.006
GBU-24	945	1	Surface	0.750	0.430	0.625	0.043	0.010	0.006
GBU-31	945	1	Surface	3.002	1.721	2.500	0.172	0.041	0.022
GBU-31	945	1	5	9.769	5.647	2.520	0.356	0.186	0.101
GBU-31	945	1	10	20.309	9.801	2.926	0.656	0.382	0.196
GBU-31	530	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
GBU-31	530	1	5	0.000	0.000	0.000	0.000	0.000	0.000
GBU-31	530	1	10	0.000	0.000	0.000	0.000	0.000	0.000
GBU-12	192	1	Surface	0.406	0.236	0.223	0.015	0.006	0.003
GBU-38	192	1	Surface	1.622	0.944	0.891	0.059	0.024	0.012
GBU-38	192	1	5	5.318	2.757	1.100	0.134	0.106	0.052
GBU-38	192	1	10	8.937	3.453	1.481	0.235	0.200	0.090
GBU-38	189	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
GBU-38	189	1	5	0.000	0.000	0.000	0.000	0.000	0.000
GBU-38	189	1	10	0.000	0.000	0.000	0.000	0.000	0.000
GBU-54	192	1	Surface	0.406	0.236	0.223	0.015	0.006	0.003
GBU-54	189	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
AGM-65E/L/K/G2	86	1	Surface	2.393	1.325	1.121	0.070	0.036	0.017
AGM-114	20	1	Surface	0.658	0.303	0.265	0.013	0.010	0.003
M-117	386	1	Surface	1.606	0.916	1.052	0.072	0.023	0.012
M-117	383	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
PGU-12 30mm	0.1	1	Surface	2.069	0.418	3.284	0.002	0.006	0.000
PGU-28 20mm	0.0228	1	Surface	0.372	0.072	1.357	0.000	0.000	0.000
CBU-103	0.631	202	Surface	2.702	1.495	0.046	0.125	0.000	0.000
TOTAL				**61.069**	**30.187**	**20.238**	**2.008**	**1.046**	**0.524**

Table A-3. Atlantic Spotted Dolphin Exposure Estimates from Maritime Strike Operations TD&E Activities

Ordnance	NEW (lbs)	Burst Size	Depth (ft)	Level B			Level A		Mortality
				Behavioral	TTS		PTS	Injury	
				177 dB SEL	182 dB SEL	23 psi	205 dB SEL	13 psi ms	30.5 psi ms
GBU-10	945	1	Surface	0.354	0.195	0.057	0.022	0.002	0.001
GBU-24	945	1	Surface	0.354	0.195	0.057	0.022	0.002	0.001
GBU-31	945	1	Surface	1.415	0.778	0.227	0.087	0.009	0.004
GBU-31	945	1	5	4.970	2.856	0.516	0.200	0.048	0.024
GBU-31	945	1	10	9.535	5.298	0.876	0.328	0.113	0.054
GBU-31	530	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
GBU-31	530	1	5	0.000	0.000	0.000	0.000	0.000	0.000
GBU-31	530	1	10	0.000	0.000	0.000	0.000	0.000	0.000
GBU-12	192	1	Surface	0.182	0.100	0.031	0.008	0.002	0.001
GBU-38	192	1	Surface	0.728	0.401	0.126	0.031	0.006	0.003
GBU-38	192	1	5	2.702	1.478	0.323	0.072	0.033	0.015
GBU-38	192	1	10	4.988	2.604	0.553	0.117	0.070	0.031
GBU-38	189	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
GBU-38	189	1	5	0.000	0.000	0.000	0.000	0.000	0.000
GBU-38	189	1	10	0.000	0.000	0.000	0.000	0.000	0.000
GBU-54	192	1	Surface	0.182	0.100	0.031	0.008	0.002	0.001
GBU-54	189	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
AGM-65E/L/K/G2	86	1	Surface	1.051	0.554	0.194	0.038	0.010	0.005
AGM-114	20	1	Surface	0.275	0.131	0.063	0.008	0.004	0.002
M-117	386	1	Surface	0.733	0.404	0.121	0.038	0.005	0.003
M-117	383	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
PGU-12 30mm	0.1	1	Surface	1.941	0.629	2.321	0.004	0.014	0.000
PGU-28 20mm	0.0228	1	Surface	0.666	0.166	1.440	0.000	0.000	0.000
CBU-103	0.631	202	Surface	1.268	0.676	0.021	0.068	0.001	0.000
TOTAL				**31.345**	**16.565**	**6.957**	**1.050**	**0.320**	**0.145**

Table A-4. Unidentified* Dolphin Exposure Estimates from Maritime Strike Operations TD&E Activities

Ordnance	NEW (lbs)	Burst Size	Depth (ft)	Level B			Level A		Mortality
				Behavioral	TTS		PTS	Injury	
				177 dB SEL	182 dB SEL	23 psi	205 dB SEL	13 psi ms	30.5 psi ms
GBU-10	945	1	Surface	0.015	0.009	0.012	0.001	0.000	0.000
GBU-24	945	1	Surface	0.015	0.009	0.012	0.001	0.000	0.000
GBU-31	945	1	Surface	0.059	0.034	0.049	0.003	0.001	0.000
GBU-31	945	1	5	0.193	0.112	0.050	0.007	0.004	0.002
GBU-31	945	1	10	0.402	0.194	0.058	0.013	0.008	0.004
GBU-31	530	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
GBU-31	530	1	5	0.000	0.000	0.000	0.000	0.000	0.000
GBU-31	530	1	10	0.000	0.000	0.000	0.000	0.000	0.000
GBU-12	192	1	Surface	0.008	0.005	0.004	0.000	0.000	0.000
GBU-38	192	1	Surface	0.032	0.019	0.018	0.001	0.000	0.000
GBU-38	192	1	5	0.105	0.055	0.022	0.003	0.002	0.001
GBU-38	192	1	10	0.177	0.068	0.029	0.005	0.004	0.002
GBU-38	189	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
GBU-38	189	1	5	0.000	0.000	0.000	0.000	0.000	0.000
GBU-38	189	1	10	0.000	0.000	0.000	0.000	0.000	0.000
GBU-54	192	1	Surface	0.008	0.005	0.004	0.000	0.000	0.000
GBU-54	189	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
AGM-65E/L/K/G2	86	1	Surface	0.047	0.026	0.022	0.001	0.001	0.000
AGM-114	20	1	Surface	0.013	0.006	0.005	0.000	0.000	0.000
M-117	386	1	Surface	0.032	0.018	0.021	0.001	0.000	0.000
M-117	383	1	Surface	0.000	0.000	0.000	0.000	0.000	0.000
PGU-12 30mm	0.1	1	Surface	0.041	0.008	0.065	0.000	0.000	0.000
PGU-28 20mm	0.0228	1	Surface	0.007	0.001	0.027	0.000	0.000	0.000
CBU-103	0.631	202	Surface	0.053	0.030	0.001	0.002	0.000	0.000
TOTAL				**1.208**	**0.597**	**0.400**	**0.040**	**0.021**	**0.010**

* Unidentified category refers to a density estimate for a separate group of dolphins that could not be identified as either bottlenose dolphins or Atlantic spotted dolphins during survey efforts (Fulling et al., 2003)

The following table (Table A-5) summarizes the total estimated acoustic exposures calculated by the model. The exposures are grouped by species and threshold and are totaled for all munitions proposed to be deployed for Maritime Strike activities. For thresholds where dual criteria are analyzed for a particular species (Level A Harassment and Level B Harassment), the threshold that resulted in the higher number of exposures was used for estimating takes in the analysis.

Table A-5. Summary of Total Exposures by Animal and Threshold

SPECIES	LEVEL B			LEVEL A		MORTALITY
	Behavioral 177 dB SEL†	TTS 182 dB SEL†	TTS 23 psi	PTS 205 dB SEL†	Injury 13 psi-msec	31 psi-msec†
Bottlenose dolphin	61.069	30.187	20.238	2.008	1.046	0.524
Atlantic spotted dolphin	31.345	16.565	6.957	1.050	0.320	0.145
Unidentified dolphin*	1.208	0.597	0.400	0.040	0.021	0.010
TOTAL	**93.622**	**47.349**	**27.595**	**3.098**	**1.387**	**0.679**

* Unidentified category refers to a density estimate for a separate group of dolphins that could not be identified as either bottlenose dolphins or Atlantic spotted dolphins during survey efforts (Fulling et al., 2003)

†Exposure estimates calculated for these thresholds were used in the take analysis.

A.6 REFERENCES

Arons, A.B. (1954). "Underwater Explosion Shock Wave Parameters at Large Distances from the Charge," *Journal of the Acoustical Society of America*. 26:343.

Bartberger, C.L. (1965). "Lecture Notes on Underwater Acoustics," NADC Report NADC=WR-6509, Naval Air Development Center Technical Report, Johnsville, PA, 17 May (AD 468 869) (UNCLASSIFIED).

Christian, E.A. and J.B. Gaspin, (1974). Swimmer Safe Standoffs from Underwater Explosions," NSAP Project PHP-11-73, Naval Ordnance Laboratory, Report NOLX-89, 1 July (UNCLASSIFIED).

Department of the Navy (1998), "Final Environmental Impact Statement, Shock Testing the SEAWOLF Submarine," U.S. Department of the Navy, Southern Division, Naval Facilities Engineering Command, North Charleston, SC, 637 p.

Department of the Navy (2001), "Final Environmental Impact Statement, Shock Trial of the WINSTON S. CHURCHILL (DDG 81)," U.S. Department of the Navy, NAVSEA, 597 p.

Finneran, J.J., R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America*. 111:2929-2940.

Finneran, J.J., and C.E. Schlundt. 2004. Effects of intense pure tones on the behavior of trained odontocetes. Space and Naval Warfare Systems Center, San Diego, Technical Document. September.

Finneran, J.J., D.A. Carder, C.E. Schlundt and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones. *Journal of Acoustical Society of America*. 118:2696-2705.

Goertner, J.F. (1982), "Prediction of Underwater Explosion Safe Ranges for Sea Mammals," NSWC TR 82-188, Naval Surface Weapons Center, Dahlgren, VA.

Keenan, R.E., Denise Brown, Emily McCarthy, Henry Weinberg, and Frank Aidala (2000). "Software Design Description for the Comprehensive Acoustic System Simulation (CASS Version 3.0) with the Gaussian Ray Bundle Model (GRAB Version 2.0)", NUWC-NPT Technical Document 11,231, Naval Undersea Warfare Center Division, Newport, RI, 1 June (UNCLASSIFIED).

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

Kryter, K.D. W.D. Ward, J.D. Miller, and D.H. Eldredge. 1966. Hazardous exposure to intermittent and steady-state noise. *Journal of the Acoustical Society of America*. 48:513-523.

McGrath, J.R. (1971). "Scaling Laws for Underwater Exploding Wires," *Journal of the Acoustical Society of America*. 50:1030-1033 (UNCLASSIFIED).

Miller, J.D. 1974. Effects of noise on people. *Journal of the Acoustical Society of America*. 56:729–764.

Nachtigall, P.E., J.L. Pawloski, and W.W.L. Au. 2003. Temporary threshold shift and recovery following noise exposure in the Atlantic bottlenose dolphin (Tursiops truncatus). *Journal of the Acoustical Society of America*. 113:3425-3429.

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, Delphinapterous leucas, after exposure to intense tones. *Journal of the Acoustical Society of America*. 107:3496-3508.

Urick, R.J. (1983). Principles of Underwater Sound for Engineers, McGraw-Hill, NY (first edition: 1967, second edition: 1975, third edition: 1983) (UNCLASSIFIED).

Ward, W.D. 1997. Effects of high-intensity sound. In Encyclopedia of Acoustics, ed. M.J. Crocker, 1497-1507. New York: Wiley.

Weston, D.E. (1960). "Underwater Explosions as Acoustic Sources," *Proceedings of the Physical Society*. 76:233 (UNCLASSIFIED).

Yelverton, J.T. 1981, Underwater Explosion Damage Risk Criteria for Fish, Birds, and Mammals, Manuscript, presented at 102nd Meeting of the Acoustical Society of America, Miami Beach, FL, December 1982. 32pp.