REQUEST FOR AN INCIDENTAL HARASSMENT AUTHORIZATION OF MARINE MAMMALS RESULTING FROM 2017 MARITIME WEAPON SYSTEMS EVALUATION PROGRAM OPERATIONAL TESTING

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AFB	Air Force Base
AGM	air-to-ground missile
CBU	Cluster Bomb Unit
CCF	Central Control Facility
CO	carbon monoxide
CO_2	carbon dioxide
dB	decibels
dB re 1 µPa	decibels referenced to 1 micropascal
dB re 1 µPa-m	decibels referenced to 1 micropascal-meter
dB re 1 μPs^2-s	decibel referenced to 1 squared micropascal-second
DoD	Department of Defense
EA	Environmental Assessment
EGTTR	Eglin Gulf Test and Training Range
ESA	Endangered Species Act
ft	feet
GBU	Guided Bomb Unit
GOM	Gulf of Mexico
GPS	Global Positioning System
GRATV	Gulf Range Armament Test Vessel
GSMFC	Gulf States Marine Fisheries Commission
HAPC	Habitat Area of Particular Concern
HEI	high explosive incendiary
IHA	Incidental Harassment Authorization
JASSM	Joint Air-to-Surface Stand-Off Missile
JDAM	Joint Direct Attack Munition
kHz	kilohertz
LJDAM	Laser Joint Direct Attack Munition
LOA	Letter of Authorization
lbs	pounds
m	meters
mm	millimeters
MMPA	Marine Mammal Protection Act
NEW	net explosive weight
NM	nautical miles
NM^2	square nautical miles
NMFS	National Marine Fisheries Service
Pa-s	pascal-second
PBR	potential biological removal
PGU	Projectile Gun Unit
PTS	permanent threshold shift
SEL	sound exposure level
SPL	sound pressure level
TNT	2,4,6-trinitrotoluene
TTP	tactics, techniques, and procedures
TTS	temporary threshold shift
WSEP	Weapon Systems Evaluation Program
ZOI	zone of influence

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EXECUTIVE SUMMARY

With this submittal, Eglin Air Force Base (AFB) 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 Weapons Systems Evaluation Program (WSEP) Operational Testing within the Eglin Gulf Test and Training Range (EGTTR), as permitted by the Marine Mammal Protection Act (MMPA) of 1972, as amended. Maritime WSEP Operational Testing is a military readiness activity and high priority for the Department of Defense (DoD). The Maritime WSEP missions are firmly scheduled to begin on 1 February 2017.

On 10 November 2015, Eglin Natural Resources submitted a Letter of Authorization (LOA) request to consolidate all EGTTR testing and training activities into one authorization for five years. The National Marine Fisheries Service (NMFS), Office of Protected Resources, planned to issue the EGTTR LOA by January 2017. However, on 23 June 2016, it became apparent that the LOA may not be completed to cover February 2017 WSEP missions due to concerns with the acoustic model. These concerns include using a two-dimensional versus three-dimensional approach for calculating takes, switching from Comprehensive Acoustic Simulation System/Gaussian Ray Bundle to normal mode modeling for calculating transmission loss and sound propagation, and using mission-day scenario approach instead of a per-detonation approach. In addition, updates to criteria and thresholds for explosive sources need to be incorporated.

While the goal of the LOA is to provide long-term coverage for all of Eglin's testing and training programs in the EGTTR, the rule-making process may not be completed in time to support Maritime WSEP's 2017 missions. Eglin Natural Resources is, therefore, requesting this IHA as an interim coverage for 2017 missions while the EGTTR LOA undergoes revisions. All future Maritime WSEP missions (mid-2017 through 2022) will be covered in the EGTTR LOA. The only difference between 2016 and 2017 Maritime WSEP missions are slight changes in weapons due to military needs and vital testing scenarios for the DoD. Location, species, and mission execution are the same.

Maritime WSEP missions may expose cetaceans within the EGTTR to noise or pressure levels currently associated with Level A harassment and Level B harassment only. No marine mammal mortalities are anticipated. Acoustic and pressure effects associated with exploding ordnance were determined to be the only elements of Maritime WSEP missions with potential to adversely affect marine species, as analyzed in the associated Environmental Assessment (U.S. Air Force, 2014). Maritime WSEP 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 0.1 to 945 pounds, and detonations will occur above the water surface, at the water surface, and below the water surface. Maritime WSEP missions include deployment of 52 live bombs/missiles, 112 rockets, and 1,000 live gunnery rounds (30-millimeter [-mm] and 7.62-mm) over a timeframe of a few weeks in February and March 2017. Although the missions are planned for February and March 2017, Eglin AFB requests that the IHA be valid for one year from signature. All ordnance will be delivered by multiple types of aircraft, including fighter jets, bombers, and gunships. The targets would consist of stationary, towed, and remotely controlled high-speed boats. The mission location is approximately 17 miles offshore of Santa Rosa Island at 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 to decrease the number of animals potentially affected. Using the most applicable density estimates for each species, the zone of influence of each type of ordnance deployed, and the total number of planned detonations in a mission-day scenario, an estimate of the potential number of animals exposed to acoustic and/or pressure thresholds is analyzed using the most recent guidance provided by NMFS. No takes in the form of mortality are anticipated. Without mitigation measures in place, a maximum of up to approximately three (3) marine mammals (all species combined) could potentially be exposed to injurious Level A harassment (permanent threshold shift). A maximum of approximately 116 marine mammals could potentially be exposed to non-injurious Level B harassment (temporary threshold shift). Approximately 210 animals could potentially be exposed to energy levels corresponding to the behavioral threshold. It is anticipated that mitigation measures, identified in Section 11, will reduce the probabilityof take, specifically mortality. Thus, an IHA is being requested as opposed to an LOA.

Marine mammal species potentially affected by Maritime WSEP missions include four bottlenose dolphin stocks and one Atlantic spotted dolphin stock. The Maritime WSEP 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 deep), 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-meter water depth), occur near the Maritime WSEP 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 Weapon Systems Evaluation Program (WSEP) Operational Testing 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 of live munitions above the water, at the water surface, and below the water surface with the potential to affect cetaceans that may be present within the action area. The mission is described in the following subsections.

1.1 INTRODUCTION

Eglin Air Force Base (AFB) (86th Fighter Weapons Squadron) seeks the ability to conduct live ordnance evaluations in the Gulf of Mexico (GOM) as part of the Maritime WSEP Operational Testing. The proposed missions are very similar to Maritime Strike Operations (Maritime Strike Incidental Harassment Authorization [IHA] issued 13 August 2013) and previous Maritime WSEP mission activities (IHAs issued 5 February 2015 and 4 February 2016). The Maritime WSEP test objectives are to evaluate maritime deployment data; evaluate tactics, techniques, and procedures (TTPs); and determine the impact of TTPs on Combat Air Force training. The results of these evaluations will be used to develop publishable TTPs for inclusion in Air Force TTP 3-1 series manuals. The need to conduct this type of testing has arisen 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 TTPs to train U.S. Air Force strike aircraft to counter small maneuvering surface vessels.

1.2 MISSION DESCRIPTION

Maritime WSEP activities include the release of multiple types of inert and live munitions in the GOM against small boat targets. Maritime WSEP Operational Testing will occur within the EGTTR in Warning Area 151 (W-151) (Figure 1-1). The specific planned mission 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). Maritime WSEP missions will be conducted in various sea states and weather conditions, up to a wave height of 4 feet.

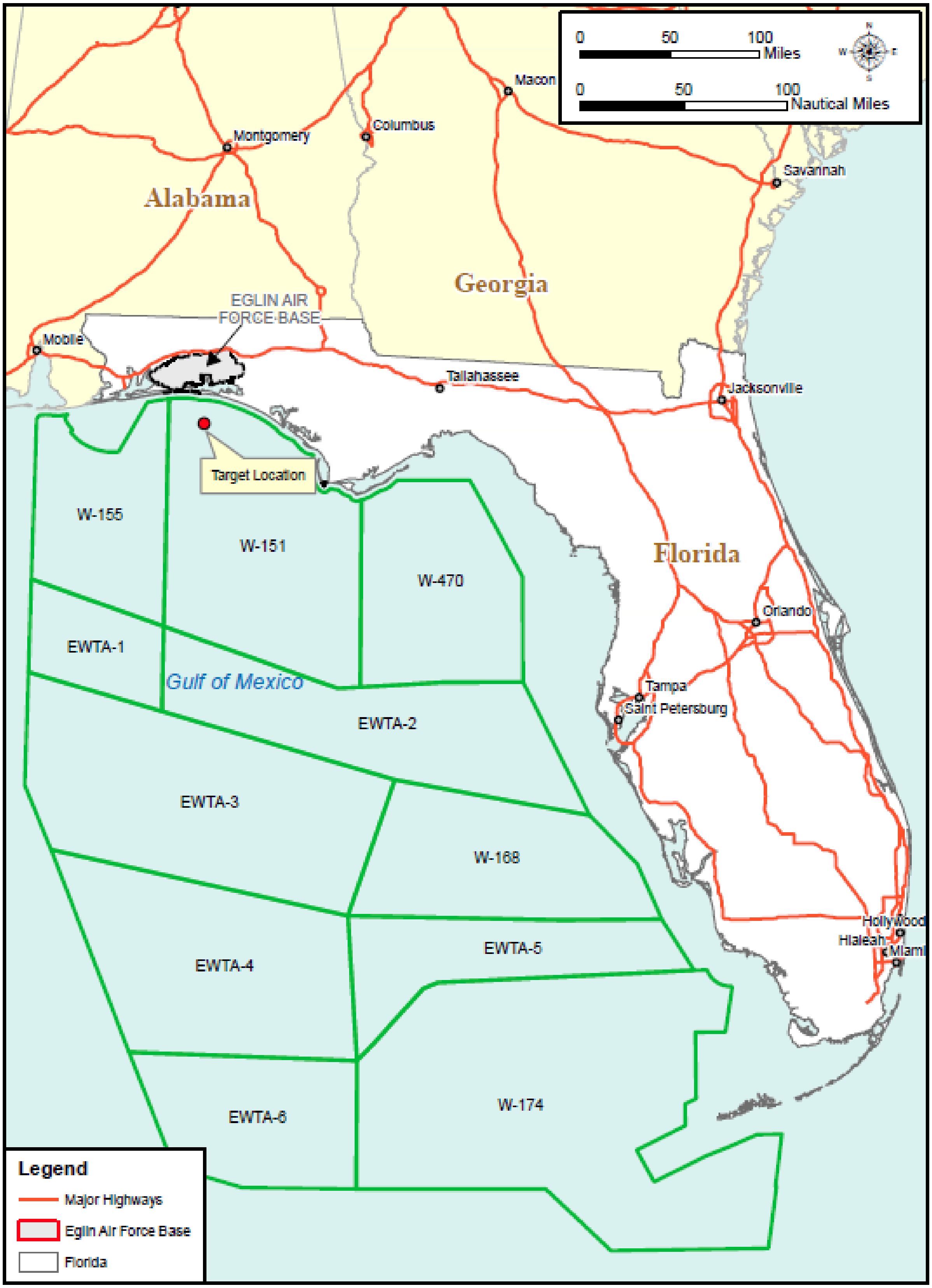

Figure 1-1. Eglin Gulf Test and Training Range (EGTTR)

Multiple munitions and aircraft will be used to meet the objectives of the Maritime WSEP Operational Tests (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 weapon release as long as it meets the delivery parameters for safety concerns. 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 known as the Gulf Range Armament Test Vessel (GRATV) that is anchored on-site and will also provide a platform for cameras and weapon-tracking equipment. Target boats will be positioned approximately 600 feet from the GRATV, depending on the munition.

Table 1-1. Live Munitions and Aircraft

Munitions	Aircraft[1]
GBU-10/-24/-31	F-16C fighter aircraft
GBU-49	F-16C+ fighter aircraft
JASSM	F-15E fighter aircraft
GBU-12 (PWII)/-54 (LJDAM)/-38/-32 (JDAM)	A-10 fighter aircraft
AGM-65 (Maverick)	B-1B bomber aircraft
CBU-105 (WCMD)	B-52H bomber aircraft
GBU-39 (Small Diameter Bomb)	MQ-1/9 unmanned aerial vehicle
AGM-114 (Hellfire)	AC-130 gunship
AGM-176 (Griffin)	
2.75 Rockets/AGR-20A/B	
AIM-9X	
PGU-12 HEI 30 mm	

AGM = air-to-ground missile; CBU = Cluster Bomb Unit; GBU = Guided Bomb Unit; HEI = high explosive incendiary; JASSM = Joint Air-to-Surface Stand-Off Missile; JDAM = Joint Direct Attack Munition; LJDAM = Laser Joint Direct Attack Munition; mm = millimeters; PGU = Projectile Gun Unit

1. Not associated with specific munitions WCMD = Wind Corrected Munitions Dispenser

Maritime WSEP missions will include three fuzing options: detonation above the water surface, at the water surface, and below the water surface. 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 WSEP 2017 Munitions

Type of Munition	NEW (lbs)	Detonation Type	Total Annual
GBU-10/-24/-31	945	Subsurface (10-ft depth)	2
GBU-49	500	Surface	4
JASSM	255	Surface	4
GBU-12 (PWII) /-54 (LJDAM)/-38/-32 (JDAM)	192	Subsurface (10-ft depth)	6
AGM-65 (Maverick)	86	Surface	8
CBU-105 (WCMD)	83	Airburst	4
GBU-39 (Small Diameter Bomb)	37	Surface	4
AGM-114 (Hellfire)	20	Subsurface (10-ft depth)	20
AGM-176 (Griffin)	13	Surface	10
2.75 Rockets or AGR-20A/B	12	Surface	100
AIM-9X	7.9	Surface	2
PGU-12 HEI 30 mm	0.1	Surface	1,000

AGM = air-to-ground missile; CBU = Cluster Bomb Unit; ft = foot; GBU = Guided Bomb Unit; HEI = high explosive incendiary; JASSM = Joint Air-to-Surface Stand-Off Missile; JDAM = Joint Direct Attack Munition; LJDAM = Laser Joint Direct Attack Munition; mm = millimeters; lbs = pounds; PGU = Projectile Gun Unit; WCMD = Wind Corrected Munitions Dispenser

A human safety zone will be established around the area prior to each live mission and will be enforced by a large number of safety boats (approximately 30 to 35). The size of this zone will vary, depending upon the particular munition used in a given mission. A composite safety footprint will be developed, which incorporates all munitions being deployed. The composite safety footprint will consist 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 before all releases.

In addition, a separate zone around the target will be established for marine species protection, based on the distance from which energy- and pressure-related impact zones could extend for a given mission-day category explained below and listed in Table 1-2 and Table 1-3. This zone will be smaller than the human safety zone. Trained marine species observers will survey the species protection zone before and after each mission. In addition, Air Force personnel will be within the mission area performing various tasks and will observe for protected marine species as feasible throughout mission preparation, execution, and cleanup. A detailed description of mitigation measures is provided in Section 11.

At least two ordnance delivery aircraft will participate in each live weapon release mission. Prior to weapon release, 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, three video cameras will be positioned on the GRATV anchored on-site. The cameras will be used to document weapon performance against the targets and to monitor for the presence of protected species. An Eglin Natural Resources representative will be located in Eglin's Central Control Facility (CCF), along with mission personnel, to view the video feed before and during mission activities. Missions will not proceed until the target area is clear of protected marine species. Furthermore, if the cameras are not operational for any reason, the mission will not be conducted. A detailed description of mitigation measures is provided in Section 11.

After each mission, a team of Air Force personnel will collect debris and retrieve damaged targets from the mission site. These vessels will be separate from dedicated protected species observer vessels that will conduct the post-mission surveys to assess potential impacts from the mission.

Mission-Day Categorization

For this IHA request, Maritime WSEP missions have been categorized based on the number of weapons released per day, instead of treating each weapon release as a separate event. This approach is meant to satisfy NMFS requests for analysis and modeling of accumulated energy from multiple detonations over a 24-hour timeframe. Eglin AFB used all available information to determine these daily estimates; however, these scenarios may not represent exact weapon releases because military needs and requirements are in a constant state of flux. These estimates do provide maximum, medium, and minimum mission-day scenarios. Up to eight missions days are planned for Maritime WSEP operations annually. Weapons would be released for up to four hours each day in the morning.

Mission-day categorization and levels of weapon release were based on historical mission data, project engineer input, and future WSEP requirements and are listed in Table 1-3. Categories of missions were grouped first using historical weapon releases per day (refer to Maritime WSEP annual reports for 2014, 2015, and 2016). Next, the most recent weapons evaluation needs and requirements were considered to develop three different scenarios: Categories A, B, and C. Mission-day Category A represents munitions with larger NEW (192 to 945 pounds) and both surface and subsurface detonations. This category includes future requirements and provides flexibility for the military mission. To date, Category A levels of activity have not been conducted under Maritime WSEP missions, and is considered a worst-case scenario. Category B represents munitions with medium levels of NEW (20 to 86 pounds) including surface and subsurface detonations. Category B was calculated using actual levels of weapon releases during Maritime WSEP missions (refer to Maritime WSEP annual reports for 2014, 2015, and 2016). Category C represents munitions with smaller NEW (0.1 to 13 pounds) and includes surface detonations only.

Table 1-3. Live Munitions Categorized as Representative Mission Days

Mission Category	Munition	NEW (lbs)	Detonation Type	Munitions per Day	Mission Days/Year	Total Munitions/Year
A	GBU-10/-24/-31	945	Subsurface (10-ft depth)	1	2	2
	GBU-49	500	Surface	2		4
	JASSM	255	Surface	2		4
	GBU-12 (PWII)/-54 (LJDAM)/ -38/-32 (JDAM)	192	Subsurface (10-ft depth)	3		6
B	AGM-65 (Maverick)	86	Surface	2	4	8
	CBU-105 (WCMD)	83	Airburst	1		4
	GBU-39 (Small Diameter Bomb)	37	Surface	1		4
	AGM-114 (Hellfire)	20	Subsurface (10-ft depth)	5		20
C	AGM-176 (Griffin)	13	Surface	5	2	10
	2.75 rockets or AGR-20A/B	12	Surface	50		100
	AIM-9X	7.9	Surface	1		2
	PGU-12 HEI 30 mm	0.1	Surface	500		1,000

AGM = air-to-ground missile; CBU = Cluster Bomb Unit; GBU = Guided Bomb Unit; HEI = high explosive incendiary; JDAM = Joint Direct Attack Munition; LJDAM = Laser Joint Direct Attack Munition; lbs = pounds; PGU = Projectile Gun Unit; mm = millimeter; WCMD = Wind Corrected Munitions Dispenser

2. DURATION AND LOCATION OF THE ACTIVITIES

Maritime WSEP missions are scheduled to occur one week in February and one week in March 2017. Missions will occur on weekdays during daytime hours only with multiple live munitions being released each day. All activities will take place within the EGTTR, which is defined as the airspace over the GOM controlled by Eglin AFB, beginning 3 nautical miles (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 1-1). Warning Area W-155, which is controlled by the Navy, is used occasionally to support Eglin missions. The EGTTR is associated with over 102,000 square nautical miles (NM^2) of underlying water surface. 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), 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 square kilometers). 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 at water depths less than 250 meters. Maritime WSEP missions will occur in the shallower, northern inshore portion of the sub-area at a water depth of about 35 meters (115 feet).

Duration and Location of the Activities

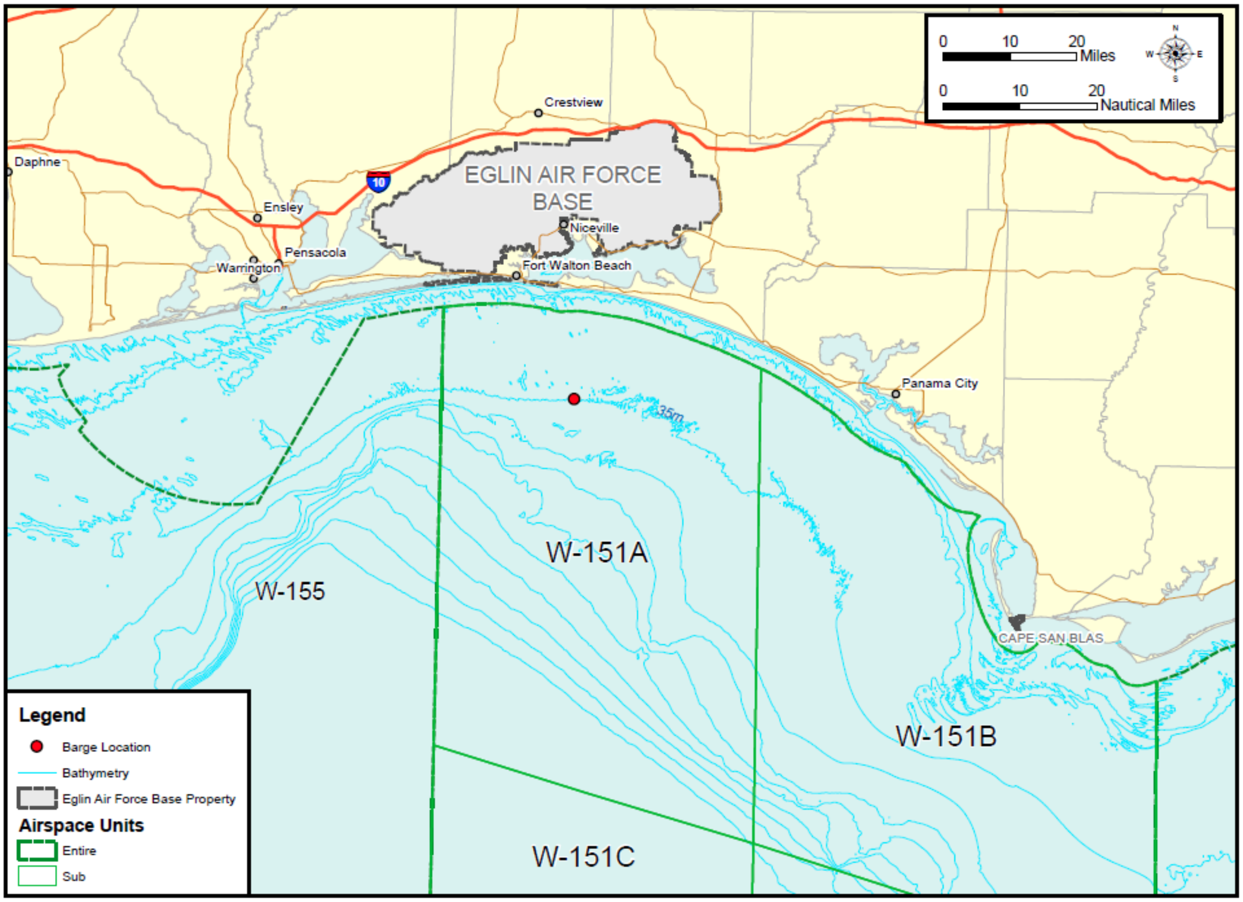

Figure 2-1. Maritime WSEP Operational Testing Location in W-151A

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 WSEP 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 which are, 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 at a water depth range that encompasses the Maritime WSEP testing location (Garrison, 2008; Department of the Navy, 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 Atlantic spotted dolphin density estimates used in this document were obtained from Duke University Marine Geospatial Ecology Lab Reports (Roberts et al., 2016), which integrated 23 years of aerial and shipboard surveys, linked them to environmental covariates obtained from remote sensing and ocean models, and developed habitat-based density models using distance sampling methodology. For bottlenose dolphins, geographic modeling strata from MMPA stock boundaries and seasonal strata were not defined because of the lack of information about seasonality in the Gulf of Mexico, as well as substantial spatial and seasonal biases in survey efforts (Roberts et al., 2015a). Therefore, numbers of bottlenose dolphin in the Gulf of Mexico were modeled using a single year-round model. Similarly, for Atlantic spotted dolphins, there is no evidence that this species migrates or exhibits seasonal patterns in the Gulf of Mexico, so a single, year-round model that incorporated all available survey data was used (Roberts et al., 2015b). The model results are available at the OBIS-SEAMAP repository found online.

Density models for bottlenose dolphins and Atlantic spotted dolphins accounted for perception and availability biases, typically captured as g(0) estimates. *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 and availability bias result in the underestimation of abundance and density numbers (negative bias).

There are no published g(0) estimates for any shipboard surveys in the Gulf of Mexico, therefore, the model used Barlow and Forney (2006) estimates for delphinids produced from surveys that utilized similar protocols. These estimates only accounted for perception bias, but since dive times for dolphins are generally short in duration, availability bias is not expected to be significant (Roberts et al., 2015a,b). For aerial surveys, Palka (2006) g(0) estimates were used for the availability bias component of g(0), which was 1 for large groups, and Carretta et al.

(2000) estimates were used for the perception bias component of g(0) for large groups, which is slightly less than 1.

Raster data provided online from the Duke University Marine Geospatial Ecology Lab Report were imported into ArcGIS and overlaid onto the Maritime WSEP mission area. Density values are provided in 100 km^2 boxes. A 30-km by 30-km (900 km^2) area centered on the Maritime WSEP mission location was selected, which consisted of nine 100-km^2 blocks. Density values from those blocks were averaged and converted to number of animals per square kilometer to obtain average annual density estimates for bottlenose and Atlantic spotted dolphins used in this analysis. These values are provided in Table 3-1.

Table 3-1. Marine Mammal Density Estimates

Species	Density Estimate (animals per square kilometer)
Bottlenose dolphin	0.433
Atlantic spotted dolphin	0.148

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, 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 1997–1998 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.

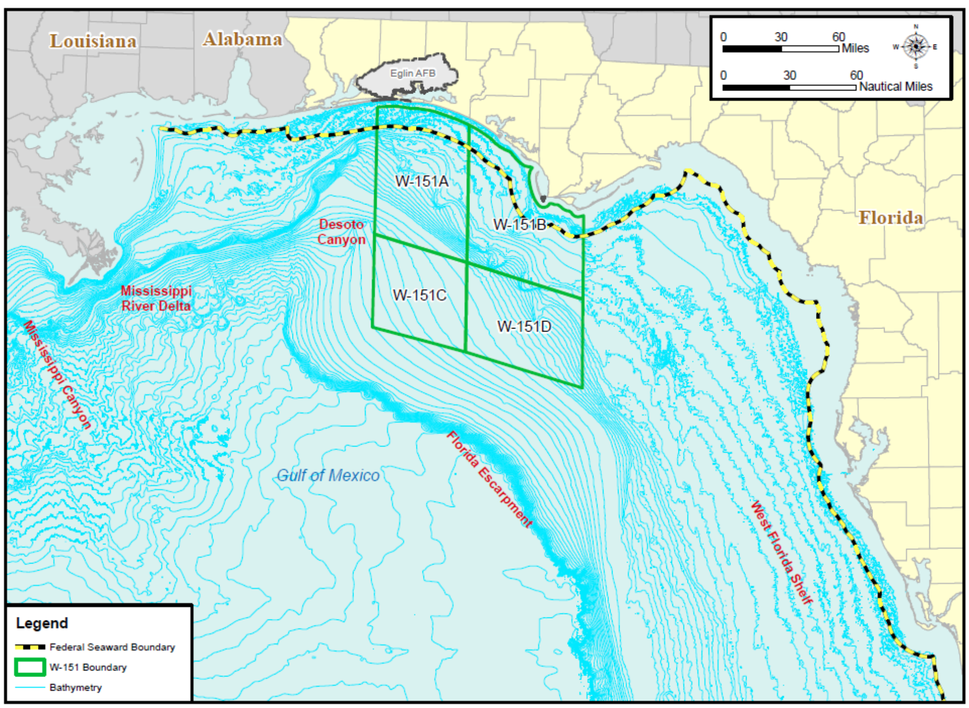

Figure 4-1. Topographical Features of the Gulf of Mexico in Relation to W-151

4.1 COMMON BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)

Status and Management – This species is not listed under the ESA but is protected under the MMPA. Along the United States east coast and northern Gulf of Mexico, the bottlenose dolphin stock structure is well studied. There are currently 34 management stocks identified by NMFS in northern Gulf of Mexico, including oceanic, continental shelf, coastal, and estuarine stocks (Waring et al., 2015).
Habitat and Geographic Range **–** The bottlenose dolphin occurs in tropical to temperate waters of the Atlantic Ocean as well as inshore, nearshore, and offshore waters of the Gulf of Mexico and United States east coast (Waring et al., 2015). They generally do not range north or south of 45° latitude (Jefferson et al., 2015; Wells and Scott, 2008). They occur in most enclosed or semi-enclosed seas in habitats ranging from shallow, murky, estuarine waters to deep, clear offshore waters in oceanic regions (Jefferson et al., 2015; Wells et al., 2009). Open ocean populations occur far from land; however, population density appears to be highest in nearshore areas (Scott and Chivers, 1990).

There are two morphologically and genetically distinct bottlenose dolphin morphotypes (distinguished by physical differences) (Duffield et al., 1983) described as coastal and offshore forms. Both inhabit waters in the Gulf of Mexico (Curry and Smith, 1997; Hersh and Duffield, 1990; Mead and Potter, 1995). The coastal morphotype of bottlenose dolphin is continuously distributed along the Atlantic coast south of Long Island, New York, around the Florida peninsula, and along the Gulf of Mexico coast. Five coastal or open ocean stocks are identified in the Gulf of Mexico: Continental Shelf, Eastern Coastal, Northern Coastal, Western Coastal, and Oceanic (Waring et al., 2016). Residency patterns of dolphins in bays, sounds, and estuaries range from transient to seasonally migratory to stable resident communities, and various stocks may overlap at times. Year-round residency patterns of some individual bottlenose dolphins in bays, sounds, and estuaries have been reported for almost every survey area where photo-identification or tagging studies have been conducted (LaBrecque et al., 2015). Based on photo-identification studies, satellite telemetry data, and genetics studies, LaBrecque et al. (2015) described 32 small and resident population areas for bottlenose dolphins within the Gulf of Mexico, all consistent with the bay, sound, and estuary stocks. Of the 32 stocks of bay, sound, and estuary bottlenose dolphins recognized by NMFS, only 11 met the criteria for small and resident populations as a biologically important area. Published data for the Choctawhatchee Bay stock suggests small and resident populations, however, it was one of the 21 remaining stocks that did not meet the biologically important area criteria (LaBrecque et al., 2015). Therefore, no biologically important areas have been identified within or around the EGTTR study area.

Gulf of Mexico – The bottlenose dolphin is the most widespread and common cetacean in coastal waters of the Gulf of Mexico (Würsig et al., 2000). The species is abundant in continental shelf waters throughout the northern Gulf of Mexico (Fulling et al., 2003; Waring et al., 2016), 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 [3,281 feet] in bottom depth) and that highest densities are in the northeastern Gulf. Significant occurrence is expected near all bays in the northern Gulf.

A survey of nearshore and continental shelf waters of the eastern Gulf of Mexico (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, and bottlenose dolphins were more evenly distributed throughout coastal and shelf waters. Table 4-1 shows the common bottlenose dolphin stocks in the north-central Gulf of Mexico.

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

<table>
<tr><th colspan="2">Stock</th><th>Distribution</th><th>Strategic Stock?</th><th>Estimated Abundance</th><th>PBR</th></tr>
<tr><td rowspan="3">Bay, sound, and estuarine stocks</td><td>Choctawhatchee Bay</td><td rowspan="3">Areas of contiguous, enclosed, or semi-enclosed water bodies</td><td>Yes</td><td>179</td><td>1.7</td></tr>
<tr><td>Pensacola/East Bay</td><td>Yes</td><td>33</td><td>U</td></tr>
<tr><td>St. Andrew Bay</td><td>Yes</td><td>124</td><td>U</td></tr>
<tr><td colspan="2">Gulf of Mexico Northern Coastal</td><td>Waters from shore to the 20-meter (66-foot) isobath, from the Mississippi River delta to the Florida Big Bend region</td><td>Yes</td><td>7,185</td><td>60</td></tr>
<tr><td colspan="2">Northern Gulf of Mexico Continental Shelf</td><td>Waters between the 20- and 200-meter (66- and 656-foot) isobaths, from Texas to Key West</td><td>No</td><td>51,192</td><td>469</td></tr>
<tr><td colspan="2">Northern Gulf of Mexico Oceanic</td><td>Waters from the 200-meter (656-foot) isobath to the seaward extent of the U.S. Exclusive Economic Zone</td><td>No</td><td>5,806</td><td>42</td></tr>
</table>

PBR = potential biological removal; U = undetermined
Source: Waring et al., 2016

Genetic, photo-identification, and tagging data support the concept of relatively discrete bay, sound, and estuary stocks (Waring et al., 2016). NMFS has provisionally identified 31 such stocks that inhabit areas of contiguous, enclosed, or semi-enclosed water bodies adjacent to the northern Gulf of Mexico. 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 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 project area. Movement between various communities has been documented (Waring et al., 2016), 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. Air-to-surface activities will occur directly seaward of the area occupied by the Choctawhatchee Bay stock. The best abundance estimate for this stock, as provided in the Stock Assessment Report, is 179. 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 bay, sound, and estuary stocks to be strategic.

Three coastal stocks have been identified in the northern Gulf of Mexico, 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° west). The Eastern Coastal stock is defined from 84° west to Key West, Florida. Of the coastal stocks, the Northern Coastal stock is geographically associated with the GRATV target location. PBR is 60 individuals. Prior to 2012, this stock was not considered strategic. However, beginning 1 February 2010, an unusual mortality event of unprecedented size and duration has been ongoing (Litz et al., 2014) that has resulted in NMFS' reclassification of this stock as strategic. The Northern Gulf of Mexico 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 469 individuals, and the stock is not considered strategic. The Northern Gulf of Mexico 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 have been 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 1 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) (Janik et al., 2006). Sound production is 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). Whistles and clicks may 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 (TTSs) in hearing have been experimentally induced in captive bottlenose dolphins using a variety of noises (i.e., broadband pulses) (Ridgway et al., 1997; Schlundt et al., 2000; Nachtigall et al., 2003; Finneran et al., 2005; Mooney et al., 2005; Mooney, 2006). 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).

4.2 ATLANTIC SPOTTED DOLPHIN (*STENELLA FRONTALIS*)

Status and Management – The Atlantic spotted dolphin occurs in two forms that may be distinct subspecies (Perrin et al., 1987, 1994; Rice, 1998; Viricel and Rosel, 2014): the large, heavily spotted form, which inhabits the continental shelf and is usually found inside or near the 200-meter isobath, and the smaller, less spotted island and offshore form, which occurs in the Atlantic Ocean but is not known to occur in the Gulf of Mexico (Fulling et al., 2003; Mullin and Fulling, 2003, 2004; Viricel and Rosel, 2014).

Habitat and Geographic Range – The Atlantic spotted dolphin is found in nearshore tropical to warm-temperate waters, predominantly over the continental shelf and upper slope (Waring et al., 2016). In the Gulf of Mexico, for instance, the species often occurs over the mid-shelf (Griffin and Griffin, 2003). In the western Atlantic, this species is distributed from New England to Brazil and is found in the Gulf of Mexico as well as the Caribbean Sea (Perrin, 2008). The large, heavily spotted coastal form of the Atlantic spotted dolphin typically occurs over the continental shelf but usually at least 4.9 to 12.4 miles offshore (Davis et al., 1998; Perrin, 2002; Perrin et al., 1994). Higher numbers of spotted dolphins are reported over the west Florida continental shelf from November to May than during the rest of the year, suggesting that this species may migrate seasonally (Griffin and Griffin, 2003). In the Gulf of Mexico, Atlantic spotted dolphins occur primarily from continental shelf waters 10 to 200 meters deep to slope waters less than 500 meters deep (Fulling et al., 2003; Mullin and Fulling, 2004; Maze-Foley and Mullin, 2006). Atlantic spotted dolphins were seen in all seasons during GulfCet aerial surveys of the northern Gulf of Mexico from 1992 to 1998 (Hansen et al., 1996; Mullin and Hoggard, 2000).

The most recent abundance estimate is 37,611 individuals in the northern Gulf of Mexico (outer continental shelf and oceanic waters) and is derived from fall surveys in 2000 – 2011 and spring/summer surveys in 2003 – 2004. According to the 2015 Stock Assessment Report, since these data are more than 8 years old, the current best population estimate is unknown (Waring et al. 2016). The northern Gulf of Mexico population is considered to be genetically distinct from western North Atlantic populations. PBR for this species is undetermined, and the stock is not considered strategic.

Diving Behavior – Information on diving depth for this species is available from a satellite-tagged individual in the Gulf of Mexico (Davis et al., 1996). 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.

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 of 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 typically range in frequency from 0.1 to 8 kHz (Richardson et al., 1995). Recorded echolocation clicks had two dominant frequency ranges at 40 to 50 kHz and 110 to 130 kHz, depending on source level (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 aggressive interactions with bottlenose dolphins (and their own species) to produce squawks (0.2- to 12-kHz broadband 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- to 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 at relatively 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 Gulf of Mexico and the Caribbean Sea (Perrin et al., 1987). Atlantic spotted dolphins may occur in both continental shelf and offshore waters (Perrin et al., 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

The Atlantic spotted dolphin is the second most abundant cetacean in the nearshore waters of the northern Gulf of Mexico. In the Gulf, 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).

5. TAKE AUTHORIZATION REQUESTED

The 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 WSEP 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 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 IHA for the incidental taking (but not intentional taking) of marine mammals is requested for Maritime WSEP Operational Testing 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 Section 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) (U.S. Navy, 2008). 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 WSEP 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.

Three key sources of information are necessary for estimating potential acoustic 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.

6.1 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 acoustic 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 were originally developed for the shock trials of the *USS SEAWOLF* and *USS Winston S. Churchill* (DDG-81) and modified over the years as the science became better understood. The analysis of potential impacts to marine mammals utilizes criteria and thresholds presented in Finneran and Jenkins (2012) and, and the most NMFS recent guidance (NMFS 2016).

The paragraphs below provide a general discussion of the various metrics, criteria, and thresholds used for impulsive or explosive noise impact assessment of marine mammals. More information on this topic is provided in Appendix A.

6.2 METRICS

Standard impulsive and acoustic metrics were used for the analysis of underwater energy and pressure waves in this document. Several different metrics are important for understanding risk assessment analysis of impacts to marine mammals.

- *SPL* (sound pressure level): A ratio of the absolute sound pressure and a reference level. Units are in decibels re 1 micropascal (dB re 1 µPa).
- *SEL* (sound exposure level): SEL is a measure of sound intensity and duration. When analyzing effects on marine animals from multiple moderate-level sounds, it is necessary to have a metric that quantifies cumulative exposures. SEL can be thought of as a

composite metric that represents both the intensity of a sound and its duration. SEL is determined by calculating the decibel level of the cumulative sum-of-squared pressures over the duration of a sound, with units of dB re 1 micropascal-squared seconds ($\mu Pa^2 \cdot s$) for sounds in water.

- *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). There is no decibel analog for impulse.

6.3 CRITERIA AND THRESHOLDS

6.3.1 Mortality

Whereas a single mortality threshold was previously used in acoustic impacts analysis, species specific thresholds are used today. Thresholds are based on the level of underwater blast noise that would cause extensive lung injury from which 1 percent of animals exposed would not recover (Finneran and Jenkins, 2012). The threshold is conservative in that it represents the onset of mortality and 99 percent of animals exposed would be expected to survive. The lethal exposure level of blast noise, associated with the positive impulse pressure of the blast, is expressed as Pa·s and determined using the Goertner (1982) modified positive impulse equation. This equation considers factors of sound propagation, source/animal depths, and the mass of a newborn calf for a given species. The threshold is conservative because animals of greater mass can withstand greater pressure shock waves, and newborn calves typically make up a very small percentage of any cetacean group.

For the Proposed Action, two species are expected to occur within the study area, the bottlenose dolphin and the Atlantic spotted dolphin. Finneran and Jenkins (2012) provide known or surrogate masses for newborn calves of several cetacean species. For the bottlenose dolphin, this value is 14 kilograms. For the Atlantic spotted dolphin, a surrogate species, the striped dolphin, is used; the mass value of a newborn calf is 7 kilograms. The Goertner equation as presented in Finneran and Jenkins was used in the acoustic model to develop impacts analysis for this IHA request:

$$I_M(M,D) = 91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$$

$I_M(M,D)$	mortality threshold, expressed in terms of acoustic impulse (Pa·s)
M	Animal mass (Table D-1)
D	Water depth (m)

6.3.2 Injury (Level A Harassment)

Finneran and Jenkins (2012) recognizes two types of blast related injury: gastrointestinal (GI) tract injury and slight lung injury, while NMFS Technical Guidance (2016) addresses irrecoverable auditory damage. These injury categories are all types of Level A harassment as defined in the MMPA.

Gastrointestinal Tract Injuries

GI tract injuries are correlated with peak pressure of an underwater detonation. For recoverable injury observed during experiments with small charges in the 1970s, the peak pressure of the shock wave was the causal agent of contusions in the GI tract (Richmond et al., 1973 in Finneran and Jenkins, 2012). The experiments found that a peak SPL of 237 dB re 1 μPa predicts the onset of GI tract injuries, which are independent of an animal's mass or size. Therefore, the unweighted peak SPL of 237 dB re 1 μPa is used in explosive impacts assessments as the threshold for slight GI tract injury for all marine mammals.

Slight Lung Injury

Thresholds for slight lung injury to marine mammals exposed to underwater blasts are defined as a survivable occurrence of slight lung injury from which all animals would survive. As with the mortality determination, the metric is positive impulse and the equation for determination is that of the Goertner injury model (1982), which is defined as:

$$I_S(M,D) = 39.1 M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2},$$

where M is the animal mass (kilograms), D is the animal depth (meters), and the units of I_S are Pa·s.

As the equation incorporates species specific body masses, the mass of a newborn calf for bottlenose and Atlantic spotted dolphins were applied to the Maritime WSEP study area.

Auditory Damage (Permanent Threshold Shift)

Another type of injury, permanent threshold shift or PTS, is auditory damage that does not fully recover and results in a permanent decrease in hearing sensitivity. As there have been no studies to determine the onset of PTS in marine mammals, this threshold is estimated from available information associated with TTS. The NMFS Technical Guidance (2016) defines PTS thresholds differently for three groups of cetaceans based on their hearing sensitivity. Bottlenose and Atlantic spotted dolphins that are the subject of the Maritime WSEP acoustic impacts analysis both fall within the mid-frequency hearing category. The PTS thresholds use dual criteria, one based on cumulative SEL and one based on peak SPL of an underwater blast. For a given analysis, the more conservative of the two is applied to afford the most protection to marine mammals. The mid-frequency cetacean criteria for PTS are:

- SEL (mid-frequency weighted) of 185 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted) of 230 dB re 1 μPa

6.3.3 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 (Maritime WSEP testing qualifies for this category of activity). 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 the non-injurious impacts but includes physiological impact of TTS and behavioral impacts.

Temporary Threshold Shift (TTS)

According to the most recent NMFS Technical Guidance (NMFS, 2016) the TTS onset thresholds for mid-frequency cetaceans are based on TTS data from a beluga whale exposed to an underwater impulse produced from a seismic watergun (Finneran et al., 2002). TTS thresholds also use a dual criterion, and in a given analysis, the more conservative of the two criteria is applied. The TTS thresholds for bottlenose and Atlantic spotted dolphins consist of the SEL of an underwater blast weighted to the hearing sensitivity of mid-frequency cetaceans and a peak SPL measure of the same. The dual thresholds for TTS in mid-frequency cetaceans are:

- SEL (mid-frequency weighted) of 170 dB re 1 $\mu Pa^2 \cdot s$
- Peak SPL (unweighted) of 224 dB re 1 μPa

Behavioral Impacts

Behavioral impacts are essentially disturbances that may occur at noise levels below those considered to cause TTS in marine mammals, particularly in cases of multiple detonations. Behavioral impacts may include decreased ability to feed, communicate, migrate, or reproduce, among others. Such effects, known as sub-TTS Level B harassment, are based on observations of behavioral reactions in captive dolphins and belugas to pure tones, a different type of noise than that produced from an underwater detonation (Finneran and Schlundt, 2004; Schlundt et al., 2000). For multiple, successive detonations (i.e., detonations happening at the same location within a 24-hour period), the threshold for behavioral disturbance is set 5 dB below the SEL-based TTS threshold, unless there are species or group specific data indicating that a lower threshold should be used. This is based on observations of behavioral reactions in captive dolphins and belugas occurring at exposure levels approximately 5 dB below those causing TTS after exposure to pure tones (Finneran and Jenkins, 2012; Finneran and Schlundt, 2004; Schlundt *et al.*, 2000). The behavioral impacts threshold for mid-frequency cetaceans exposed to multiple, successive detonations is:

- SEL (mid-frequency weighted) of 165 dB re 1 $\mu Pa^2 \cdot s$

Table 6-1 summarizes the thresholds and criteria discussed above and used in this document to estimate potential noise impacts to marine mammals. All criteria and thresholds for cetaceans are derived from NMFS Technical Guidance (NMFS, 2016).

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

Mortality*	Level A Harassment			Level B Harassment	
	Slight Lung Injury[1]	GI Tract Injury	PTS	TTS	Behavioral
$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$	$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$	Unweighted SPL: 237 dB re 1 μPa	Weighted SEL: 185 dB re 1 μPa^2·s Unweighted SPL: 230 dB re 1 μPa	Weighted SEL: 170 dB re 1 μPa^2·s Unweighted SPL: 224 dB re 1 μPa	Weighted SEL: 165 dB re 1 μPa^2·s

D = water depth (meters); dB re 1 μPa = decibels referenced to 1 micropascal; dB re 1 μPa^2·s = decibels reference to 1 micropascal-squared – seconds; *M* = animal mass based on species (kilograms); psi = pounds per square inch; PTS = permanent threshold shift; TTS = temporary threshold shift; SEL = sound exposure level; SPL = sound pressure level

1. Expressed in terms of acoustic impulse (Pacsal – seconds [Pa·s]

6.4 MARINE MAMMAL DENSITY

Density estimates for marine mammals occurring in the EGTTR are provided in Table 3-1. As discussed in Section 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). 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 can present a distorted view of marine mammal distribution in any region. Based on current guidance from NMFS, density is assumed to be two-dimensional, and exposure estimates are, therefore, simply calculated as the product of affected area, animal density, and number of events. The resulting exposure estimates are considered conservative, because all animals are presumed to be located at the same depth, where the maximum sound and pressure ranges would extend from detonations, and would, therefore, be exposed to the maximum amount of energy or pressure. In reality, it is highly likely that some portion of marine mammals present near the impact area at the time of detonation would be at various depths in the water column and not necessarily occur at the same depth corresponding to the maximum sound and pressure ranges.

6.5 NUMBER OF EVENTS

Historically, the Air Force has conservatively used the number of live weapons deployed (a per-detonation analysis that assumes a fresh population of marine mammals for each detonation) as the number of events for Maritime WSEP activities. However, as described in Section 1.2, a mission-day based analysis was requested by NMFS in order to model accumulated energy over a 24-hour timeframe where each mission-day scenario would be considered a separate event. As shown in Table 1-3, Eglin developed three mission-day categories and estimated the number of days each category would be executed during 2017 Maritime WSEP missions. In total, there would be up to eight events per year. The total number of days Maritime WSEP missions are planned each year are as follows: Category A would be conducted two days per year, Category B would be conducted four days per year, and Category C would be conducted two days per year.

6.6 EXPOSURE ESTIMATES

Table 6-2 provides the maximum range of effects for all criteria and thresholds for mission-day Categories A, B, and C. These ranges were calculated based on explosive acoustic characteristics, sound propagation, and sound transmission loss in the study area, which incorporates water depth, sediment type, wind speed, bathymetry, and temperature/salinity profiles. Refer to Appendix A for a description of the acoustic modeling methodology used in this analysis.

Table 6-2. Criteria and Threshold Radii (in meters) for Maritime WSEP Mission-Day Categories

Mission-Day Category	Mortality	Level A Harassment					Level B Harassment		
		Slight Lung Injury	GI Tract Injury	PTS			TTS		Behavioral
	Modified Goertner Model 1	Modified Goertner Model 2	237 dB SPL	185 dB SEL	230 dB Peak SPL		170 dB SEL	224 dB Peak SPL	165 dB SEL
Bottlenose Dolphin									
A	193	534	180	945	705		4,666	1,302	7,479
B	110	180	156	248	180		2,225	180	3,959
C	37	73	83	286	169		1,128	180	1,863
Atlantic Spotted Dolphin									
A	216	595	180	945	705		4,666	1,302	7,479
B	136	180	156	248	180		2,225	180	3,959
C	47	84	83	286	169		1,128	180	1,863

dB = decibels; GI = gastrointestinal; SEL = sound exposure level; SPL = sound pressure level; PTS = permanent threshold shift; TTS = temporary threshold shift

The ranges presented above were used to calculate the total area (circle) of the zones of influence for each criterion/threshold. To eliminate "double-counting" of animals, impact areas from higher impact categories (e.g., mortality) were subtracted from areas associated with lower impact categories (e.g., Level A harassment). The estimated number of marine mammals potentially exposed to the various impact thresholds was calculated with a two-dimensional approach, as the product of the adjusted impact area, animal density, and annual number of events for each mission-day category. The calculations generally resulted in decimal values, suggesting that, in most cases, a fraction of an animal was exposed. The results were therefore rounded at the annual mission-day level and then summed for each criterion to obtain total annual take estimates from all Maritime WSEP mission activities. A "take" is considered to occur for SEL metrics if the received level is equal to or above the associated threshold within the appropriate frequency band of the sound received, adjusted for the appropriate weighting function value of that frequency band. Similarly, a “take” would occur for impulse and peak SPL metrics if the received level is equal to or above the associated threshold.. For impact categories with multiple criteria (e.g., slight lung injury, GI tract injury, and PTS for Level A harassment) and criteria with two thresholds (e.g., 187 decibels [dB] SEL and 230 peak SPL for PTS), the criterion and/or threshold that yielded the higher exposure estimate was used for detonation impact analyses. Table 6-3 through Table 6-5 show the annual numbers of marine mammals potentially affected by Category A, B, and C missions, respectively. These exposure estimates do not take into account the required mitigation and monitoring measures described in Chapter 11 of this document; these measures are expected to decrease the potential for impacts.

Table 6-6 sums the total number of marine mammals potentially affected by all Maritime WSEP missions for the year and indicates the potential for injury and non-injurious harassment (including behavioral harassment) to marine mammals in the absence of mitigation measures. Mortality was calculated as zero (0) for bottlenose dolphin**s,** zero (0) animals for Atlantic spotted dolphin. It is expected that, with implementation of the mitigation and monitoring measures outlined in Section 11, potential impacts would be mitigated to the point that there would be no mortality takes.

Table 6-3. Annual Number of Marine Mammals Potentially Affected by Category A Maritime WSEP Missions in the EGTTR (2 days)

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Bottlenose dolphin	0	2	57	93
Atlantic spotted dolphin	0	1	19	32
Total	0	3	57	93

PTS = permanent threshold shift; TTS = temporary threshold shift

Table 6-4. Annual Number of Marine Mammals Potentially Affected by Category B Maritime WSEP Missions in the EGTTR (4 days)

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Bottlenose dolphin	0	0	27	58
Atlantic spotted dolphin	0	0	9	19
Total	0	0	27	59

PTS = permanent threshold shift; TTS = temporary threshold shift

Table 6-5. Annual Number of Marine Mammals Potentially Affected by Category C Maritime WSEP Missions in the EGTTR (2 days)

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Bottlenose dolphin	0	0	3	6
Atlantic spotted dolphin	0	0	1	2
Total	0	0	3	6

PTS = permanent threshold shift; TTS = temporary threshold shift

Table 6-6. Total Annual Number of Marine Mammals Potentially Affected by All Maritime WSEP Missions in the EGTTR

Species	Mortality	Level A Harassment (PTS)	Level B Harassment (TTS)	Level B Harassment (Behavioral)
Bottlenose dolphin	0	2	87	157

Numbers and Species Taken

Atlantic spotted dolphin	0	1	29	53
Total	**0**	**3**	**116**	**210**

PTS = permanent threshold shift; TTS = temporary threshold shift

7. IMPACTS TO MARINE MAMMAL SPECIES OR STOCKS

Based on the acoustic model results, zero marine mammals would be affected by acoustic impulse levels associated with mortality. Therefore, Eglin AFB is requesting an IHA, as opposed to a Letter of Authorization.

A maximum of up to approximately 3 marine mammals could potentially be exposed to injurious Level A harassment (approximately 2 bottlenose dolphin and 1 Atlantic spotted dolphin). Level A harassment could result from acoustic impulse resulting in slight lung injury, peak SPL resulting in GI tract injury, or one of the thresholds resulting in the onset of PTS. Since the threshold with the highest exposure estimates was used to determine takes, impacts are associated with the 185 dB SEL threshold, which corresponds to the onset of PTS, or a permanent decrease in hearing sensitivity.

A maximum of approximately 116 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. Similar to Level A harassment, the SEL metric (170 dB re 1 $\mu Pa^2 \cdot s$) results in higher exposure estimates compared to the peak SPL metric (224 dB re 1 μPa).

Approximately 210 animals could potentially be exposed to noise corresponding to the behavioral threshold of 165 dB SEL during Maritime WSEP 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 above estimates take into account the mitigation measures outlined in Section 11, which may significantly reduce the number of exposures.

Atlantic spotted dolphins potentially affected by Maritime WSEP 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 deep 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 WSEP 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- 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 WSEP 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 WSEP 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 WSEP Environmental Assessment (EA) (U.S. Air Force, 2014) 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 EFFECTING 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.

11.1 VISUAL MONITORING

Visual monitoring will be required during Maritime WSEP missions from surface vessels and high-definition video cameras. A large number of range-clearing boats (approximately 30 to 35) will be stationed around the test site to prevent non-participating vessels from entering the human safety zone. Based on the composite footprint, range-clearing boats will be located approximately 15,289 meters (9.5 miles) from the detonation point (Figure 11-1). 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.

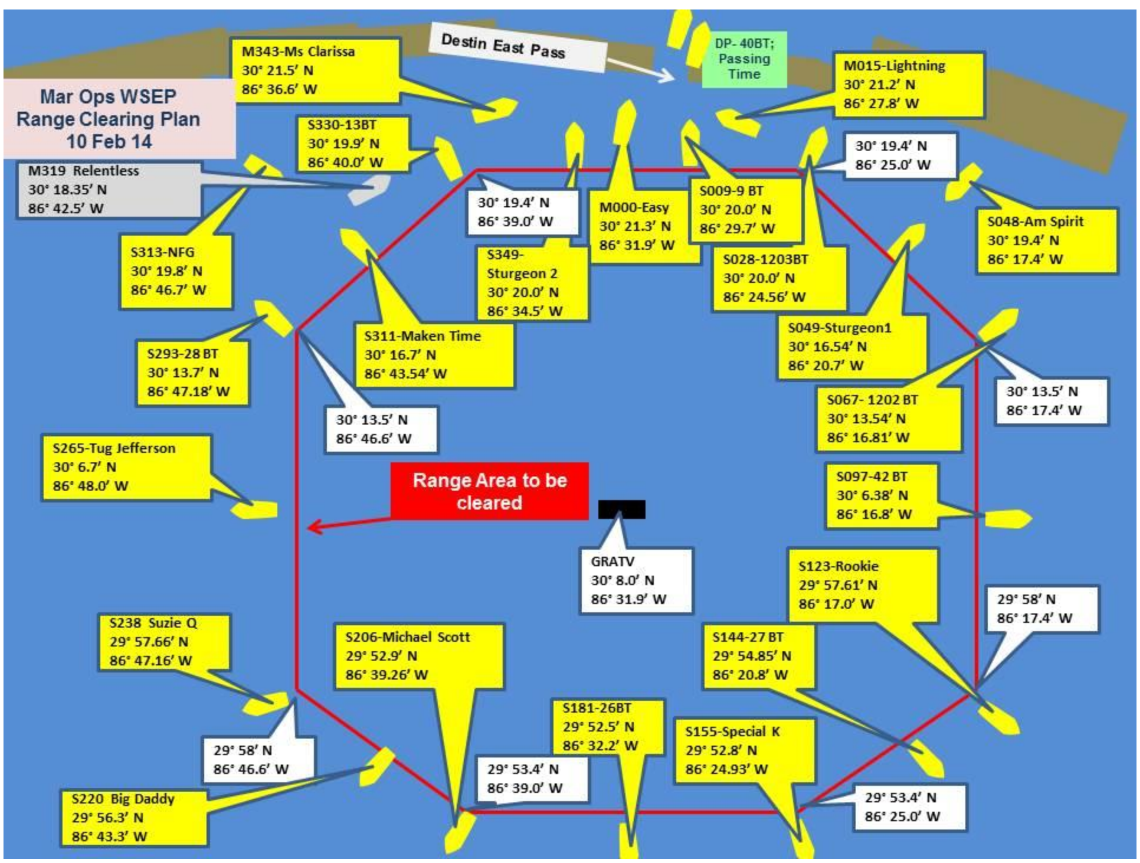

Figure 11-1. Range Area to be Cleared for Human Safety Zone

Trained marine species observers will be aboard five of these boats and will conduct protected species surveys before and after each test. The protected species survey vessels will be dedicated solely to observing for marine species during the pre-mission surveys while the remaining safety boats clear the area of non-authorized vessels.

11.1.1 Determination of Survey Areas

The ranges that are presented in Table 6-2 represent a radius of impact for each threshold and criterion from Maritime WSEP mission-day Categories A, B, and C. These categories consider accumulated energies from multiple detonations occurring within the same 24-hour time period and represent three levels of intensity of weapon impacts. It is unknown exactly which munitions will be released each day. Multiple variables, such as weather, aircraft mechanical issues, munition malfunctions, target availability, etc., may prevent munitions to be released precisely as planned. Therefore, it is difficult to state with full accuracy the number of munitions of each type that will be released on any given day. Prior to conducting each mission, the proponent will provide the weapon release plan to Eglin Natural Resources. The list of weapons will be evaluated to include NEW, detonation location/fusing options, and total number of munitions proposed to be released. After evaluation of the list, Eglin Natural Resources will assign a category level of A, B, or C based on the intensity of the weapons impact, which will be used to determine the pre-mission survey area.

As previously stated, the mission-day categories were developed to represent the maximum number of munitions that could be released per category based on historical Maritime WSEP missions and future weapon evaluation requirements. The acoustic energy from multiple detonations associated with each category were summed and compared against thresholds with energy metric criteria to generate the accumulated energy ranges for each category (refer to Appendix A). These categories are only a representation and may not accurately reflect how actual operations will be conducted. However, they are used as the most conservative assumption to calculate the impact ranges for mitigation strategies. The ranges of effects for Level A (PTS) and Level B (TTS and Behavioral) Harassment are listed in Table 11-1.

Table 11-1. Threshold Ranges for Mission-Day Categories (in meters)

Mission-Day Category	Level A Harassment	Level B Harassment	
	PTS	TTS*	Behavioral
	185 dB SEL	170 dB SEL	165 dB SEL
A	945	4,666	7,479
B	248	2,225	3,959
C	286	1,128	1,863

* Represents proposed radius to be monitored during pre-mission surveys for A, B, and C mission-day categories. PTS = permanent threshold shift; SEL = sound exposure level; TTS = temporary threshold shift

The proponent will be responsible for surveying an area with a radius equal to the Level B TTS impact range from the mission-day category assigned by Eglin Natural Resources, as shown in Table 11-1. Factoring operational limitations associated with conducting vessel-based surveys for the missions, the radius to be monitored during pre-mission surveys would range between 4.7 and 1.1 kilometers (2.5 and 0.61 NM) from the target area. Because of human safety issues, observers will be required to leave the test area at least 30 minutes in advance of live weapon deployment and move to a position on the safety zone periphery, approximately 9.5 miles (15 kilometers) 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. Figure 11-2 shows example routes used during Maritime Strike missions in 2013 and 2014.

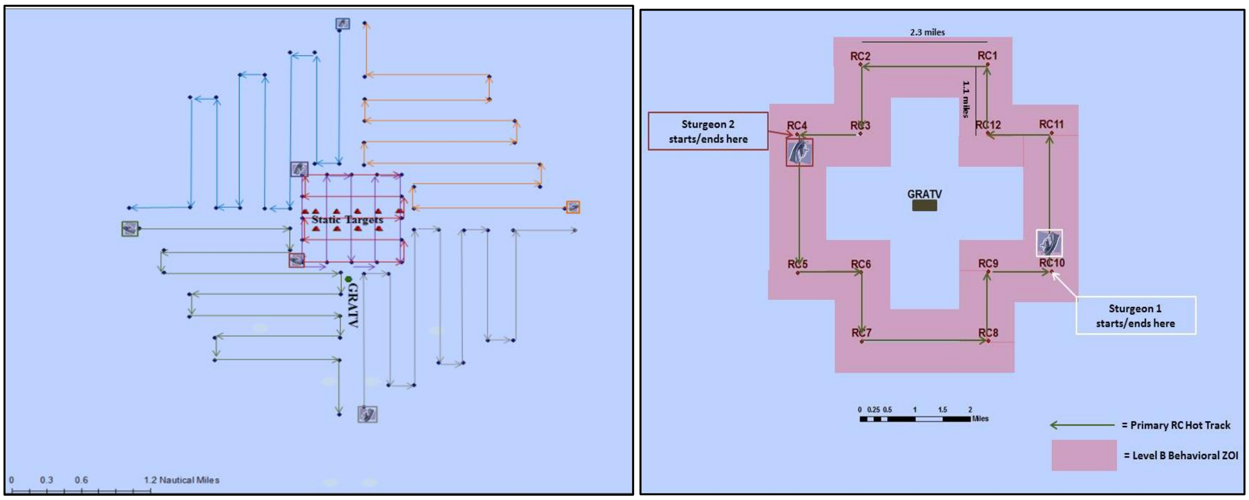

Figure 11-2. Example Routes Used During Maritime Strike Missions in 2013 and 2014

11.1.2 Additional Monitoring Assets

Air Force personnel will be within the mission area (on approximately six boats and the GRATV) on each day of testing well in advance of weapon deployment, typically near sunrise. 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 Lead Biologist, as described in the detailed mitigation procedures below.

In addition to vessel-based monitoring, three video cameras will be positioned on the GRATV anchored on-site, as described in Section 1.2, to allow for real-time monitoring for the duration of the mission. The camera configuration used would depend on specific mission requirements. In addition to monitoring the area for mission objective issues, the cameras will also be used to monitor for the presence of protected species. A trained marine species observer from Eglin Natural Resources will be located in Eglin's CCF, along with mission personnel, to view the video feed before and during test activities. All cameras have a zoom capability of up to at least a 300 millimeter (mm) equivalent. At this setting, when targets are at a distance of 2 NM from the GRATV, the field of view would be 195 ft by 146 ft. Video observers can detect an item with a minimum size of one square foot up to 4,000 meters away. The Air Force is in the process of acquiring cameras with even greater zoom capability (up to a 1,200 mm zoom lens).

The mortality and slight lung injury threshold ranges are adjusted for the weight of an Atlantic spotted dolphin calf, and extend from 47 to 216 meters from the target for mortality, and from 84 to 595 meters from the target for slight lung injury, depending on the mission-day category.

Given these distances, observers could reasonably be expected to view a substantial portion of the mortality and slight lung injury 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 Figure 11-3 through Figure 11-5. If the situation arises such that no cameras are operational due to equipment malfunctions, weather impacts, or other issues, then the mission would not be conducted.

Figure 11-3. Representative Screen Shot, Camera 1

Figure 11-4. Representative Screen Shot, Camera 2

Figure 11-5. Representative Screen Shot, Camera 3

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. 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.

11.2 ENVIRONMENTAL CONSIDERATIONS

Weather conducive for marine mammal monitoring 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 WSEP missions will be delayed or rescheduled if the sea state is greater than number 4 of Table 11-2 at the time of the test. The Lead Biologist aboard one of the survey vessels will make the final determination of whether conditions are conducive for sighting protected species or not. If the weather conditions are not conducive for proper sighting, the mission will be delayed or cancelled. In addition, the missions 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 11-2. Sea State Scale for Maritime WSEP 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.

11.3 AIR FORCE SUPPORT VESSELS

Air Force support vessels will consist of a combination of Air Force and civil service/civilian personnel. Vessel-based and video monitoring will be conducted for all missions. The Eglin Range Safety Officer, in cooperation with the Santa Rosa Island Tower Control at Test Site A-13B and CCF, will coordinate and manage all range clearing and protected species observation efforts. All support vessels will be in radio contact with one another and with Tower Control on the government VHF channel 81a or 82a. CCF will monitor all radio communications, but Tower will relay messages between the vessels and CCF. 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 mission delay or cancellation 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 11-6. Responsibilities of each survey component are described in the following paragraphs.

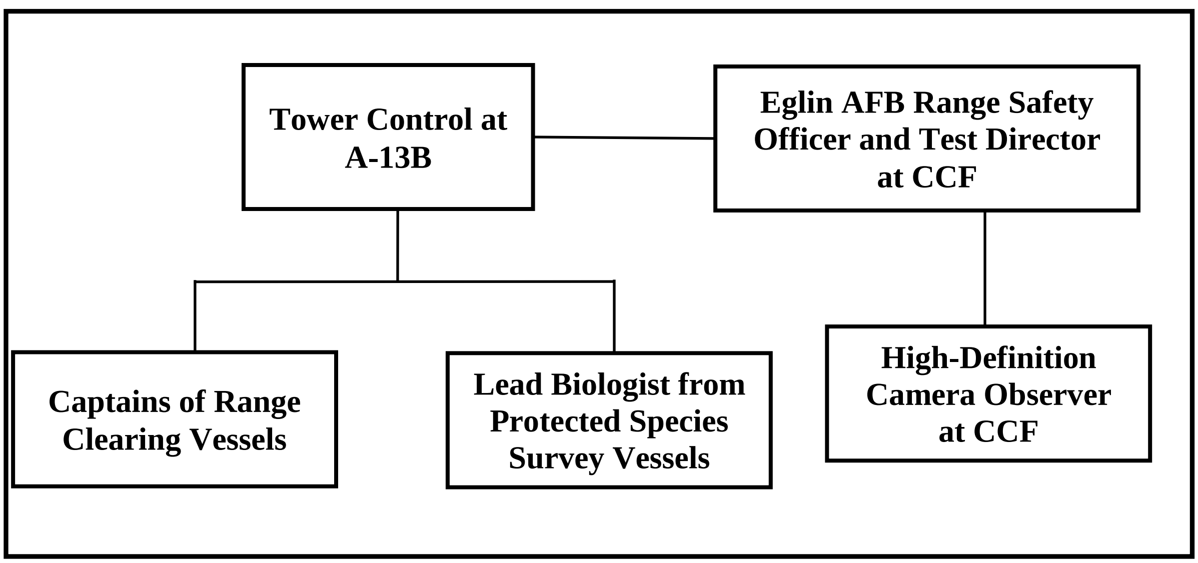

Figure 11-6. Marine Species Observer Lines of Communication

11.4 ROLES AND RESPONSIBILITIES OF DEDICATED OBSERVERS

The following subsections describe the roles and responsibilities of each component of the entire monitoring team. The overall objective of these efforts is to provide sufficient and continual monitoring support before, during, and after each mission that will enable effective observations without putting undue burden on the mission.

11.4.1 Protected Species Survey Vessels

Protected species and species indicator monitoring would be conducted from five surface vessels, with emphasis on the mortality and slight lung injury zones. These survey vessels will run pre-determined line transects, or survey routes, that will provide sufficient coverage of the survey area within a one-hour timeframe. Monitoring activities will be conducted from the highest point feasible on the vessels (Figure 11-7). Each vessel will have at least two dedicated observers who are trained in identifying protected marine species and indicators of protected species occurrence, such as large schools of fish and flocks of birds. One vessel will contain the Lead Biologist who will be the point of contact between all survey vessels and Tower Control.

Figure 11-7. Marine Species Observer

11.4.2 High-Definition Video Camera Observer

Maritime WSEP missions will be monitored from the GRATV via live high-definition video feed. Video monitoring would, in addition to facilitating assessment of the mission, make possible remote viewing of the area for determination of environmental conditions and the presence of marine species right up to the release of live munitions. For the duration of the mission, a trained marine species observer from Eglin Natural Resources will be in CCF monitoring all live video feed. Although not part of the surface vessel survey team, the Eglin Natural Resources representative will report any marine mammal sightings to the Range Safety

Officer, who will also be sitting in CCF. The entire ZOI will not be visible through the video feed for all missions; however, the targets and immediately surrounding areas will be in the field of view of the cameras and the observer will be able to identify any protected species that may enter the target area right before the detonations and determine if any were injured immediately following the detonations. Should a protected marine species be detected on the live video, the weapon release can be stopped almost immediately, because the video camera observer is in direct contact with Test Director and Safety Officer at CCF. If all of the cameras are not operational for any reason, the mission will not be conducted.

11.5 LINES OF COMMUNICATION

The protected species survey vessels and the video camera observer will have open lines of communication to facilitate real-time reporting of marine mammals and other relevant information, such as safety concerns and presence of non-participating vessels in the human safety zone. Direct radio communication between all surface vessels, GRATV personnel, and Tower Control will be maintained throughout the mission. The Range Safety Officer will monitor all radio communications from CCF, and information between the Safety Officer and the support vessels will relayed via Tower Control. All sighting information from pre-mission surveys will be communicated to the Lead Biologist on a separate radio channel than the range clearing vessels to reduce overall radio chatter and potential confusion. After compiling all the sighting information from the other survey vessels, the Lead Biologist will inform Tower Control on whether the area is clear of protected species or not. If the range is not clear, the Lead Biologist will provide recommendations on whether the mission should be delayed or cancelled. A mission delay recommendation would occur, for example, if a small number of protected species are in the ZOI but appear to heading away from the mission area. On the other hand, a mission cancellation recommendation could occur if one or more protected species in the ZOI are found and there is no indication that they would leave the area on their own preference within a reasonable timeframe. Tower Control will relay the Lead Biologist's recommendation to the Safety Officer in CCF. The Safety Officer and Test Director will collaborate regarding range conditions based on the information provided by the Lead Biologist and the status of range-clearing vessels. Ultimately, the Safety Officer will have final authority on decisions regarding delays and cancellations of missions.

11.6 DETAILED MITIGATION PLAN

The level B harassment TTS zone for each mission-day category (from Table 11-1) will be monitored for the presence of marine mammals and indicators. Maritime WSEP mitigations will be regulated by Air Force safety parameters. Any mission may be delayed or cancelled due to technical issues or range-clearing issues. If a delay occurs during pre-mission surveys, all mitigation procedures would continue either for the duration of the delay or until the mission is cancelled. To ensure the safety of survey personnel, the team will depart the mission area approximately 30 minutes to one hour before live ordnance delivery. Stepwise mitigation procedures for the Maritime WSEP missions are outlined below.

Pre-Mission Monitoring: The purposes of pre-mission monitoring are to (1) evaluate the mission site for environmental suitability and (2) verify that the ZOI is free of visually detectable marine mammals, as well as potential indicators of these species. On the morning of the mission, the Test Director and Safety Officer will confirm that there are no issues that would preclude mission execution and that weather and sea state is adequate to support mitigation measures.

(a) Sunrise or Two Hours Prior to Mission

Air Force range-clearing vessels and protected species survey vessels will be on-site at least two hours prior to the mission. Lead Biologist onboard one survey vessel will assess the overall suitability of the mission site based on environmental conditions (sea state) and presence/absence of marine mammal indicators. This information will be communicated to Tower Control and relayed to the Safety Officer in CCF.

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

Vessel-based surveys will begin approximately 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, GPS location, and direction of travel, if known, to the Lead Biologist. The Lead Biologist will document all sighting information on report forms to be submitted to Eglin Natural Resources after each mission. Surveys will continue for approximately one hour. During this time, Air Force personnel in the mission area will also observe for marine species as feasible. If marine mammals or indicators are observed within the ZOI, the 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 mission area). If no marine mammals or indicators are observed, the range will be declared clear of protected species.

(c) One-Half Hour Prior to Mission

At approximately 30 minutes to one hour prior to live weapon deployment, marine species observers will be instructed to leave the mission 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. The survey team will continue to monitor for protected species while leaving the area. As the survey vessels leave the area, marine species monitoring of the immediate target areas will continue at CCF through the live video feed received from the high definition cameras on the GRATV. 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 range will be declared "green" and mission will be allowed to proceed, assuming all non-participating vessels have left the safety zone as well.

(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, or cancel the mission. The mission would be postponed if:

1. Any marine mammal is visually detected within the ZOI. Postponement would continue until the animal(s) that caused the postponement is:
    a. Confirmed to be outside of the ZOI on a heading away from the targets or
    b. Not seen again for 30 minutes and presumed to be outside the ZOI due to the animal swimming out of the range.
        i. Average swim speed of dolphins assumed to be 5.6 kilometers/hour.
        ii. Distance traveled in 30 minutes would be approximately 2,800 meters.
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.
3. Any technical or mechanical issues related to the aircraft or target boats occur.
4. Non-participating vessels enter the human safety zone prior to weapon release.

In the event of a postponement, protected species monitoring would continue from CCF through the live video feed.

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 commence once the mission has ended or, if required, as soon as explosive ordnance disposal personnel declare the mission area safe. Vessels will move into the survey area from outside the safety zone and monitor for at least 30 minutes, concentrating on the area downcurrent of the test site. This area is easily identifiable because of the floating debris in the water from impacted targets. Up to 10 Air Force support vessels will be cleaning debris and collecting damaged targets from this area, thus, spending many hours in the area once the mission is completed. All vessels will be instructed to report any dead or injured marine mammals to the Lead Biologist. The protected species survey vessels will document any marine mammals that were killed or injured as a result of the mission 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 Eglin Natural Resources.

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.

11.7 MITIGATION EFFECTIVENESS

The effectiveness of the mitigation measures described above depends largely on the ability to visually locate marine mammals at or near the water surface, as visual observation is the primary measure used. Aerial surveys are not feasible for Maritime WSEP missions due to airspace and mission complexity; therefore, observation will occur primarily from vessels and video cameras. NMFS has evaluated the effectiveness of visual observation for a similar previous Air Force action in the same area of the Gulf (Maritime Strike Incidental Harassment Authorization issued

13 August 2013). This qualitative analysis for mitigation effectiveness is largely based on the successes during Maritime Strike missions conducted in 2013.

In summary, 34 total sightings were reported during pre-mission surveys of between 179 and 189 individuals, including bottlenose dolphins, Atlantic spotted dolphins, and sea turtles. One mission day was cancelled due to sea state conditions that prevented a proper pre-mission survey and high numbers of marine mammals observed in the area. Two other mission days were delayed due to extended surveys to ensure marine mammals were clear of the area. Two sightings of dolphin pods were reported during post-mission surveys approximately 4.5 hours after the last detonation; however, all animals were swimming normally, displaying normal behaviors, and not showing any signs of distress or injury (Department of the Air Force, 2014). Given the time lapse between the last detonation and the post-mission sighting, it is likely these animals were well outside the area during mission activities. While it is possible that the pods were in the vicinity during pre-mission surveys but were not detected by the observers, the normal behaviors and activities of the animals documented during the post-mission sighting suggests that they did not experience acoustic impacts from Maritime WSEP missions.

The overall effectiveness of these measures in reducing take levels has not been quantified. However, the high numbers of documented sightings during the pre-mission surveys indicate a significant level of success in executing the survey plans and identifying protected species in the area. Furthermore, there were no observed impacts to any protected species during post-mission surveys, and none were identified in the days immediately following the end of all Maritime Strike missions. Therefore, Eglin AFB believes the proposed mitigations will provide a large measure of protection to marine mammals from potential acoustic impacts while enabling the military mission.

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 WSEP missions, prospective mission sites will be monitored for marine mammal presence prior to commencement of activities. Vessel-based pre-mission monitoring will be conducted for at least one hour. Furthermore, after the survey vessels have exited the safety footprint, a trained marine species observer located in the CCF will continue monitoring the immediate target area through live video feed for the duration of the mission. Post-mission surveys will be carried out in all cases for at least 30 minutes. If any marine mammals are detected during pre-mission surveys or the live video feed received from cameras on the GRATV, activities will be immediately halted until the area is clear of all marine mammals. Refer to Section 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.

- All protected species observers will receive the Marine Species Observer Training Course developed by Eglin AFB in cooperation with NMFS within a year of the planned missions.
- The Eglin Natural Resources Office will track use of the EGTTR and protected species observation results through the use of protected species observer 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
- 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 led 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 AFB conducts other research efforts that utilize marine mammal stranding information as a potential means of ascertaining the effectiveness of mitigation techniques. Stranding data are 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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APPENDIX A
ACOUSTIC MODELING METHODOLOGY

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APPENDIX A
MMPA ACOUSTIC IMPACT MODELING

A.1 BACKGROUND AND OVERVIEW

A.1.1 Federal Regulations Affecting Marine Animals

All marine mammals are protected under the Marine Mammal Protection Act (MMPA). The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

The Endangered Species Act of 1973 (ESA) provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of their ecosystems. A "species" is considered endangered if it is in danger of extinction throughout all or a significant portion of its range. A species is considered threatened if it is likely to become an endangered species within the foreseeable future. Some marine mammals, already protected under MMPA, are also listed as either endangered or threatened under ESA, and are afforded special protections. In addition, all sea turtles are protected under the ESA.

Actions involving sound in the water may have the potential to harass marine animals in the surrounding waters. Demonstration of compliance with the MMPA and ESA, using best available science, has been assessed using criteria and thresholds accepted or negotiated, and described here.

Sections of the MMPA (16 USC 1361 et seq.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity, other than commercial fishing, within a specified geographical region. Through a specific process, if certain findings are made and regulations are issued or, if the taking is limited to harassment, notice of a proposed authorization is provided to the public for review.

Authorization for incidental takings may be granted if National Marine Fisheries Service (NMFS) finds that the taking will have no more than a negligible impact on the species or stock(s), will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses, and that the permissible methods of taking, and requirements pertaining to the mitigation, monitoring and reporting of such taking are set forth.

NMFS has defined negligible impact in 50 CFR 216.103 as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.

Subsection 101(a)(5)(D) of the MMPA established an expedited process by which citizens of the United States can apply for an authorization to incidentally take small numbers of marine mammals by harassment. The National Defense Authorization Act of 2004 (NDAA) (Public Law

108-136) removed the small numbers limitation and amended the definition of "harassment" as it applies to a military readiness activity to read as follows:

> (i) *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*
>
> (ii) *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 [Level B Harassment].*

The primary potential impact to marine mammals from underwater acoustics is Level A and Level B harassment, as defined by the MMPA from noise. Potential impacts to sea turtles from underwater acoustic exposure are primarily behavioral responses and impairment, with some potential for injury, and a very small potential for mortality.

A.1.2 Development of Animal Impact Criteria

A.1.2.1 Marine Mammals

For explosions of ordnance planned for use under Maritime WSEP missions in the EGTTR area, in the absence of any mitigation or monitoring measures, there is a chance that a marine mammal could be injured or killed when exposed to the energy generated from an explosive force. Analysis of noise impacts is based on criteria and thresholds initially presented in U.S. Navy Environmental Impact Statements for ship shock trials of the Seawolf submarine and the Winston Churchill (DDG 81), and subsequently adopted by NMFS.

<u>Mortality</u>

Lethal impact determinations currently incorporate species-specific thresholds that are based on the level of impact that would cause extensive lung injury from which one percent of exposed animals would not recover (Finneran and Jenkins, 2012). The threshold represents the expected onset of mortality, where 99 percent of exposed animals would be expected to survive. The lethal exposure level of blast noise, associated with the positive impulse pressure of the blast, is expressed as Pascal-seconds (Pa·s) and is determined using the Goertner (1982) modified positive impulse equation. This equation incorporates sound propagation, source/animal depths, and the mass of a newborn calf of the affected species. The Goertner equation used in the acoustic model to develop mortality impact analysis, is as follows:

$$I_M(M,D) = 91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$$

$I_M(M,D)$	mortality threshold, expressed in terms of acoustic impulse (Pa·s)
M	Animal mass (Table D-1)
D	Water depth (m)

Level A Harassment

Non-lethal injurious impacts (Level A Harassment) are defined in those documents as onset of slight lung injury, gastro-intestinal (GI) tract damage, and permanent (auditory) threshold shift (PTS).

The criteria for onset of slight lung injury were established using partial impulse because the impulse of an underwater blast wave was the parameter that governed damage during a study using mammals, not peak pressure or energy (Yelverton, 1981). Goertner (1982) determined a way to calculate impulse values for injury at greater depths, known as the Goertner "modified" impulse pressure. Those values are valid only near the surface because as hydrostatic pressure increases with depth, organs like the lung, filled with air, compress. Therefore the "modified" impulse pressure thresholds vary from the shallow depth starting point as a function of depth.

The shallow depth starting points for calculation of the "modified" impulse pressures are mass-dependent values derived from empirical data for underwater blast injury (Yelverton, 1981). During the calculations, the lowest impulse and body mass for which slight, and then extensive, lung injury found during a previous study (Yelverton et al, 1973) were used to determine the positive impulse that may cause lung injury. The Goertner model is sensitive to mammal weight such that smaller masses have lower thresholds for positive impulse so injury and harassment will be predicted at greater distances from the source for them. The equation used for determination of slight lung injury is:

$$I_S(M,D) = 39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2},$$

where M is animal mass (kg), D is animal depth (m), and the units of I_s are Pa-s. Following Finneran and Jenkins (2012), the representative mass for each species is taken to be that of an average newborn calf or pup for that species.

The criterion for slight injury to the GI tract was found to be a limit on peak pressure and independent of the animal's size (Goertner, 1982). A threshold of 103 psi (237 dB re 1 µPa) is used for all marine mammals. This level at which slight contusions to the GI tract were reported from small charge tests (Richmond *et al.*, 1973).

Two thresholds are used for PTS, one based on cumulative sound exposure level (SEL) and the other on the peak sound pressure level of an underwater blast. Thresholds follow the approach of NMFS 2016 Technical Guidance. The threshold producing either the largest Zone of Influence (ZOI) or higher exposure levels is then used as the more protective of the dual thresholds. In previous assessments Type I and Type II weighting functions (Finneran and Jenkins, 2012) have been applied for each functional hearing group as appropriate. Following recent guidance from NMFS (NMFS, 2016), the newer TAP Phase 3 weighting functions are utilized within this assessment. PTS thresholds for mid-frequency (MF) cetaceans are 185 dB re 1 $\mu Pa^2 \cdot s$ SEL (Phase 3 weighted) and 230 dB re 1 µPa Peak SPL (unweighted).

Level B Harassment

Level B (non-injurious) Harassment includes temporary (auditory) threshold shift (TTS), a slight, recoverable loss of hearing sensitivity. Similar to PTS, the 2016 NMFS Guidance details two criteria to be evaluated for TTS exposure, the cumulative sound exposure level (SEL, weighted), and the peak sound pressure level (SPL, unweighted). NMFS applies the more conservative of these two. For species where no data exist, TTS thresholds are based on the most closely related species for which data are available. The TTS thresholds for MF cetaceans are 170 dB re 1 $\mu Pa^2 \cdot s$ SEL (Phase 3 weighted) and 224 dB re 1 µPa Peak SPL (unweighted).

Level B Behavioral Harassment

For multiple successive explosions, the acoustic criterion for non-TTS behavioral disturbance is used to account for behavioral effects significant enough to be judged as harassment, but occurring at lower sound energy levels than those that may cause TTS. The threshold for behavioral disturbance is set 5 dB below the Phase 3 weighted total SEL-based TTS threshold, or 165 dB re 1 μPa^2-s. This is based on observations of behavioral reactions in captive dolphins and belugas occurring at exposure levels approximately 5 dB below those causing TTS after exposure to pure tones (Schlundt et al., 2000). The behavioral impacts threshold for MF mammals exposed to multiple, successive detonations is 165 dB re 1 $\mu Pa^2 \cdot s$ SEL (Phase 3 weighted).

Table A-1 summarizes the current threshold levels for marine mammals used to analyze explosives identified for use in the Maritime WSEP mission area. The two mammal species of interest, Atlantic spotted dolphins and bottlenose dolphins , both are in the mid frequency (MF) functional hearing group.

Table A-1. Explosive Criteria and Thresholds Used for Impact Analyses

Mortality*	Level A Harassment			Level B Harassment	
	Slight Lung Injury[1]	GI Tract Injury	PTS	TTS	Behavioral
$91.4M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$	$39.1M^{1/3}\left(1+\frac{D}{10.1}\right)^{1/2}$	Unweighted SPL: 237 dB re 1 µPa	Weighted SEL: 185 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 170 dB re 1 $\mu Pa^2 \cdot s$	Weighted SEL: 165 dB re 1 $\mu Pa^2 \cdot s$

M = Animal mass based on species (kilograms); *D* = water depth (meters); dB re 1 µPa = decibels referenced to 1 micropascal; dB re 1 µPa^2·s = decibels reference to 1 micropascal-squared – seconds; *M* = animal mass based on species (kilograms); psi = pounds per square inch; PTS = permanent threshold shift; TTS = temporary threshold shift; SEL = sound exposure level; SPL = sound pressure level
1. Expressed in terms of acoustic impulse (Pacsal – seconds [Pa·s]

A.2 EXPLOSIVE ACOUSTIC SOURCES

A.2.1 Acoustic Characteristics of Explosive Sources

The acoustic sources to be deployed during Maritime WSEP missions 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). Detailed descriptions of the sources in the Maritime WSEP mission area are provided in this subsection.

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 (or NEW) accounts for the first two parameters. The NEW of an explosive is the weight of TNT required to produce an equivalent explosive power.

A.2.2 Animal Harassment Effects of Explosive Sources

The harassments expected to result from these sources are computed on a per event basis, where an event lasts for 24 hours and takes into account multiple explosives that would detonate within that time period. Within that 24-hour time period it is assumed that the animal population remains constant, or in other words, animals exposed to sounds at the beginning of the 24-hour period would also be exposed to any sounds occurring at the end of the period. A new animal population is assumed for each consecutive 24-hour period. In some cases this can be a more conservative approach than assuming each detonation, or burst of detonations, is received by a new population of animals. It is important to note that only energy metrics are affected by the accumulation of energy over a 24-hour period. Pressure metrics (e.g., peak pressure and positive impulse) do not accumulate. Rather, a maximum is taken over all of the detonations specified within the 24-hour period. A more detailed description of pressure and energy considerations resulting from munition bursts is provided in Section A.2.3 below.

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.

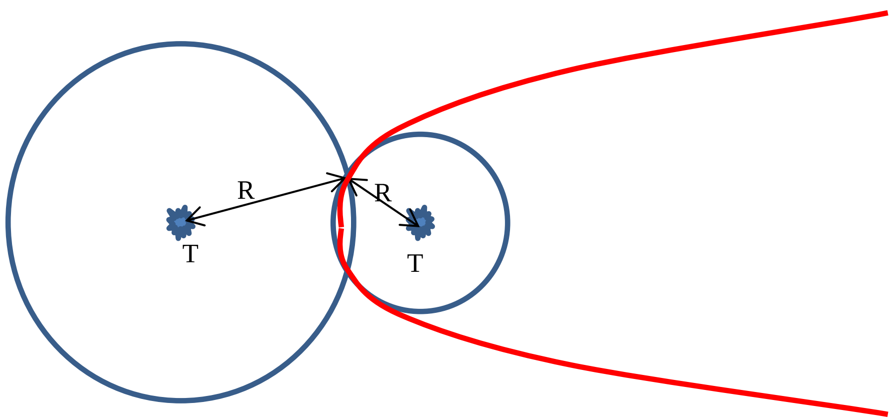
For sources that are detonated at shallow depths, it is frequently the case that the explosion may breach the surface with some of the acoustic energy escaping the water column. We model surface detonations as occurring one foot below the water surface. The source levels have not been adjusted for possible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

A.2.3 Zone of Influence: Per-Detonation Versus Net Explosive Weight Combination

It may useful to consider why and when it is appropriate to treat rounds within a burst as separate events, rather than combining the NEW of all rounds and treating it as a single, larger event. The basic information necessary to address this issue is provided below, where pressure-based metrics are considered separately from energy-level metrics.

Peak Pressure and Positive Impulse

Peak pressures add if two (or more) impulses reach the same point at the same time. Since explosive rounds go off at different times and locations, this will only be true for a small set of points. This problem is mathematically the same as the passive sonar problem of localizing a sound source based on the time difference of arrival (TDOA) of a signal reaching two receivers (*R1* and *R2*). The red curve in the figure (half of a hyperbola) represents the set of all points



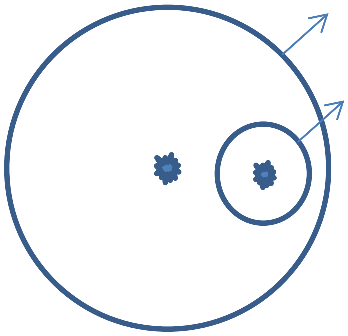
where:

$R1 - R2 = c(T2 - T1)$, for

c = the speed of sound in water, and

T1 and *T2* being the detonation times of the two rounds.

Such a curve can only be drawn when c*(T2-T1) is less than the distance between the two explosions. If, for instance, 30 rounds/second are fired (and the difference in impact time is assumed to be roughly the distance in firing time), then the peak impact pressure from the first round will have traveled 1,500 meters/second * 1/30 second = 50 meters. If the second round hits less than 50 meters from the first round, the impact wave from the second round will never catch the impact wave from the first.



In the first case (loose grouping), the pressures will only add along a curve with very narrow width and negligible volume. The pressure on this curve is less than twice the pressure of the closest round, as it will be the pressure at R2 and at (R2+c*dT). In the second case (tight grouping), the pressures will never add.

If this logic is extended to a many-shot burst, the logic becomes even more persuasive. For the impulse peak from a third shot to interact with the peaks from the first two using the 30 rounds/second assumption, it would have to impact the water more than 100 meters away from the impact of the first round and more than 50 meters away from the impact of the second round. Even in that case, there would be at most two places in the ocean where the curve from the 1st and 3rd impacts would meet the curve from 2nd and 3rd explosions (and the travel distances would have to be 50 meters longer for one and 100 meters longer for the other). In summary:

- There would be 0 to 4 directions where a curve (a hyperbola approaches an asymptotic line far from the source) of negligible thickness, and volume would have less than two times the pressure from the closest source
- There would be 0 to 2 very small points with no extent in range or bearing where one would see less than three times the pressure from the closest source
- In every other part of the ZOI, the impulse from each round would be received separately by any animal present

For the 4th round and any subsequent round, another curve could be added, if it was far enough away from the previous shots so that their peak had not already passed the impact point. However, this new curve would intersect with the previous 2 curves at a different location than where the first two curves intersected. No matter how many rounds are fired, there would not be any point in the ocean where more than 3 peaks arrive at the same time. These points would have almost no volumetric extent and required range increases from the closest source of N*dt*c, where N is the difference in shot number and dt is the time between shots.

If the rate of fire is increased, there is a decrease in the additional required separation in order to have any coherent increase in pressure or positive impulse. However, the end result is that almost all of the ocean experiences only one pressure peak at a time.

If the rounds are far enough apart in space and close enough in time, there will be curves where sequential rounds add coherently; however,

- They will not occupy any significant volume, and
- They will be less than a factor of 2 above the pressure or positive impulse of the nearest source.

Contrast this with the alternative assumption that pressures from separate rounds be added. This models the event as if all rounds went of exactly at the same place and exactly at the same time. That is the only way that travelling pressure peaks from separate rounds would go through space together and add pressures at all points. This is not realistic and would over-estimate pressure and positive impulse metrics by a factor equal to the number of rounds in the burst, which could be 10 or 20 dB in pressure levels.

Energy Metrics

Energy metrics accumulate the integral of the power density of each explosion over the duration of the impulse. Thus, even though the peaks from separate explosions arrive at different times, the energy from all of their arrivals will be added. If you fire a number of rounds close together in a burst (N_{burst}), the energy from all of the rounds will add and the sound exposure level will be 10*log10(N_{burst}) higher than if a single shot had been fired. The area affected, A_{burst}, would be larger than the area affected by a single shot (A_1), because additional transmission loss would be needed to reduce the larger energy level to a given threshold.

Following guidance from NMFS, three mission scenarios have been defined, with each scenario capturing the munitions expected to be dropped within a 24-hour period. Energy metrics such as Total Energy are accumulated over this period while peak level metrics are maximized over the set of munitions in order to capture that with the largest peak amplitudes.

A.3 ENVIRONMENTAL CHARACTERIZATION

A.3.1 Important Environmental Parameters for Estimating Animal Harassment

Propagation loss ultimately determines the extent of the 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.

Due to the importance that propagation loss plays in Anti-Submarine Warfare, the Navy has, over the last four to five decades, invested heavily in measuring and modeling these environmental parameters. The result of this effort is the following collection of global databases containing these environmental parameters, which are accepted as standards for Navy modeling efforts. Table A-2 contains the version of the databases used in the modeling for this report.

Table A-2. 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, but only the winter was used for this analysis.

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 SVP 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 for the area. 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 HFEVA (High Frequency Environmental Acoustic Algorithms) 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 that tend to capture extremes in both the environmental variability as well as animal populations. Since Maritime WSEP events are expected to occur in February and March, calculations were made for the winter season only.

Impact volumes in the operating area are then computed using propagation loss estimates and the explosives model derived for the representative environment. The longest radial within the impact volumes were then used to calculate the area of impact.

A.3.3 Description of the Maritime WSEP Environment

The Maritime WSEP mission area is located south of Eglin AFB, roughly 17 miles offshore from Santa Rosa Island. The bottom is characterized as sand and silty sand according to the Bottom Sediments Type Database. Environmental values were extracted from unclassified Navy standard databases in a radius of 50 kilometers around the center point at

N 30° 8.5' W 86° 28'.

Water depth at the central point is 35 meters. The seafloor in this area is downwards sloping to the south, reaching a depth of 150 meters at a range of 50 kilometers to the SW of the center point. To the north, the seafloor quickly shoals, reaching land after about 25 kilometers.

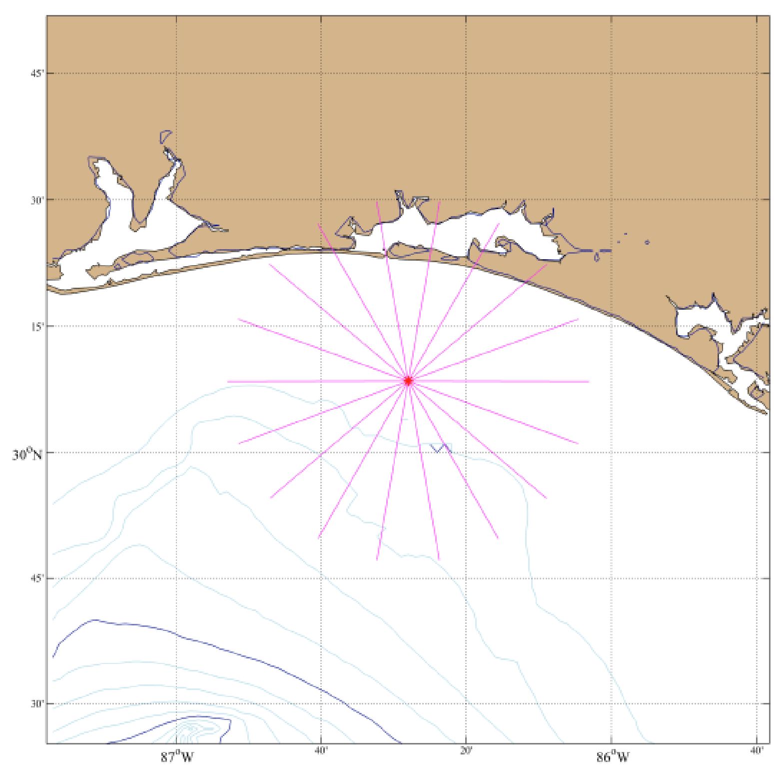


Figure A-1. Bathymetry (in 50-meter contours) for the Maritime WSEP mission area. Radials shown are in 20-degree increments out to 40 km.

An example of the range-dependent bathymetry along the 170° radial is depicted in Figure A-2. Figure A-3 shows summer and winter profiles for the center of the op area.

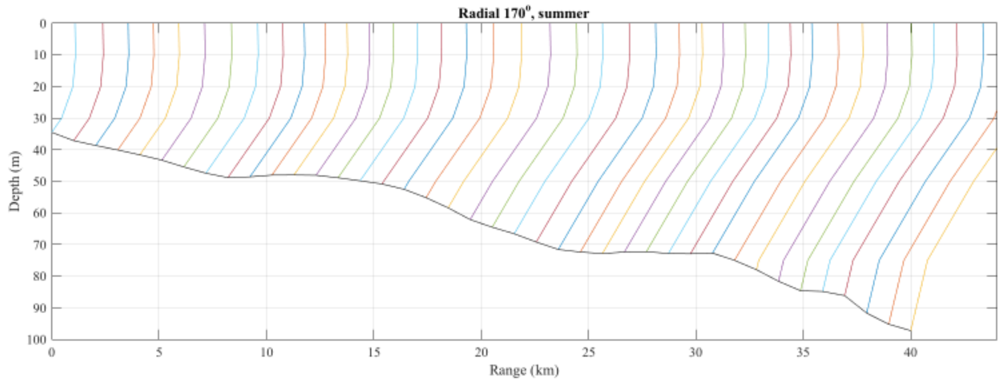


Figure A-2. Bathymetry along 170° radial from center point

The seasonal variability in wind speed was modeled as 8.6 knots in the summer and 13 knots in the winter.

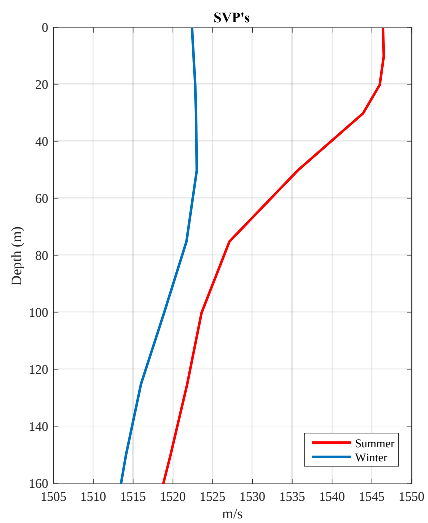


Figure A-3. Seasonal sound speed profiles shown for deepest portion of the exercise area. Upper portion of the profiles does not vary significantly going into shallower water.

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 weighted total 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.
- Finally, the number of harassments is estimated. The maximum range at which sound energy still exceeds threshold is taken to be the radius of a circle defining a zone of influence.

This 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 30 bands had one-third octave spacing around center frequencies from 50 Hertz (Hz) to 40 kHz. At the request of NMFS, a normal mode model was used instead of the Navy Standard CASS/GRAB (v4.3) model that is typically used. In this case, the normal mode model KRAKEN (Porter, 1985) was integrated into the software Leidos has developed for estimating marine mammal acoustic impacts. To accommodate the strong variability in bathymetry, the acoustic pressure fields were computed using a coupled mode calculation. While normal mode models are ideally suited to waveguide propagation similar that found in the EGTTR area, these models are not typically used at the upper frequency ranges of interest here so care had to be taken in setting up step sizes within the model to maintain accuracy.

The TL results were interpolated onto a variable range grid with logarithmic spacing. The increased spatial resolution near the source provided greater fidelity for estimating impact volumes and ranges.

The 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 meter depth, the depth interval was 2 meters. Between 10 meters and 100 meters water depth, the depth interval was 5 meters. For waters greater than 100 meters, the depth interval was 10 meters. For the Maritime WSEP area environment, there were 30 depth bins spanning 0 to 160 meters. The depth grid is used to make the surface image interference correction and to capture the depth-dependence of the positive impulse threshold. Because of the sloping bathymetry within the area, only a few radials actually reached 160 meters of water depth.

In shallow water areas such as the EGTTR, the environmental parameters with the greatest influence on the acoustic propagation are those having to do with the seafloor properties. This is particularly true when sound speed profiles bend energy down towards the bottom. Standard modeling practice is to rely on environmental properties found in databases. Bottom properties, however, are highly site-dependent and can deviate significantly from what is in the database. A literature search was conducted to see if better information on bottom acoustic properties was available. As it turns out, the Sediment Acoustics Experiment-99 (SAX99) was conducted not far from the EGTTR area, in roughly 20 meters of water over a sandy bottom. Bottom sound speed and attenuation were measured and modeled over a wide range of frequencies, making this an ideal dataset (Thorsos, 2001 and Zhou, 2009). Geoacoustic properties consistent with both Biot-Stoll theory as well as the measured SAX99 data were derived for the frequency band 50 Hz – 40 kHz and then used in the propagation model.

A.4.2 Computing Impact Areas

This section and the next provide a detailed description of the approach taken to compute impact areas for explosives. The impact area associated with a particular activity is defined as the area of water in which some acoustic metric exceeds a specified threshold. The product of this impact area and 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 (weighted or un-weighted cumulative SEL, 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 area 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 either for a single source emission or accumulation of source emissions over a 24-hour period, defines the range to which marine mammal activity is monitored in order to meet mitigation requirements. Based on the latest guidance, this impact range is used to provide conservative two-dimensional calculations of the exposure estimates simply by multiplying the impact area by the animal density and the total number of events proposed each year. Refer to Section A.5.3 below. This two-dimensional, maximum-range approach conservatively assumes all ranges and depths, out to the maximum range, are above threshold. In deep water environments with near-surface sources, this is a particularly conservative approach as it does not consider shadow zones where sound levels are greatly diminished due to vertical gradients in the speed of sound within the water column.

The effective energy source level is modeled directly for the sources to be used at the BT-9 target area. 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:

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

where the peak pressure for the shock wave at 1 meter is defined as

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

and the time constant is defined as:

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

For each explosive source, the amount of acoustic energy injected into the water column is calculated, conservatively assuming that all explosive energy is converted into acoustic energy. The propagation loss for each frequency, expressed as a pressure term, modulates the sound energy found at each point along the range (logarithmic spacing). If a threshold is exceeded at a point, the impact volume of that annular sector is added to the total impact volume. The impact area is calculated as the area of a circle with the radius equal to the maximum range across all depth bins and azimuths for each threshold and criteria.

A.4.3 Effects of Metrics on Impact Areas

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 TAP Phase 3 weighting functions as shown in the NMFS Technical Guidance (2016), 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. The total weighted energy flux at each range/depth combination is obtained by summing the product of the TAP Phase 3 frequency weighting function, $W_{II}(f)$, and the energy flux density at each frequency. The Phase 3 weighting function in dB is given by:

$$W(f) = C + 10log\left\{\frac{\left(f/f_1\right)^{2a}}{\left[1+\left(f/f_1\right)^a\right]^2\left[1+\left(f/f_2\right)^2\right]^b}\right\}$$

where *W(f)* is the weighting function in dB for a given frequency *f*.

The component lower cutoff frequency f_1 , upper frequency f_2, low- and high- frequency exponents *a* and *b*, and weighting function gain *C*, are given in Table A-3.

Table A-3. TAP Phase 3 Weighting Parameters used for MF Cetaceans

Functional Hearing Group	C(dB)	f_1(kHz)	f_2(kHz)	a	b
MF cetaceans	1.20	8.8	110	1.6	2

Note that because the weightings are in dB, we will actually weight each frequency's EFD by $10^{(W(f)/10)}$, sum the EFDs over frequency and then convert the weighted total energy to back to dB, with level = 10 $\log_{10}$(total weighted EFD). Note that accumulating the EFD across frequency is equivalent to summing the energy in time over the pulse duration, both of which lead to the cumulative sound exposure level metric with units of μPa^2-s. Single-impulse SEL levels are then accumulated over a pre-determined set of munition detonations that are likely to occur within a single 24-hour period.

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 1 meter (given by equation B-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

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

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 1 meter (see, equation B-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 $K\,(M)^{1/3}\,(1 + z_a/33)^{1/2}$. The coefficient K depends upon the level of exposure. For the onset of slight lung injury, K is 39.1; for the onset of extensive lung hemorrhaging (1% mortality), K is 91.4.

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. Note that for our calculations we use species-dependent masses.

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 "Two-Dimensional" Harassment Estimates

The conservative approach to estimating harassment is to compute only a two-dimensional impact. In this approach, the impact volume is essentially a cylinder extending from the surface to the seafloor, centered at the sound source and with a radius set equal to the maximum range, R_{max}, across all depths and azimuths at which the particular metric level is still above threshold. The number of animals impacted is computed simply by multiplying the area of a circle with radius R_{max}, by the original animal density given in animals per square kilometer. Impacts computed in this manner will always exceed or equal impacts based on depth-dependent animal distributions.

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