EGLIN AIR FORCE BASE
Florida

EGLIN GULF TEST AND TRAINING RANGE

FINAL PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

November 2002

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Submitted to:

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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AAC	Air Armament Center
AACI	Air Armament Center Instruction
ac	Acre
ACE	U.S. Army Corps of Engineers
ACM	Air Combat Maneuvering
ACT-1	Area Characterization Test I
AFB	Air Force Base
AFI	Air Force Instruction
AFSOC	Air Force Special Operations Command
AGL	Above Ground Level
AGM	Air-to-Ground Missiles
AIM	Air Intercept Missiles
Al	Aluminum
ANDES	Ambient Noise Directionality Estimation System
ANSI	American National Standards Institute
ARTC	Air Route Traffic Control
A/S	Air-to-Surface
ATOC	Acoustic Thermometry of Ocean Climate
C	Centigrade
CAA	Clean Air Act
CATEX	Categorically Excluded
CDNL	C-weighted Day-Night Sound Levels
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm	Centimeter
CMAN	Coastal Marine Automated Network Program
CNET	Chief of Naval Education and Training
CO	Carbon Monoxide
CSEL	C-weighted Sound Exposure Level
CTD	Conductivity-Temperature-Depth
CWA	Clean Water Act
DARPA	Defense Advanced Research Projects Agency
dB	Decibel
dBP	Unweighted Peak Sound Pressure Level
DoD	Department of Defense
DODIC	Department of Defense Identification Code
DPI	Direct Physical Impact
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EF	Emission Factors
EFD	Energy Flux Density
EFDL	Energy (Flux Density) Level
EGTTR	Eglin Gulf Test and Training Range
EIS	Environmental Impact Statement
EMC	Eglin Military Complex
ENA	Expected Number of Animals Affected
ERCF	Eglin Range Control Facility
ESA	Endangered Species Act
EWTA	Eglin Water Test Areas
F	Fahrenheit
FAA	Federal Aviation Administration
FAMU	Florida A&M University
FDEP	Florida Department of Environmental Protection
FDOC	Florida Department of Commerce
FDOT	Florida Department of Transportation

LIST OF ACRONYMS, ABBREVIATIONS AND SYMBOLS CONT'D

FL	Flight Level
FU	Full-up
FWC	Florida Fish and Wildlife Conservation Commission
FY	Fiscal Year
g	Grams
GDEM	Generalized Digital Environmental Model
g/L	Grams per Liter
GOM	Gulf of Mexico
HAPC	Habitat of Particular Concern
HE	High Explosive
HEI	High Explosive Incendiary
HESS	High Energy Seismic Survey
HFBL	High-Frequency Bottom Loss
HITS	Historical Temporal Shipping
HP	Horsepower
Hz	Hertz
IFE	In-flight Emergencies
IR	Infrared
J	Joules
kg	Kilogram
kHz	KiloHertz
km	Kilometer
km^2	Square Kilometer
kph	Kilometers per Hour
lbs	Pounds
L_{cdn}	C-weighted Day-Night Sound Levels
L_{dnmr}	Day-Night Average Sound Level
LFA	Low Frequency Active
LFBL	Low Frequency Bottom Loss
LMRIS	Living Marine Resources Information System
LWAD	Littoral Warfare Advanced Development
m	Meter
m^2	Square Meters
mb	Millibars
MBTA	Migratory Bird Treaty Act
Mg	Magnesium
mg	Milligrams
mg/L	Milligrams Per Liter
mg/m^3	Milligrams per Cubic Meter
mi^2	Square Miles
mm	Millimeter
MMPA	Marine Mammal Protection Act
MMRP	Marine Mammal Research Program
MMS	U.S. Minerals Management Service
MMSN	Marine Mammal Stranding Network
MOU	Memorandum of Understanding
MRTFB	Major Range Test Facility Base
MSL	Mean Sea Level
Mta	Metric Tons Annually
NAAQS	National Ambient Air Quality Standard
NASP	Naval Air Station Pensacola
NAVOCEANO	Naval Oceanographic Office
NDBC	National Data Buoy Center
NEPA	National Environmental Policy Act
NEW	Net Explosive Weight

LIST OF ACRONYMS, ABBREVIATIONS AND SYMBOLS CONT'D

ng/L	Nanograms per Liter
NHPA	National Historic Preservation Act
nmi	Nautical Mile
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
NO_x	Nitrogen Oxides
NO_2	Nitrogen Dioxide
NPDES	National Pollutant Discharge Elimination System
NPS	U.S. National Park Service
NRC	National Research Council
OCS	Outer Continental Shelf
ONR	Office of Naval Research
PM_{10}	Particulate Matter Less than or Equal to 10 Microns in Diameter
$PM_{2.5}$	Particulate Matter Less than or Equal to 2.5 Microns in Diameter
ppb	Parts per Billion
ppm	Parts per Million
ppt	Parts per Thousand
psf	Per Square Foot
psi	Pounds Per Square Inch
PTS	Permanent Threshold Shift
ROI	Region of Influence
RUR	Range Utilization Report
SAM	Surface-to-Air Missiles
SEL	Sound Exposure Level
SERO	Southeast Regional Office
SI	System International d'Unites
SO_2	Sulfur Dioxide
SO_x	Sulfur Oxides
SPL	Sound Pressure Level
SURTASS	Surveillance Towed Array Sensor System
THC	Total Hydrocarbon Content
TL	Transmission Loss
TR	Training Round
TRAWING	Training Air Wing
TTS	Temporary Threshold Shift
TV	Television
$\mu g/cm^3$	Micrograms per Cubic Centimeter
μg/L	Micrograms per Liter
$\mu g/m^3$	Micrograms per Cubic Meter
μPa	MicroPascal
UERD	Underwater Explosives Research and Development
USDI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOC	Volatile Organic Compounds
W	Warning Area
XBT	Expendable Bathythermograph
ZOI	Zone of Influence

EXECUTIVE SUMMARY

The purpose of this document, *Eglin Gulf Test and Training Range (EGTTR) Programmatic Environmental Assessment,* is to provide environmental analysis and necessary National Environmental Policy Act (NEPA) documentation to ensure compliance with Air Force policy and applicable federal, state, and local environmental laws. The preferred alternative (Alternative 3) authorizes a baseline level of Air Force mission activity captured during the fiscal year (FY) 95−99 time frame, with the addition of limited nighttime gunnery training with 105-millimeter (mm) training rounds. By authorizing the level of activity in the preferred alternative, similar mission requests may be quickly and efficiently approved. The FY 95−99 baseline encompasses mission activities over several years in order to capture infrequent, yet repetitive, mission events conducted within the EGTTR and represents the most current data available. Complete detailed analyses for the baseline level of mission activities are presented in this document.

Two mission categories generally contain all missions conducted by the Air Force within the EGTTR: air operations and ordnance testing and training. Air operations include all aircraft flights through the EGTTR.

Potential Impacts from Air Operations

Noise – During some air operations, supersonic and subsonic flights may result in acoustic energy reaching the surface of the water. Most of the acoustic energy produced would reflect off the surface of the water and would be directed upward, except under certain speeds and maneuvers, which may cause limited amounts of energy to penetrate into the water. Even under the worst-case conditions, noise produced from supersonic and subsonic flights would not exceed known criteria for biological or socioeconomic resources. ***Thus, supersonic and subsonic noise from EGTTR missions is not likely to adversely affect biological or socioeconomic resources.***

Chemical Materials **–** Aircraft flight operations occurring in the airspace over the EGTTR have the greatest potential to impact air quality. As shown in the analysis, due to the vast areas encompassed by these airspace elements, and the relatively few aircraft operations occurring below 3,000 feet, aircraft operations from Eglin AFB produce an almost insignificant impact on air quality over the Gulf of Mexico. ***Therefore, no adverse air quality impacts to the physical/chemical, biological, or anthropogenic environments are anticipated.***

Fuel Releases **–** During in-flight emergencies, fuel may be released in the air or a fuel tank may be jettisoned and impact the surface. Drones may also be shot down and release fuel upon surface impact, though the Air Force desires to land them safely and reuse them. The type of fuel, JP-8, is very volatile and, when released at altitude, evaporates quickly. Temporary localized effects to air and water quality may result from fuel releases. Naturally occurring air currents, wind velocity, and fast moving storm systems should minimize any potential long-term adverse impacts to air quality. The location of the test range in open water, Gulf diurnal tidal cycles, and high wave action caused by wind and storms should minimize the potential for adverse impacts. Localized degradations in water quality may temporarily affect the distribution of threatened and endangered species and fish populations. However, cumulative effects are not expected for threatened and endangered species, fish populations, or commercial fisheries. ***Thus, fuel releases from air operations are expected to have minimal or no effect on most resources within physical, biological, anthropogenic, or socioeconomic environments due to the extremely low incidence of recorded fuel release events and high rate of evaporation for JP-8.***

Restricted Access - The EGTTR is composed of Warning Areas 151, 168, 174, and 470 plus the individual Eglin Water Test Areas (EWTAs) 1 through 6. The Warning Areas and EWTAs only include the airspace. There are no restrictions on public or commercial use of the surface waters. These areas are restricted to DoD use except when the airspace-controlling agency either authorizes joint use or turns the airspace back over to FAA control. A Warning Area restricts all public and commercial use of the airspace due to the hazardous nature of military testing and training. **Airspace Restrictions** - All parts of the EGTTR, when activated, are Warning Areas that restrict all public and commercial use of this airspace. Closures must comply with the limitations as stated in the Letter of Agreement. These closures for operations above FL240 cannot exceed four hours and at or below FL240, the block of time is not to exceed 12 hours. There will also be a minimum of three hours between successive blocks to permit utilization of the airspace by nonparticipating aircraft. ***Restricted access should not impact socioeconomic resources.***

Potential Impacts from Ordnance Testing and Training

Chaff - A remote potential does exist for clumps of chaff to be mistaken as a food source and unintentionally ingested by aquatic organisms. However, the chances of this are unlikely, given the amounts of chaff deposited and the wide dispersion of the clumps into individual fibers. Injury to biological resources has been studied and it has been determined that these components weigh so little that no injury would be anticipated if an animal were to be struck. ***Therefore, no adverse effects from chaff to fishes, marine mammals, sea turtles, nor threatened or endangered species would result from chaff deployment over the eastern Gulf.***

Flares - The type of flares typically used in training missions in the affected area is the MJU-7 flare. The principle chemical element of concern regarding the use of the MJU-7 flare is magnesium. “Closed box” analysis revealed that the total amounts of magnesium added to the Gulf surface waters would be less than 1.40 μg/L (W-151) and 10.09 μg/L (W-470) and represents less than 0.0002 (W-151) and 0.0005 (W-470) percent of the background concentration (1.35 g/L) of Mg in the Gulf surface waters. ***Due to the extremely small amounts of magnesium potentially dissolving in seawater, no adverse effects are anticipated to fishes, marine mammals, sea turtles, nor threatened or endangered species as a result of flare use over the eastern Gulf.***

Debris –The total weight of solid material (debris) expended in the EGTTR by mission activities is approximately 1,323 tons. Debris material contributed from nonmilitary activities was found to be significantly less than materials from state and county artificial reef programs. In the short term, concrete, steel, and aluminum debris serve as a substrate for settling and encrusting organisms and thus provide structural heterogeneity to the bottom communities. The long-term fate of such inert materials is relatively unknown beyond a slow corrosive process. ***It is not anticipated that debris would cause adverse impacts to biological resources.***

Chemical Materials – Chemical materials are introduced into the marine environment through drones, gun ammunition, missiles, chaff, flares, smokes and obscurants. Impacts to water quality and marine organisms were assessed. Analysis indicated that potential chemical contamination concentrations were extremely low and not likely to impact marine species. ***Thus, no adverse impacts are expected from chemical materials to natural, biological, or socioeconomic resources.***

Restricted Access - Airspace control is essentially the same for Ordnance Testing and Training as for Air Operations. Specific items with regard to surface water restrictions were assessed. There are no restrictions on public or commercial uses of the surface water under the Warning Areas unless this activity also requires airspace, or other DoD activities are planned. These activities must then schedule through the controlling agency for that airspace. It is the responsibility of the testing/training activity to ensure that there is no surface traffic in the area. Due to the level of cooperation provided by local commercial and public users of the surface and the offshore nature of EGTTR waters, only one test in the past seven years was required to be rescheduled. ***Restricted access should not impact socioeconomic resources.***

Direct Physical Impacts – Direct physical impacts to marine species resulting from inert bombs, Air-to-Surface (A/S) Gunnery ammunition, and shrapnel from live missiles falling into the water was assessed. The impacts to marine mammals and sea turtles swimming at the surface that could potentially be injured or killed by projectiles and falling debris was determined to be an average of 0.2059 marine mammals and 0.0414 sea turtles per year. ***Thus, direct physical impacts are not likely to show significant adverse effects to biological resources.***

Noise – A key element of this EGTTR PEA is gunnery noise impacts resulting from aircraft shooting at in-water targets. Using the adjusted density estimate of each species, the zone of influence (ZOI) of each type of round deployed, and the total number of events per year, an estimate of the potential number of animals exposed (harassed, injured, or killed) per year from noise were analyzed. Estimates for ZOI distances (radii) and the total number of marine mammals and sea turtles exposed to various noise thresholds for A/S Gunnery ordnance (105 mm, 40 mm, and 25 mm) are reported. Impacts from alternatives are detailed regarding the increase in expendable use for nighttime training activities. Appendix B explores the potential permit conditions and management practices that could be implemented for nighttime A/S Gunnery activities. Under the preferred alternative (Alternative 3), impacts to cetaceans and sea turtles are estimated to potentially occur from noise generated from the nighttime A/S Gunnery mission activity. Limited daytime A/S Gunnery, however, is a permitted activity with management practices in place to offset impacts, facilitated by surveying and clearing the area of marine mammals. The effectiveness of nighttime surveys is unproven, and therefore it cannot be assumed that nighttime A/S Gunnery impacts can be managed to the same degree as daytime impacts. ***Thus, noise from ordnance testing and training may impact biological resources during nighttime training activities.***

1. PURPOSE AND NEED FOR ACTION

1.1 INTRODUCTION

The Eglin Military Complex (EMC) is a Department of Defense (DoD) Major Range Test Facility Base (MRTFB) that exists to support the DoD mission (Figure 1-1). Its primary function is to support research, development, test, and evaluation of conventional weapons and electronic systems. Its secondary function is to support training of operational units. The range is composed of four components:

- Test Areas/Sites
- Interstitial Areas (areas beyond and between the test areas)
- The Eglin Gulf Test and Training Range
- Airspace (over land and water)

The Air Force Air Armament Center (AAC) has responsibility for the EMC and for supporting all its users, which include DoD, other government agencies, foreign countries, and private companies. For range operations, AAC provides environmental analyses and necessary National Environmental Policy Act (NEPA) documentation to ensure compliance with Air Force policy and applicable federal, state, and local environmental laws and regulations.

AAC includes two wings and four directorates at Eglin AFB that collectively operate, manage, and support all activities on the EMC. AAC (Eglin AFB) accomplishes its range operations through the 46th Test Wing with support from the 96th Air Base Wing. The 46th Test Wing Commander is responsible for day-to-day scheduling, executing, and maintaining of this national asset. The continued DoD utilization of the EMC requires flexible and unencumbered access to land ranges and airspace, which support all of Eglin's operations. Eglin controls airspace overlying 127,868 square miles (mi^2), of which 2.5 percent (3,226 mi^2) is over land and 97.5 percent (124,642 mi^2) is over water as shown in Figure 1-1.

1.2 PROPOSED ACTION

Eglin's air operations supported nearly 39,000 sorties per year (a sortie is an individual flight of one aircraft) during the 1995 through 1999 time frame, which were accomplished predominately over the Gulf of Mexico. This airspace is referred to as the Eglin Gulf Test and Training Range (EGTTR) and is controlled by the Federal Aviation Administration (FAA), but scheduled by Eglin Air Force Base. This airspace includes Warning Areas (W-151, W-168, and W-470), as well as Eglin Water Test Areas (EWTA-1 through EWTA-6) (Figure 1-1). The EGTTR is currently proposed to support a variety of mission activities, which are summarized into two categories: Air Operations and Ordnance Testing and Training.

The **Proposed Action** is for the 46th Test Wing Commander to establish an authorized level of activity with an accompanying set of management practices for the EGTTR that is based on an anticipated maximum usage. The **purpose and need for this proposed action** is two-fold as described in the following. The first purpose is to quickly and efficiently process new programs

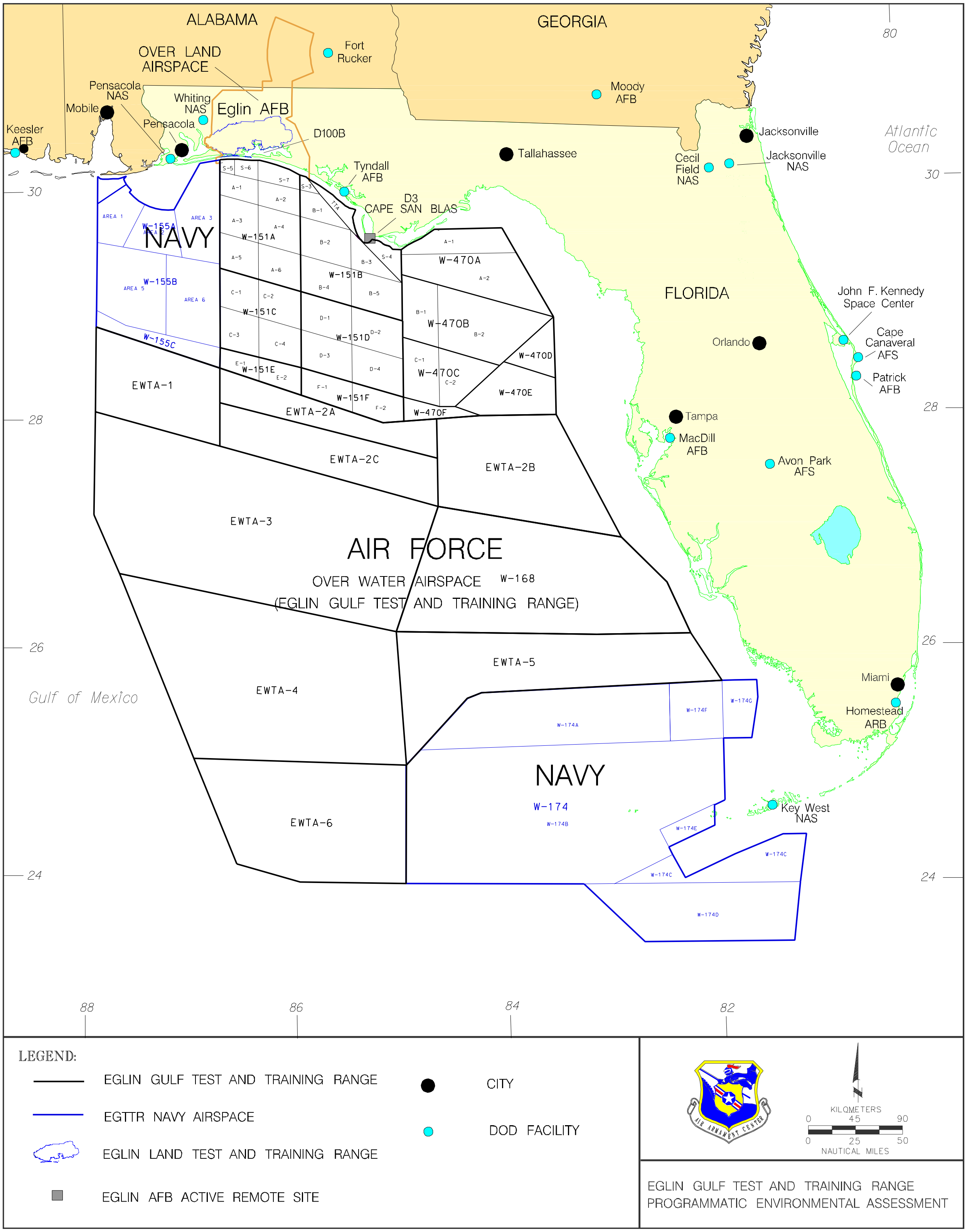


Figure 1-1. Illustration of Land and Water Ranges Comprising the Eglin Military Complex

requesting access to the EGTTR during routine and crisis situations. The need associated with this purpose is to provide military users a quick response to priority needs during war or other significant military involvement, as well as improve the current approval process for routine uses. The second purpose is to update the NEPA analysis by re-evaluating the mission activities and by performing a cumulative environmental analysis of all mission activities. The need associated with this purpose is multifaceted and described below.

Eglin has performed environmental analyses on its mission activities on a case-by-case (i.e., each individual program) basis since NEPA was enacted in 1970. Many of Eglin's mission activities have not ceased since the original environmental analyses were done to initiate the mission; thus new environmental reviews have not been required or performed. Currently, when approval for a new mission is requested, it may be categorically excluded from additional environmental analysis if it is similar in action to a mission that has been previously assessed and the assessment resulted in a finding of no significant environmental impact. The categorical exclusion (CATEX) designation is in accordance with NEPA and Air Force regulations (Council on Environmental Quality [CEQ] and 32 CFR 1989.

Since some of these ongoing mission activities were originally assessed, and also since some of the mission activities that are used for CATEX purposes were assessed, changes have occurred at Eglin that could affect environmental analysis. These changes, outlined below, create a need to re-evaluate the NEPA analysis individually and cumulatively.

- Additional species have been given federal and state protection status.
- Species have been discovered that were not previously known to exist at Eglin.
- Additional cultural resources have been discovered and documented.
- The population of communities along the EGTTR borders has increased.
- Air Force regulations and manuals have changed to a new series of Air Force Instructions.
- Military missions and weapons systems have evolved.

Additionally, work performed during the 1990s by Eglin, along with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), has enabled a greater understanding of the habitats and species of the Gulf of Mexico. Finally, while each program has been analyzed individually, a cumulative analysis of potential environmental impacts from all mission activities has not been performed. The programmatic analysis performed in this report allows for a cumulative look at the impact on natural resources from all mission activities. By implementing an authorized level of activity, range management would be streamlined and cumulative environmental impacts would be more fully considered.

1.3 SCOPE OF THE PROPOSED ACTION

This document encompasses only the mission activities that occurred in the Eglin Gulf Test and Training Range (Figure 1-1). Overland air operations are covered in a separate document: *Overland Air Operations - Programmatic Environmental Assessment* (U.S. Air Force, 1998c).

Mission activities conducted within the EGTTR are summarized primarily by Air Operations and Ordnance Testing and Training.

The EGTTR is described as the airspace over the Gulf of Mexico beyond three nautical miles (nmi) from shore that is controlled by Eglin Air Force Base. At present this area is comprised of Warning Areas W-151, W-168, W-174, and W-470, as well as Eglin Water Test Areas (EWTA) 1 through 6. Warning Area W-155, which is controlled by the Navy, is used occasionally to support Eglin missions. The definition of the EGTTR is taken from the AAC Instruction (AACI) 11-201, Air Operations, dated 1 November 1998. This airspace description is further defined in a "Letter of Agreement" between the Jacksonville, Houston, and Miami Air Route Traffic Control (ARTC) Centers, Training Air Wing Six (TRAWING 6), and the Air Armament Center (AAC), dated (revised) 20 May 1998, attached as Appendix K. The EGTTR is also sometimes referred to as the "Eglin Water Range."

The EGTTR annually supports nearly 39,000 sorties that were baselined at the level of activity captured during fiscal years (FY) 95, 96, 97, 98 and 99. This baseline encompasses mission activities over several years in order to capture infrequent, yet important, mission events conducted in the EGTTR. The baseline is represented by the maximum number of each mission type from any one year over the five-year period. The maximum amount of activity rather than a five-year average was selected to best represent typical sortie activity since some mission types were not conducted in every year. This baseline database represents the most current data available and identifies types of aircraft, where they were flown, where expendables were released, and types of missions flown. The baseline database was compiled from data extracts of the *FY95, FY96, FY97, FY98 and FY99 Range Utilization Reports* (U.S. Air Force, 1996, 1998a, 1998b, 2000, 2000a).

1.4 DECISION DESCRIPTION

The 46th Test Wing desires to authorize a level of activity for the EGTTR, replacing the current approval process, which evaluates each program individually. A decision is to be made on the *level* of activity to be authorized. Currently, any new program must anticipate at least a 60-day planning cycle. This period is required to complete the Test Directive, which includes the Method-of-Test, safety analysis and the environmental impact analysis. If the action does not qualify for a categorical exclusion, or if further environmental analysis is required, this process can be adjusted. By authorizing a level of activity and analyzing the effects of this level of activity, future similar actions submitted to the Environmental Management Directorate via an AF Form 813, Request of Environmental Impact Analysis, may be categorically excluded from further environmental analysis. This would save both time and money in the review of proposed actions and would enable users to access the range more quickly and efficiently.

Procedures are in-place that, in time of crisis, allow the AAC Commander to authorize an expedited evaluation process. This process reduces planning time from 60 days to 3 days. These crisis procedures operate at the expense of all other work and cause major disruptions in the process, while ensuring environmental mission accomplishment. The authorization of the type and level of activity in the selected alternative should streamline the environmental process, enhancing Eglin's ability to quickly respond to high priority or crisis requirements.

1.5 ISSUES

The potential environmental consequences of EGTTR mission activities were examined and characterized by the following broad issue categories: ***Restricted Access, Noise, Debris, Chemical Materials,*** and ***Direct Physical Impacts***.

1.5.1 Restricted Access

Restricted access applies to the availability of Eglin resources to the general public. Guidance for restricted access is utilized to coordinate public and military use of airspace and water space (e.g., the Gulf of Mexico). Restricted access issues concerning airspace are not anticipated in the EGTTR as this airspace is authorized for Eglin use via agreements with the FAA. Restricted access issues concerning these may result from temporary safety buffer zones established for designated test or training areas. Water surface issues are coordinated through "Notice to Mariners" announcements and warnings. Restricted Access is an infrequent issue for the EGTTR.

1.5.2 Noise

Noise is defined as the unwanted sound produced by the test and training missions and their associated expendables. Analyses of potential noise impacts include discussions of two noise components: the physical overpressure and the acoustic sound. Noise is an occasional issue for supersonic Air Operations activities. Noise is also an issue for Ordnance Testing and Training activities during underwater explosive detonations within the EGTTR.

1.5.3 Debris

Debris is the physical material deposited in the waters of the EGTTR during mission activities, analogous to litter. This category differs from chemical materials by focusing on the physical disturbance rather than the chemical alterations that could result from the residual materials. Examples of EGTTR debris include ordnance and shrapnel deposits from bombs and missiles, drones, chaff and flare cartridges, and intact inert bombs. Debris is considered an issue during Ordnance Testing and Training activities within the EGTTR.

1.5.4 Chemical Materials

Chemical materials encompass a broad category of liquid, solid, or gaseous substances that are released to the environment as a result of mission activities. These include organic and inorganic materials that can produce a chemical change or toxicological effect to an environmental resource (air or water quality). For example, the gaseous chemical materials include aircraft exhausts, smokes, and combustion products of explosives; examples of liquid chemical materials are fuel releases; solid chemical materials range from particulate brass and aluminum generated by using obscurants to lead released from small arms ammunition. Chemical materials are considered an issue during Air Operations with air emissions and fuel releases. Chemical materials are also considered an issue during Ordnance Testing and Training activities within the EGTTR.

1.5.5 Direct Physical Impacts

Direct physical impact (DPI) is the physical harm that can occur to an animal or other resource (cultural) if it comes into direct contact with an expendable or other mission activity. Bird strikes (i.e., birds getting hit by an aircraft) are an example of a DPI. Bird strikes can cause damage to the aircraft or harm to the pilot, and these effects are included as part of the evaluation of this issue. Other examples include wildlife being struck by ordnance and shrapnel. Direct physical impact is considered an issue during Ordnance Testing and Training activities within the EGTTR.

1.6 FEDERAL PERMITS, LICENSES, AND ENTITLEMENTS

Although no Federal Licenses or Entitlements are necessary in order to conduct the proposed EGTTR mission activities, several Federal and state permits may be necessary. Other agencies potentially involved in the permitting process for EGTTR mission activities include the Florida Department of Environmental Protection (with Clean Water Act issues); National Pollutant Discharge Elimination System (NPDES); the U.S. Fish and Wildlife Service (with Endangered Species Act issues; Incidental Takes Permit); and the National Marine Fisheries Service (with Endangered Species Act and Marine Mammal Protection Act issues; Incidental Takes and/or Harassment Permits). The U.S EPA requires an NPDES permit for activities within 12 nmi of the shore that result in the discharge of a pollutant, including a munition, into United States waters. An Endangered Species Act and/or Marine Mammal Protection Act permit would be required for actions that affect endangered species or marine mammals.

Additionally, Executive Order 12114, 44 FR 1957, 3 CFR (04-Jan-79) “Environmental Effects Abroad of Major Federal Actions” is relevant to proposed activities within the EGTTR. Due to the size of the EGTTR, activities outside the jurisdiction of the United States that result in environmental effects that significantly harm the natural or physical environment (global commons) must be evaluated.

1.7 ENVIRONMENTAL JUSTICE

Executive Order 12898, (Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations), requires federal agencies to identify community issues of concern during the NEPA process, particularly those issues relating to decisions that might have a disproportionate effect on low-income or minority populations. There are no disproportionately high populations of minorities nor low-income households within reach of the mission impacts that are proposed to be conducted within the EGTTR study area; consequently, no analyses will be performed. Environmental Justice has been considered and, in this case, determined to be inapplicable.

1.8 ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation & Management Act requires federal agencies to assess potential impacts to Essential Fish Habitat for commercial fisheries managed by the National Marine Fisheries Service. An Essential Fish Habitat is described as those waters and substrate necessary for fish spawning, feeding or growth to maturity. Adverse impacts to Essential Fish Habitat have been further defined as those that reduce quality and/or quantity of Essential Fish Habitat. The proposed action and alternatives have been analyzed and include potential consequences resulting from Air Operations expendables (chaff, flares, downed drones, and JP-8 fuel releases) and Air-to-Surface Operations (ordnance and gunnery operations) in the EGTTR.

No adverse impacts to Essential Fish Habitat are anticipated as a result of implementing the proposed action or the alternatives. Items and materials expended into the EGTTR would not result in any adverse impacts to the chemical or biological environments that would reduce the quality and/or quantity of Essential Fish Habitat. The proposed testing and training activities would occasionally introduce small quantities of chemical compounds into the marine waters of the eastern Gulf of Mexico, which would rapidly disperse. These additions would be too small to adversely impact any of the Essential Fish Habitat of the Gulf waters.

2. ALTERNATIVES

2.1 INTRODUCTION

This section introduces the alternatives that are evaluated for potential environmental impacts in the Eglin Gulf Test and Training Range Programmatic Environmental Assessment. The proposed alternatives, which are analyzed in this document, are:

- **Alternative 1:** (No Action Alternative): Baseline level of mission activities and expended items (e.g. munitions) as captured during FY95-99, which exercised very limited high explosive (HE) usage. If selected, future missions would continue to be analyzed separately.
- **Alternative 2:** Authorization of Alternative 1. The baseline level of missions would be authorized to occur without having to conduct separate analyses for new but similar missions.
- **Alternative 3:** (Preferred Alternative): Alternative 2 to include the addition of Nighttime Air to Surface (A/S) Gunnery Training using a new 105 mm Training Round (~0.3 lbs HE)
- **Alternative 4:** Alternative 2 to include the addition of Nighttime A/S Gunnery Training using the traditional 105 mm Full-up Live Round (~4.7 lbs HE)

2.2 ALTERNATIVES CONSIDERED

2.2.1 Alternative 1: No Action Alternative

The No Action Alternative is based on the current level of activity, baselined at the level captured during fiscal years FY95-99. This baseline encompasses the maximum annual number of expended items per year over the 5-year period in order to capture infrequent, yet repetitive, mission events conducted at EGTTR Expendables data was obtained from Eglin Range Utilization Reports (RUR) from the baseline years, which are a compilation of data from the Eglin Range Operations and Maintenance Management Information System extract database, Test Files database, Resource, Scheduling and Operational Management Systems database, Site Chiefs Form 44 Reports Database, Weapons Storage Area Database and test engineer interviews. Therefore, the baseline RUR database represents the most current data available to date. Because the baseline spans a period of five years, specific munitions or aircraft that have been discontinued and will not be used again (e.g. QF-106 drones, 20 mm high explosive incendiary [HEI] A/S Gunnery) over this timeframe are technically no longer part of the current baseline. While past activities are analyzed in order to understand cumulative impacts, they do not support the current baseline analysis, which is structured toward present day and future activities.

The No Action Alternative is defined as continuing the current practice of analyzing each EGTTR action on an individual basis. This process has served Eglin well and has allowed good stewardship of the Eglin resources for many years. *This alternative does not authorize any level of activity*. Therefore, each action is identified by the proponent and evaluated by a working group. If further environmental analysis is required, an Environmental Assessment is prepared, which is a time and resource intensive process. Crisis or surge activities can be handled reasonably quickly, but at the expense of other programs.

Continuing to analyze actions on an individual basis without an authorized level of activity has certain drawbacks as demonstrated by the recent history of A/S Gunnery training in the Gulf. Due to environmental concerns associated with underwater noise impacts of the 105 mm live round, the A/S Gunnery test and training activity (105 mm, 40 mm, and 25 mm) was suspended in January 1997. In an effort to regain the vital A/S Gunnery test mission in the EGTTR, Eglin initiated discussions with NMFS to discern Section 7 consultation requirements. On August 4, 1997, NMFS concluded an informal consultation that permitted a short-term resumption of limited daytime testing of the A/S Gunnery live rounds through December 1, 1997. Although only one test mission was conducted during that time frame, three additional missions were conducted in 1998 in support of a critical military need.

On April 9, 1998, a biological assessment was submitted to initiate a Section 7 consultation in order to resume daytime A/S Gunnery test missions in the Gulf. NMFS concluded the formal consultation with a biological opinion on December 17, 1998, which provided a “No Jeopardy” opinion (“not likely to adversely effect”) for five listed sea turtle species, in addition to establishing an incidental take statement (sea turtles) for this action. Continuing with limited A/S Gunnery live fire during test mission activity was therefore legally permitted and required the adherence to strict mitigation guidelines. In summary, A/S Gunnery activity was virtually shut down for two years and only allowed to resume within specific limitations.

Two major categories of missions were performed over the water range, Test (1.2.1) and Training (1.2.2) missions. These categories are divided into the various mission activities specific to each category. Sorties are defined as an individual flight of an aircraft where one or more sorties comprise a mission. Expendables data were extracted from the FY95-99 Range Utilization Reports (RUR). Expendables are items that are deployed, released, or consumed (or potentially consumed) while performing an activity. These may include bombs, missiles, bullets, drones, chaff, flares, people, boats, and fuel bladders, etc. Mission Drivers are mission level categories of activities identified by the Air Force as those actions or items that potentially affect the environment.

Testing

Test missions are missions designed to test, verify, validate, demonstrate, or prove that the new or improved hardware, system, software, or tactic will work safely and accomplish the desired effect. Testing has been divided into eight categories, and in some cases sub-categories, to describe activities; major testers typical expendables, and aircraft used in performance; and identify mission drivers.

Air-To-Air (A/A) Testing

In the development/upgrade of missile systems, testing is routinely performed in the EGTTR. A/A Testing uses live launches of missiles at full or subscale targets. This may involve one or more "shooters" firing at one or more target A/C. Most common targets are the QF-4 full-scale drone, and the BQM-34 and MQM-107 subscale drones. During the baseline, the use of the QF-106 drone (full scale) as a target was discontinued. A/A testing missions usually require four

A/C: a Telemetry (TM) Relay A/C (E - 9), a smaller relay A/C (MU - 2), the shooter, and the target. This type of testing requires a very controlled environment with exact airspeeds, altitudes, and maneuvers. This activity is commonly done in W-151 and W-470 but not in the Aircraft Combat Maneuvering Instrumentation (ACMI) Range. Activities involved with the recovery of drones and other expendables are discussed within the section on Surface/Subsurface Testing/Support.

Testers:	46TW AWC 475 TEG	**Expendables:**	AIM-120 Missile ASRAAM (British msl) AIM-7, AIM-9 Chaff & Flares, Drones
Typical A/C:	F-15s, F-16s, Drones, E-9s, and MU-2s	**Mission Drivers:**	Air Operations Ordnance Chaff & Flares

Note: Training missions shoot on an average about 300 missiles per year, while Testing missions shoot on an average about 20-30 missiles per year.

A/A A/C Gunnery Testing

Same as A/A Combat Training LEVEL IIIB, but done to verify software upgrades to the fire-control system, ballistics, or qualify new ammunition. Again, the order of magnitude is very low (maybe 6/yr.) vs. training and usually is accomplished in W-151.

Testers:	46 TW AWC	**Expendables:**	20mm TP
Typical A/C:	F-15s and F-16s	**Mission Drivers:**	Air Operations

Air-to-Surface (A/S) Testing I (Bombs and Missiles)

This category of testing includes the Loads, Flutter, and Separation missions, which are done over the water to verify aircraft/weapons characteristics leaving the aircraft environment. Missions are performed over the water because it is unimportant where the bomb or missile goes after leaving the aircraft environment. These types of missions usually use a new weapon or a new mix of weapons not currently authorized for carriage; therefore, the ballistics are not known or verified. These missions routinely require supersonic releases.

Testers:	46 TW AWC	**Expendables:**	Bombs (all types) Missiles (all types)
Typical A/C:	F-15s, F-16s, F-111s	**Mission Drivers:**	Air Operations Ordnance

Note: Bombs are almost always inert, whereas missiles usually have a live motor and an inert warhead.

A/S Testing II (A/C Guns/Ammunition)

Special Operations has been the only tester of new A/S Gun Systems or ammunitions over water. Currently they are engaged in extensive testing of the AC-130U Gunship, 25mm gun system. On occasion, new rounds for the 40mm gun plus life-cycle testing of 105mm rounds are tested. This testing is almost always done in W-151.

Tester:	46 TW	**Expendables:**	25mm HE 40mm HE l05mm HE Chaff & Flares
Typical A/C:	AC-130U and AC-130H	**Mission Drivers:**	Air Operations Ordnance Chaff & Flares

Electric Countermeasures (ECM) And Electronic Systems Testing

Testing of ECM systems against threats both on land and airborne. Electronic Systems Testing includes radar software testing, radios, radar cross-section, and any electronic system except ECM. These missions are usually flown at a low speed and moderate altitude usually 5,000-15,000 feet, but sometime as low as 500 feet. Since munitions are not involved, this type of testing is considered benign.

Testers:	46 TW AWC	**Expendables:**	Calibration Spheres Chaff & Flares
Typical A/C:	F-15s, F-16s, occasionally E-3s, B-1s, MC-130s, EF-111s	**Mission Drivers**	Air Operations Chaff & Flares

Air Operations Testing

Air Operations Testing includes any use of the airspace not previously described. Most common of these is "speed soaking." Ordnance is carried on an A/C and flown for an extended period of time through the entire A/C speed range usually including supersonic flight. A typical mission is three hours long with Air Refueling.

Testers:	46 TW AWC	**Expendables:**	None
Typical A/C:	F-15s, F-16s, occasionally F-111s	**Mission Drivers:**	Air Operations

Surface-To-Surface (S/S) Or Surface-To-Air (S/A) Testing

Typical S/S missions are Cruise Missile launches. A surface ship or submarine launches the missile in the EGTTR, which is followed at all times by at least two A/C while it flies its programmed course. These A/C accompany the missile for redirect/destroy if necessary. After flying its programmed course over water, the missile transitions to land, usually recovering on Test Area B-70. S/A Missile Tests are missiles launched from a variety of platforms, usually from D-3 (Cape San Blas), A-15 (a site on Santa Rosa Island) or a surface vessel. These missiles are usually shot at target A/C in the EGTTR.

Testers:	46 TW AWC	**Expendables:**	Cruise Missile Patriot Missile Foreign Missiles Navy Std Block II msl Drones
Typical A/C:	F-15s, F-16s, E-9, Drones, and MU-2s	**Mission Drivers:**	Air Operations Ordnance

Surface/Subsurface Testing/Support

Several types of activities require surface/subsurface vessel interaction or support. Examples of this are surface/subsurface vessels to launch the Navy Cruise Missiles for testing and AGEIS Cruiser testing. Support functions include the 3-120 ft. Missile Retrieval Vessels (MRVs) owned by the 475 WEG to "pickup" subscale drones out of the water during drone recovery. Other activities include USN LCAC (Landing Craft, Air Cushion) work done around Panama City and Santa Rosa Island and training. Training routinely uses boats for Water Survival and Parasailing (parachute water entry) training. On occasion, the Navy brings an aircraft carrier into the EGTTR area and conducts Naval Air Operations.

Testers:	Navy 475 WEG 46TW	**Expendables:**	Navy Std Block II msl Drones .50 Cal ammo
Typical Vessels:	Naval Vessels MRVs Range Patrol Boats (2-25 ft. boats owned by 475 WEG) USN LCAC	**Mission Drivers:**	Air Operations Ordnance

Training

Training missions or activities are designed to teach, maintain, or increase the operator's proficiency to perform these activities. Training is divided into categories, and in some cases levels within these categories. Under these categories or levels, the activity is described, the major trainees listed, typical expendables and aircraft used in performing that activity are shown, and the mission drivers identified.

A/A Combat Training

Air-to-Air Combat Training is broken-down into 3 levels of intensity or realism.

LEVEL I:
Simple A/A Combat Training involving two or more A/C engaged in a simulated dogfight. This level of training only uses the systems onboard the participating A/C and no weapons are expended. This training may be accomplished in any water range but is most commonly done in W-151 and W-470.

Trainees:	33 FW 46 TW AWC 325 FW	**Expendables:**	Chaff & Flares
Typical A/C:	F-15s and F-16s	**Mission Drivers:**	Air Operations Chaff & Flares

LEVEL II:
Air-to-Air Combat Training using electronic interplay between A/C through instrumentation pods on each A/C and a ground-based computer and communications system. This system allows for <u>simulated</u> missile launches, scoring (Probability of Kill), threats, and replay/debriefing of the mission. This type of activity can only be done on an ACMI Range. The ACMI Range is divided into sub-areas allowing for multiple missions of two or more A/C (Max. 36 A/C on one sub-area) engaged in this type of activity. The only ACMI Range in the Eglin Water Range is located in W-470.

Trainees:	33 FW 325 FW	**Expendable:**	Usually none, but can have Chaff & Flares
Typical A/C:	F-15s and F-16s	**Mission Drivers:**	Air Operations Chaff & Flares

LEVEL III:
Air-to-Air Combat Training using live ordnance. This is further divided into missile launches (LEVEL IIIA) and A/C guns (LEVEL IIIB) usage.

<u>LEVEL IIIA:</u>
Air-to-Air Combat Training uses live launches of missiles at full or subscale targets. Similar to A/A Testing, this training utilizes the same targets and support aircraft but usually in a much more “free wheeling” scenario involving one or more "shooters" firing at one or more target A/C. This activity is commonly done in W-151 and W-470 but <u>not</u> in the ACMI Range. Activities involved with the recovery of drones and other expendables are captured within the section on Surface/Subsurface Testing/Support.

Trainees:	AWC-A/A WSEP AWC-William Tell (ACC competition) 475 WEG	**Expendables:**	Missiles: AIM-7, AIM-9, AIM-120 Drones Chaff & Flares
Typical A/C:	F-15s, F-16s, Drones E-9s and MU-2s, with limited F-14 activity	**Mission Drivers:**	Air Operations Ordnance Chaff & Flares

<u>LEVEL IIIB:</u>
A/A Combat Training using A/C guns only. This is usually accomplished by shooting at a towed banner. The banner is towed by either an F-15 or C-130 (usually an F-15). After shooting, the banner is either dropped in the water (boat recovery), on B-70, or along the drone runway at Tyndall AFB. At all locations, the tow banner is recovered.

Trainees:	33 FW AWC- A/A WSEP AWC-William Tell	**Expendables:**	20mm TP (Training Ammo)
Typical A/C:	F-15s and F-16s	**Mission Drivers:**	Air Operations Ordnance Surface Operations

A/S Training

The EGTTR does not have permanent surface targets. Consequently, bombs and missiles are not generally dropped or launched in the EGTTR for A/S training. The most common use of A/S training over water is by Special Operations. AC-130 Gunships routinely fire live 20/25mm, 40mm and 105mm rounds at a sea marker or flares in the water for training. Also, Special Operations MH-53 and MH-60 helicopters commonly shoot .50 Cal and 7.62 mm rounds from machine guns into the water. Any water range can be used for this training, but the most commonly utilized is W-151. A/S training is never done in the ACMI Range.

Trainees:	Hurlburt & Duke Special Operations	**Expendables:**	20mm High Explosive (HE), 25mm HE, 40mm HE, 105mm HE, .50 Cal, 7.62mm Chaff & Flares
Typical A/C:	AC-130s, MC-130s, MH-53s, MH-60s	**Mission Drivers:**	Air Operations Ordnance Chaff & Flares

Personnel and Equipment Drops

Special Operations routinely drops personnel and equipment into the water either at low-altitude (no parachutes used) or high-altitude (parachutes used) typically using W-151S (S-Shoreline) with occasionally "over the horizon" drops in other sections of W-151. The typical drop is 3-5 personnel at a height of 5-2,000 feet above the surface.

Trainees:	Special Operations (Joint Services)	**Expendables:**	Paratroops Smoke, Boats Fuel Bladders Debris (chem-lites, drop gear, etc.)
Typical A/C:	MH-53s, MH-60s, some C-130s and C-141s (several types)	**Mission Drivers:**	Air Operations Surface Operations Smokes & Obscurants

Air-To-Air Refueling

This is an air refueling A/C (either KC-135, KC-10, C-130) passing fuel to one or more "receiver" A/C. For KC-135 and KC-10, this is almost always done at altitudes ranging from 16,000-26,000 feet and flown at moderate speeds (255k for large A/C, 280-300k for fighter aircraft). Refueling of helicopters and C-130s is performed at lower altitudes, usually 4,000-8,000 feet for helicopters and 10,000-14,000 feet for C-130s (all types). Speeds are 80-100k for helicopters and 200-220k for C-130s. Procedures are the same if done for training or test mission support and therefore will not be repeated in the Test section.

Trainees:	46 TW, 33 FW, 325 FW, AWC, Special Operations	**Expendables:**	None
Typical A/C:	Almost all	**Mission Drivers:**	Air Operations

ECM Training And Other

Training on how to combat electronic signals designed to degrade onboard equipment or confuse the operator and any "other" use of the Airspace. ECM Training is routinely done A/C against A/C or A/C against ground/surface ship systems. Any part of the Eglin Water Range can be used for this type of training. "Other" can include navigation and aerobatics maneuvers plus any other use of the airspace.

Trainees:	33 FW 325 FW Special Operations	**Expendables:**	Chaff & Flares
Typical A/C:	Almost all	**Mission Drivers:**	Air Operations Chaff & Flares

Table 2-1 shows the distribution of munitions expendables throughout the EGTTR study area for the Alternative 1 baseline level of activity. As such, this alternative includes only A/S Gunnery live fire associated with the limited test missions (shaded), which occurred during daylight hours. The A/S Gunnery live fire activity associated with nighttime training missions will be covered in subsequent alternatives.

2.2.2 Alternative 2: Authorization of Alternative 1

Alternative 2 is defined as authorizing the baseline level of mission activity identified in Alternative 1, where the FY95-99 baseline period captures and quantifies the mission activities and the associated number of expendables utilized within the EGTTR study area. Alternative 2 includes a cumulative evaluation of all activities within the EGTTR study area during the baseline level of activity. By authorizing this level of activity, similar mission requests may be quickly and efficiently approved. A summary of mission activity and all expendables that were deployed within the EGTTR study area during the baseline level of activity test and training missions are listed in Table 2-1.

2.2.3 Alternative 3: Alternative 2 to Include the Addition of Nighttime A/S Gunnery Training Using a New 105 mm Training Round (~0.3 lbs High Explosives)

Alternative 3 includes the authorization of the baseline activity level described in Alternative 1 plus the inclusion of the nighttime A/S Gunnery test and training missions, which would utilize a newly developed 105 mm A/S Gunnery training round (TR). Daytime missions would continue to use the traditional 105 mm full up (FU) round as needed. The number of 25 mm and 40 mm rounds expended would also increase compared to Alternative 1. The nighttime A/S Gunnery training activity would utilize the 105 mm TR round that has a smaller quantity of HE (approximately 0.3 lbs) than is typically found in the 105 mm FU round (approximately 4.7 lbs). Like existing gunnery activities, this activity would take place in W-151. Table 2-2 lists the estimated Alternative 3 A/S Gunnery training expendables for the EGTTR water areas. Alternative 3 additionally includes all other non-A/S Gunnery expendables as listed in Table 2-1 (Alternative 1).

Table 2-1. Summary of Alternative 1 Annual Baseline Operations in the EGTTR (FY95-99)

Test Area	Category	Expendable	Condition	Baseline Quantity (number of items)
W-151A	**SORTIES**	-	-	3,970
	BOMB	BDU-33	INERT	170
		BDU-50	INERT	74
		CBU-58	INERT	3
		CBU-87	INERT	6
		CBU-89	INERT	11
		GBU-10	INERT	2
		GBU-12	INERT	18
		GBU-22	INERT	9
		GBU-24	INERT	1
		GBU-31	INERT	3
		GBU-32	INERT	4
		JASSM (Boeing)	INERT	2
		JDAM (2,000 lbs)	INERT	7
		JSOW (AGM-154)	INERT	5
		Laser Guided Training Round	INERT	6
		MK-106	INERT	18
		MK-20	INERT	37
		MK-82 HD	INERT	3
		MK-82 LD	INERT	14
		MK-84 HD	INERT	4
		MK-84 LD	INERT	3
		SUU-25	INERT	1
	CHAFF	Bol Chaff	LIVE	640
		RR-170	LIVE	37,228
		RR-180	LIVE	135
		RR-185	LIVE	2,112
		RR-188	LIVE	7,583
		RR-ZZZ	LIVE	2,112
	DRONE	BQM-34	LIVE	2
		BQM-74E	LIVE	1
		MQM-107	LIVE	4
		QF-106	LIVE	5
		QF-4	LIVE	3
	FLARE	M-206	LIVE	15,144
		MJU-10	LIVE	3,453
		MJU-7	LIVE	13,644
		MK-25	LIVE	1,332
		MK-6 Signal	LIVE	25
		SDM Decoy	LIVE	15
		SM-206 Simulator	LIVE	671
	GUN	105 MM FU	LIVE	128
		20 MM	LIVE	0
		25 MM	LIVE	1,275
		40 MM	LIVE	536
		20 MM TR	LIVE	14,630

Table 2-1. Summary of Alternative 1 Annual Baseline Operations in the EGTTR (FY95-99) Cont'd

Test Area	Category	Expendable	Condition	Baseline Quantity (number of items)
W151A	**MISSILE[1]**	2.75 " Rocket	INERT	602
Cont'd		AGM-130	INERT	4
		AGM-88	INERT	3
		AIM-120	INERT	24
		AIM-7	INERT	28
		AIM-9	INERT	31
		AIM-9	INERT	1
		STD Block II	INERT	2
		Stinger (FIM-92A)	INERT	1
		TGM-65B	INERT	1
	OTHER[2]	Air Drop Sensor	INERT	5
		ALE-50 (towed radar decoy)	INERT	13
		Banner Tow (AGTS-36)	INERT	5
		Banner Tow (TDK-39)	INERT	5
		Rubber Boat	INERT	51
		Calibration Sphere	INERT	7
		Cart, Impulse, M796	LIVE	308
		Cart, Impulse, BBU-35	LIVE	109
		Fuel Tank, 300 gal	INERT	1
		Fuel Tank, 370 gal	INERT	1
		Fuel Tank, 600 gal	INERT	2
		LAU-117 Launcher	INERT	1
		LAU-118 Rack	INERT	3
		LAU-131 Launcher	INERT	3
		Marine Marker	INERT	9
		Paradrop	INERT	410
		Paratroop	INERT	350
	SMALL ARMS	.50 Cal Ball	LIVE	90,983
		5.56 mm Linked	LIVE	10,199
		7.62 mm Ball	LIVE	931,468
	SMOKE	Smoke, Green, M-18	LIVE	41
		Smoke, M-18	LIVE	10
		Smoke, Red, M-18	LIVE	32
		Smoke, Violet, M-18	LIVE	70
		Smoke, White, M-18	LIVE	27
		Smoke, Yellow, M-18	LIVE	20
W-151B	**SORTIES**	-	-	3,970
	BOMB	BDU-33	INERT	29
		BDU-50	INERT	15
		GBU-10	INERT	1
		GBU-12	INERT	2
		GBU-32	INERT	3
		Laser Guided Training Round	INERT	1
		MK-106	INERT	9
		MK-20	INERT	1
		MK-82 LD	INERT	2
		MK-84 LD	INERT	2

Table 2-1. Summary of Alternative 1 Annual Baseline Operations in the EGTTR (FY95-99) Cont'd

Test Area	Category	Expendable	Condition	Baseline Quantity (number of items)
W-151B Cont'd	**CHAFF**	RR-163	LIVE	72
		RR-170	LIVE	20,563
		RR-180	LIVE	135
		RR-188	LIVE	26,168
	DRONE	AQM-37 Navy	LIVE	2
		BQM-34	LIVE	5
		MQM-107	LIVE	5
		QF-106	LIVE	4
		QF-4	LIVE	5
	FLARE	LUU-2	LIVE	1
		M-206	LIVE	4,060
		MJU-10	LIVE	2,782
		MJU-7	LIVE	11,075
		MK-25	LIVE	159
		SM-206 Simulator	LIVE	671
	GUN	105 MM FU	LIVE	46
		20 MM	LIVE	0
		25 MM	LIVE	294
		40 MM	LIVE	146
		20 MM TR	LIVE	26,023
	MISSILE	AGM-130	INERT	1
		AIM-120	INERT	37
		AIM-7	INERT	30
		AIM-9	INERT	55
		AIM-9	LIVE	1
		ASRAAM	INERT	1
		Caesar Trumpet	INERT	8
	OTHER	Air Drop Sensor	INERT	3
		ALE-50	INERT	4
		Banner Tow (AGTS-36)	INERT	8
		Banner Tow (TDK-39)	INERT	8
		Paradrop	INERT	60
		Paratroop	INERT	150
	SMALL ARMS	.50 Cal Ball	LIVE	2,584
		7.62 mm Ball	LIVE	26,606
	SMOKE	MK-58	LIVE	24
		Smoke M-18	LIVE	20
		Smoke, Signal Illum	LIVE	1
W-151C	**SORTIES**	-	-	3,766
	BOMB	BDU-33	INERT	6
		BDU-50	INERT	3
		CBU-58	INERT	5
		CBU-89	INERT	4
		GBU-10	INERT	3
		GBU-12	INERT	7
		GBU-31	INERT	1

Table 2-1. Summary of Alternative 1 Annual Baseline Operations in the EGTTR (FY95-99) Cont'd

Test Area	Category	Expendable	Condition	Baseline Quantity (number of items)
W-151C Cont'd	**BOMB Cont'd**	JSOW (AGM-154)	INERT	2
		Laser Guided Training Round	INERT	1
		MK-20	INERT	1
		MK-82 HD	INERT	4
		MK-82 LD	INERT	5
		MK-83 LD	INERT	2
		MK-84 LD	INERT	6
		SUU-25	INERT	1
	CHAFF	Bol Chaff	LIVE	160
		RR-163	LIVE	24
		RR-170	LIVE	27,871
		RR-180	LIVE	135
		RR-188	LIVE	25,841
	DRONE	AQM-37 Navy	LIVE	2
		BQM-34	LIVE	4
		MQM-107	LIVE	4
		QF-106	LIVE	5
		QF-4	LIVE	4
	FLARE	LUU-19	LIVE	8
		LUU-2	LIVE	1
		LUU-4	LIVE	8
		M3 Signal Illum	LIVE	1
		M-206	LIVE	3,249
		MJU-10	LIVE	4,975
		MJU-7	LIVE	12,098
		MK-25	LIVE	120
		SDM Decoy Flare	LIVE	15
		Slap Flare	LIVE	1
		SM-206 Simulator	LIVE	670
	GUN	105 MM FU	LIVE	10
		20 MM	LIVE	0
		25 MM	LIVE	142
		40 MM	LIVE	50
		20 MM TR	LIVE	13,091
	MISSILE	AIM-130	INERT	1
		AIM-88	INERT	2
		AIM-120	INERT	25
		AIM-120	LIVE	1
		AIM-7	INERT	30
		AIM-7	LIVE	1
		AIM-9	INERT	31
		AIM-9	LIVE	1
		STD BLOCK II S-A MSL	INERT	8
		TGM-65B	INERT	1
	OTHER	Air Drop Sensor	INERT	3
		Banner Tow (AGTS-36)	INERT	5

Table 2-1. Summary of Alternative 1 Annual Baseline Operations in the EGTTR (FY95-99) Cont'd

Test Area	Category	Expendable	Condition	Baseline Quantity (number of items)
W-151C Cont'd	**OTHER Cont'd**	Banner Tow (TDK-39)	INERT	5
		Gallons of Water	INERT	1,500
		LAU-117 Launcher	INERT	1
	SMALL ARMS	.50 Cal Ball	LIVE	2,584
		7.62 mm Ball	LIVE	26,606
	SMOKE	Smoke, Signal Illum	LIVE	4
W-151D	**SORTIES**	-	-	3,766
	BOMB	BDU-33	INERT	6
		BDU-50	INERT	3
		MK-20	INERT	1
		MK-82 LD	INERT	2
		MK-84 LD	INERT	4
	CHAFF	RR-163	LIVE	24
		RR-170	LIVE	20,151
		RR-180	LIVE	135
		RR-188	LIVE	19,184
	DRONE	BQM-34	LIVE	5
		MQM-107	LIVE	6
		QF-106	LIVE	8
		QF-4	LIVE	6
	FLARE	LUU-19	LIVE	7
		LUU-4	LIVE	7
		M-206	LIVE	3,957
		MJU-10	LIVE	2,474
		MJU-7	LIVE	7,645
		MK-25	LIVE	275
		SM-206 Simulator	LIVE	670
	GUN	105 MM FU	LIVE	39
		20 MM	LIVE	0
		25 MM	LIVE	567
		40 MM	LIVE	198
		20 MM TR	LIVE	7,620
	MISSILE	AGM-142	INERT	1
		AGM-88	INERT	1
		AIM-120	INERT	37
		AIM-120	LIVE	1
		AIM-7	INERT	29
		AIM-9	LIVE	2
		AIM-9	INERT	55
		ASRAAM	INERT	1
		STD BLOCK II S-A MSL	INERT	4
W-151S	**SORTIES**			2,423
	BOMB	GBU-10	INERT	12
		GBU-31	INERT	2
		GBU-32	INERT	2

Table 2-1. Summary of Alternative 1 Annual Baseline Operations in the EGTTR (FY95-99) Cont'd

Test Area	Category	Expendable	Condition	Baseline Quantity (number of items)
W-151S Cont'd	**CHAFF**	RR-170	LIVE	5,655
		RR-185	LIVE	352
		RR-188	LIVE	2,082
		RR-ZZZ (Classified)	LIVE	352
	DRONE	BQM-74E	LIVE	2
		MQM-107	LIVE	1
	FLARE	M-206	LIVE	1,765
		MJU-10	LIVE	1,735
		MJU-7	LIVE	1,643
		MK-25	LIVE	261
		MK-6 Signal	LIVE	2
		SM-206 Simulator	LIVE	670
	GUN	105 MM FU	LIVE	19
		20 MM	LIVE	0
		25 MM	LIVE	283
		40 MM	LIVE	99
		20 MM TR	LIVE	0
	MISSILE	AGM-88	LIVE	1
		AIM-120	LIVE	1
		Stinger (FIM-92A)	LIVE	2
	OTHER	Air Drop Sensor	INERT	2
		ALE-50	INERT	4
		Calibration Spheres	INERT	9
		Marine Marker	INERT	100
		Paradrop	INERT	888
		Paratroop	INERT	654
	SMALL ARMS	.50 CAL	LIVE	2,631
		7.62 BLANKS	LIVE	1,844
		7.62 MM	LIVE	15,034
	SMOKE	Smoke, Green, M-18	LIVE	50
		Smoke, M-18	LIVE	3
		Smoke Signal, Illum.	LIVE	74
		Smoke, Red, M-18	LIVE	35
		Smoke, Violet, M-18	LIVE	40
		Smoke, Yellow, M-18	LIVE	25
W-168	**SORTIES**	-	-	700
	CHAFF	RR-170	LIVE	4,160
		RR-185	LIVE	1,040
		RR-188	LIVE	1,040
W-470[4]	**SORTIES**	-	-	20,324
	BOMB	BDU-33	INERT	2
	CHAFF	RR-170	LIVE	23,485
		RR-188	LIVE	205,224
	DRONE	BQM-34	LIVE	4
		MQM-107	LIVE	2
		QF-106	LIVE	7
		QF-4	LIVE	3

Table 2-1. Summary of Alternative 1 Annual Baseline Operations in the EGTTR (FY95-99) Cont'd

Test Area	Category	Expendable	Condition	Baseline Quantity (number of items)
W-470[4] Cont'd	**FLARE**	M-206	LIVE	1,741
		MJU-10	LIVE	11,800
		MJU-7	LIVE	93,757
	GUN	20 MM TR	LIVE	13,454
	MISSILE	AIM-120	LIVE	4
		AIM-120	INERT	36
		AIM-7	LIVE	3
		AIM-7	INERT	25
		AIM-9	LIVE	3
		AIM-9	INERT	39
		ASRAAM	INERT	3
	OTHER	Banner Tow (AGTS-36)	INERT	4
		Banner Tow (TDK-39)	INERT	8
EWTA-1	**SORTIES**	None	-	16
	MISSILE	STD BLK MSL	INERT	1
EWTA-2	**SORTIES**	None	-	16
	GUN	20 MM TR	LIVE	762
	MISSILE	AIM-9	INERT	2
		AIM-120	INERT	1
	CHAFF	RR-170	LIVE	252
		RR-188	LIVE	360
	FLARE	M-206	LIVE	86
		MJU-7	LIVE	46
		MJU-10	LIVE	28
EWTA-3[5,6]	**SORTIES**	None	-	16

Notes:
1) Live missile motor, inert warhead
2) Other includes: Paratroops and Calibration Spheres
3) Sorties per area were determined by aircraft scheduled for a particular area; therefore, if an aircraft was scheduled for W-151A and C, both W-151 and W-151C received credit for a sortie. The rational is assumed since the mission requested multiple areas; it flew in each area, and therefore each area received credit for a sortie.
4) Tyndall AFB only scheduled one F-15 and one F-16 per day for their ACMI Range (JON 9994TS01) and for ADC ECM and Chaff Training (JON 9994TS02) for EGTTR W-470. The estimated number of sorties to EGTTR W-470 is 17,700 F-15s and 1,416 F-16s or an average of 76 sorties per day.
5) EWTA-6 was approved 25 May 95 but was not added to the scheduling list of available resources until the start of FY96.
6) No expendables were deployed nor sorties flown in EWTA-4, EWTA-5, or EWTA-6 during FY95-99.

General: The quantities of A/S Gunnery ordnance (105 mm, 40 mm, 25 mm, 20 mm, 7.62 mm, and 0.50 cal) were adjusted to reflect the most recent (09/01/99) AFSOC aircraft loading requirements. Shaded areas = A/S gunnery.

Source: U.S. Air Force, 2000b

Table 2-2. Summary of Alternative 3 A/S Gunnery Training Operations in the EGTTR

Test Area	Category	Expendable	Condition	Missions (#)	Events/Rounds (#)
W-151A	GUN	105 mm FU	LIVE	6	128
		105 mm TR	LIVE	45	902
		25 mm	LIVE	9	9,139
		40 mm	LIVE	108	10,347
W-151B	GUN	105 mm FU	LIVE	2	46
		105 mm TR	LIVE	13	255
		25 mm	LIVE	3	1,746
		40 mm	LIVE	32	3,169
W-151C	GUN	105 mm FU	LIVE	1	10
		105 mm TR	LIVE	9	197
		25 mm	LIVE	3	2,443
		40 mm	LIVE	25	2,352
W-151D	GUN	105 mm FU	LIVE	2	39
		105 mm TR	LIVE	7	133
		25 mm	LIVE	2	1,397
		40 mm	LIVE	18	1,781
W-151S	GUN	105 mm FU	LIVE	1	19
		105 mm TR	LIVE	1	13
		25 mm	LIVE	2	337
		40 mm	LIVE	2	181
		TOTAL		**291**	**34,634**

Source: Author created

Note: The quantities of A/S Gunnery ordnance (105 mm, 40 mm, and 25 mm) were adjusted to reflect the most recent (09/01/99) AFSOC aircraft loading requirements. Typical number of expendables per mission for 105 mm is 20, for 40 mm is 96, and for 25 mm is 1,000.

2.2.4 Alternative 4: Alternative 2 to Include the Addition of Nighttime A/S Gunnery Training Using the Traditional 105 mm Full Live Round (~4.7 lbs)

Alternative 4 includes the authorization of the baseline activity level described in Alternative 1 plus the inclusion of the nighttime A/S Gunnery training missions, which would utilize the traditional 105 mm FU round (approximately 4.7 lbs HE). The number of 25 mm and 40 mm rounds expended would also increase compared to the baseline described in Alternative 1. Table 2-3 lists the estimated Alternative 4 A/S Gunnery training expendables for the EGTTR water areas. Alternative 4 additionally includes all other non-A/S Gunnery expendables as listed in Table 2-1 (Alternative 1).

Table 2-3. Summary of Alternative 4 A/S Gunnery Training Operations in the EGTTR

Test Area	Category	Expendable	Condition	Missions (#)	Events/Rounds (#)
W-151A	GUN	105 mm FU	LIVE	51	1,030
		25 mm	LIVE	9	9,139
		40 mm	LIVE	108	10,347
W-151B	GUN	105 mm FU	LIVE	15	301
		25 mm	LIVE	3	1,746
		40 mm	LIVE	32	3,169
W-151C	GUN	105 mm FU	LIVE	10	207
		25 mm	LIVE	3	2,443
		40 mm	LIVE	25	2,352
W-151D	GUN	105 mm FU	LIVE	9	172
		25 mm	LIVE	2	1,397
		40 mm	LIVE	18	1,781
W-151S	GUN	105 mm FU	LIVE	2	32
		25 mm	LIVE	2	337
		40 mm	LIVE	2	181
		TOTAL		**291**	**34,634**

Source: Author created

Note: The quantities of A/S Gunnery ordnance (105 mm, 40 mm, and 25 mm) were adjusted to reflect the most recent (09/01/99) AFSOC aircraft loading requirements. Typical number of expendables per mission for 105 mm is 20, for 40 mm is 96, and for 25 mm is 1,000.

2.3 COMPARISON OF ALTERNATIVES

The primary differences between Alternatives 1, 2, 3 and 4 are centered on the use of A/S Gunnery (105 mm, 40 mm, and 25 mm) in the area of highest gunnery activity (EGTTR airspace block W151A) in the Gulf of Mexico.

- **Alternative 1:** (No Action Alternative): Baseline level of mission activities as captured during fiscal years FY95-99, which exercised very limited high explosive (HE) usage. If selected, future missions would continue to be analyzed separately.
- **Alternative 2:** Authorization of Alternative 1. The baseline level of missions would be authorized to occur without having to conduct separate analyses for new but similar missions.
- **Alternative 3:** (Preferred Alternative): Alternative 2 to include the addition of Nighttime Air to Surface (A/S) Gunnery Training using a new 105 mm Training Round (~0.3 lbs HE)
- **Alternative 4:** Alternative 2 to include the addition of Nighttime A/S Gunnery Training using the traditional 105 mm Full-up Live Round (~4.7 lbs HE)

Potential environmental issues explored for the four alternatives include noise, restricted access, chemical materials, debris, and direct physical impacts. Table 2-4, which compares potential environmental effects of the four alternatives, summarizes the Chapter 4 environmental analysis.

Noise

Subsonic and supersonic aircraft noise from Air Operations would be essentially the same for all alternatives, while Ordnance Testing and Training noise (i.e. A/S Gunnery) would vary. Underwater noise impacts to protected species (cetaceans [dolphins and whales] and sea turtles) resulting from A/S Gunnery activity are of primary concern.

For underwater noise, each alternative was analyzed by determining the zones of influence (ZOI) that A/S Gunnery detonation noise would have on protected species. ZOIs were defined as the predicted distance that noise of a certain level would travel. The noise levels selected were thresholds recognized by scientists and regulators and correlate to impacts (e.g. hearing impairment) potentially occurring in cetaceans. These thresholds have been previously referenced in recent environmental assessments (EA) and environmental impact statements (EIS). The presence, species, and density of animals within the ZOI were determined from available surveys of the northern Gulf of Mexico.

Since noise can be measured in combinations of pressure, energy, and frequency, no one measurement exists to adequately assess noise effects on cetaceans. Thus, three types of noise metrics were considered: peak pressure, total energy flux density, and energy flux density at the greatest 1/3-octave band. A detailed discussion of noise metrics is provided in Appendix H. Further, animal hearing is not well understood and there exists disagreement among scientists and regulators regarding when impacts occur and how to accurately measure them.

The number of noise events and types of ordnance used factored prominently into the potential each alternative had for impacts to protected species. Alternative 1 produced the smallest ZOI and the fewest events of all alternatives. Additionally, mitigations are presumed to be more effective during the day; thus, potential A/S Gunnery noise impacts of Alternative 1 could be reduced or possibly eliminated altogether. Alternative 3 has a larger ZOI and more events than Alternative 1 due to the addition of nighttime training. Alternative 4 has the same number of events as Alternative 3, but has the largest ZOI of the alternatives due to the use of 105 mm FU rounds at night.

Using the energy flux density metric (greatest 1/3 octave band energy flux density), a total of 14.5 animals would potentially be exposed to the 170 dB re 1 $\mu Pa^2 \cdot s$ noise level for Alternative 1, 121 animals for Alternative 3, and 165 animals for Alternative 4. Comparative ZOIs and impacts for other metrics (peak pressure, total energy flux density) may be found in Appendix E. Mitigations discussed in the Appendices are anticipated to reduce potential impacts.

Chemical Materials

The level of chemical materials inputs would not increase appreciably between alternatives. The baseline chemical materials include air emissions, fuel releases, chaff, flare residues, and small amounts of explosive by-products. Of these, fuel releases account for the majority of chemical materials inputs. Fuel releases occur as a result of in-flight emergencies or downed drones. Compared to other sources of petroleum inputs into the Gulf, such as commercial shipping or the oil industry, the amounts are low, at less than two percent of contaminant volumes relative to the petroleum industry alone.

Table 2-4. Comparison of Alternatives

Environmental Issues		Alternative 1 No Action Alternative	Alternative 2 Authorization	Alternative 3 105 mm Training	Alternative 4 105 mm Full Up
AIR OPERATIONS					
Sorties		119,623	119,623	119,886	119,886
Noise (modeled)					
Subsonic (L_{nmr})		61.8	61.8	61.8	61.8
Supersonic (CDNL)		66.3	66.3	66.3	66.3
Chemical Materials					
Air Quality:	CO (1-Hour) as mg/m^3	2.79 E-05	2.79 E-05	2.79 E-05	2.79 E-05
	NO_2 (Annual) as mg/m^3	8.58 E-02	8.58 E-02	8.58 E-02	8.58 E-02
	SO_2 (3-Hour) as mg/m^3	5.37 E-03	5.37 E-03	5.37 E-03	5.37 E-03
	PM_{10} (24 Hour) as $\mu g/m^3$	4.01 E-03	4.01 E-03	4.01 E-03	4.01 E-03
Water Quality:	JP-8 Fuel Release Exposure as µg/L	3.0 E-02	3.0 E-02	3.0 E-02	3.0 E-02
Restricted Access					
Airspace Restrictions (# Closures/Year)		2	2	2	2
ORDNANCE TEST AND TRAINING					
Debris					
	Plastic (tons)	26	26	26	26
	Steel (tons)	233	233	233	233
	Aluminum (tons)	1,048	1,048	1,048	1,048
	Other (tons)	16	16	16	16
Chemical Materials					
Ordnance:	NEW (µg/L)	1.64 E-03	1.64 E-03	1.64 E-03	1.64 E-03
	CO_2 (µg/L)	9.30 E-04	9.30 E-04	9.30 E-04	9.30 E-04
	CO	5.00 E-05	5.00 E-05	5.00 E-05	5.00 E-05
	NO_2 (µg/L)	< 1.00 E-05	< 1.0 E-05	< 1.0 E-05	< 1.0 E-05
	NO (µg/L)	< 1.00 E-05	< 1.0 E-05	< 1.0 E-05	< 1.0 E-05
Flares:	Mg (ng/L)	3.00 E-05	3.00 E-05	3.00 E-05	3.00 E-05
Chaff:	Al (µg/L)	7.78 E-03	7.78 E-03	7.78 E-03	7.78 E-03
Direct Physical Impact					
	Cetaceans	0.21	0.21	0.21	0.21
	T&E Cetaceans	0.0005	0.0005	0.0005	0.0005
	Sea Turtles (#/Yr)	0.04	0.04	0.04	0.04
Noise (modeled)					
1/3-Octave EFD	Animals Exposed (# / 160 dB - # / 200 dB)	221 - 0.013	221 - 0.013	1,285 - 0.12	2,181 - 0.17

Restricted Access

Restricted access is the same for all alternatives. The management of EGTTR airspace for military testing and training has been occurring for many years. Military use rarely places restrictions on the use of airspace over the Gulf by civilian commercial aircraft that traverse through Eglin Water Test Areas (EWTA) along Federal Aviation Administration designated jet airways. Approximately once or twice a year, an EWTA will be activated for a mission and cause a temporary closure of the airspace to civilian commercial aircraft. Closures of this airspace must comply with the limitations as stated in the Letter of Agreement between the Air Force and the Federal Aviation Administration. The letter states that for an operation above FL240 (24,000 feet), the period of activation cannot exceed four hours and at or below FL240, no period or block of time shall exceed 12 hours. It is not anticipated that Alternatives 3 and 4 would have increased restricted access issues because activation of EWTAs is infrequent, the FAA and Air Force have an existing cooperative relationship that allows for mutual use of the EGTTR by military and commercial aircraft, and the increased level of activity under Alternatives 3 and 4 would primarily occur at least 50 miles away in another airspace block.

Debris

Debris from EGTTR operations generally falls into the major categories of aluminum, steel, plastic, concrete, and other components (i.e. copper, lead) and originates largely from inert bombs and missiles and downed drones. An increase in A/S Gunnery operations (Alternative 3 and Alternative 4) is not expected to appreciably increase the level of debris when compared to all other mission types. The major components of EGTTR debris, aluminum and steel, are also typical components used in artificial reef programs. By comparison, the amount of aluminum and steel deposited into the Gulf from EGTTR debris was 40 percent lower than amounts deposited from artificial reef programs.

Direct Physical Impacts

Direct physical impacts could result from A/S Gunnery and small caliber ammunition being fired into the water. Protected marine species (marine mammals and sea turtles) swimming at the surface could potentially be injured or killed. Alternatives 3 and 4 represent an increase in the number of expended 25 mm, 40 mm, and 105 mm rounds. Subsequently, the potential for directly impacting an animal at the surface would potentially increase as well. DPI to marine mammals and sea turtles, however, is only determined from the small arms gun ammunition, excluding the 25 mm, 40 mm, and 105 mm rounds. As with Alternative 1, these rounds were not considered in the DPI analyses, as the noise analyses constitute a far more conservative impact assessment for these exploding round types of ordnance. As such, the DPI to marine mammals and sea turtles under Alternatives 3 and 4 would be the same as those determined for Alternative 1. Consultation requirements, discussed in the Appendices, are anticipated to reduce the potential impacts.

2.4 PREFERRED ALTERNATIVE

Alternative 3 is the preferred alternative. The Air Force desires to continue with the level of activity for all missions outlined in Alternatives 1 and 2 with the addition of nighttime A/S Gunnery training using the 105 mm Training Round. This level provides for the greatest degree of flexibility for conducting the testing and training operations necessary for military readiness across all mission types, while reducing potential impacts to protected marine species. With respect to potential environmental issues, noise from A/S Gunnery activities from Alternative 3 may require the implementation of certain management practices or consultation requirements presented in Appendix B.

3. AFFECTED ENVIRONMENT

The marine resources are described for a region in the eastern Gulf of Mexico corresponding to the area under special use airspaces W-155, W-151, W-470 and W-168. A brief description of the meteorology, marine resources, and physical and biological environment of the eastern Gulf of Mexico is provided for reference.

3.1 METEOROLOGY

The following meteorological discussions of the eastern Gulf will include air quality, climate, and storm systems. Oceanographic weather and climate data are monitored in the Gulf of Mexico by National Oceanographic and Atmospheric Administration's (NOAA) Data Buoys (Figure 3-1). NOAA operates and maintains a network of fixed-position deep ocean buoys outfitted with instrumentation for collecting weather data. In addition to the buoys, instrument systems are also located on some offshore platforms, beach areas, piers, and lighthouses as part of the Coastal Marine Automated Network Program (CMAN). These primarily fixed inshore stations are known as CMAN stations. The buoy data are generated by the National Data Buoy Center (NDBC) and stored at the NOAA National Oceanographic Data Center. In a 1988 report, Florida A & M University (FAMU) synthesized NOAA data buoy and coastal station data, as well as National Weather Service coastal station data for the Minerals Management Service. Only a few buoys are presently operating in the eastern Gulf.

3.1.1 Air Quality

Air quality in a given location is described by the concentration of various pollutants in the atmosphere, generally expressed in units of parts per million (ppm) or micrograms per cubic meter (μ/m^3), or milligrams per cubic meter (mg/m^3). Air quality is determined by the type and amount of pollutants emitted into the atmosphere, the size and topography of the air basin, and the prevailing meteorological conditions.

Identifying the affected area for an air quality assessment requires knowledge of pollutant types, source emissions rates and release parameters, proximity relationships of project emission sources to other emissions sources, and local and regional meteorological conditions. For inert pollutants (those that do not participate in photochemical reactions; i.e., all pollutants other than ozone and its precursors), the affected area is generally limited to an area extending a few miles downwind from the source.

Pollutant concentrations are compared to federal and state ambient air quality standards to determine potential effects. These standards represent the maximum allowable atmospheric concentration that may occur and still protect public health and welfare, with a reasonable margin of safety. The national ambient air quality standards (NAAQS) are established by the Environmental Protection Agency (USEPA). In order to protect public health and welfare, the USEPA has developed numerical concentration-based standards or NAAQS for six "criteria" pollutants (based on health related criteria) under the provisions of the Clean Air Act (CAA) Amendments of 1970.

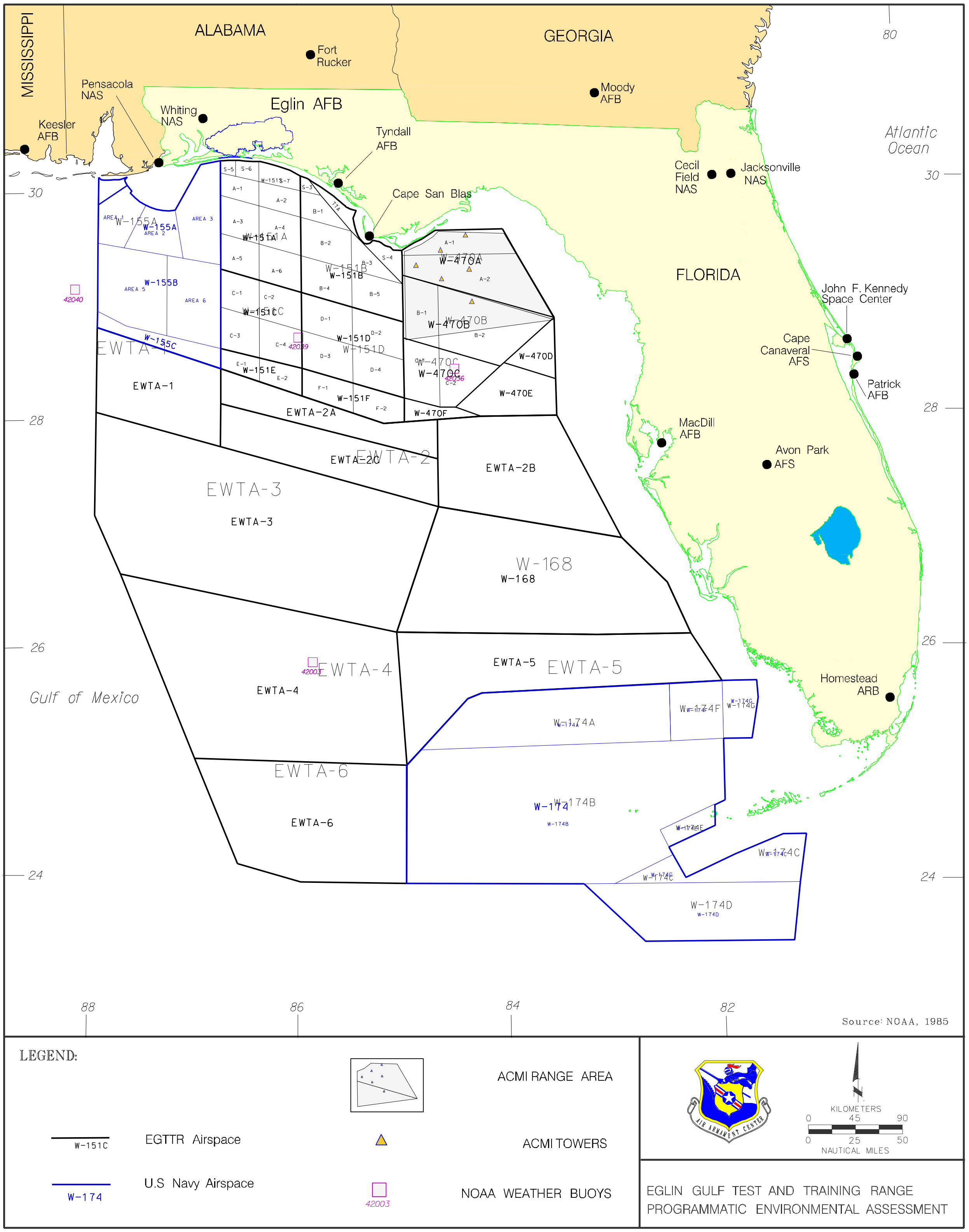


Figure 3-1. Location of NOAA Weather Buoys and ACMI Towers within the EGTTR

There are two kinds of NAAQS, primary and secondary standards. Primary standards prescribe the maximum permissible concentration in the ambient air to protect public health including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards prescribe the maximum concentration or level of air quality required to protect public welfare including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

National ambient air quality standards have been established for: 1) ozone (O_3), 2) nitrogen dioxide (NO_2), 3) carbon monoxide (CO), 4) sulfur oxides (SO_x), 5) lead (Pb), and 6) particulate matter with an aerodynamic diameter less than or equal to 10 microns (PM_{10}) (Table 3-1). The NAAQS are the cornerstone of the CAA. Although not directly enforceable, they are the benchmark for the establishment of emission limitations by the states for the pollutants that the USEPA determines may endanger public health or welfare.

Table 3-1. National and Florida Ambient Air Quality Standards

CRITERIA POLLUTANT	AVERAGING TIME	PRIMARY STANDARD[1,2,3]	SECONDARY STANDARD[1,2,4]	FLORIDA STANDARDS
CO	8-hour	10 mg/m³	No standard	10 mg/m³
	1-hour	40 mg/m³	No standard	40 mg/m³
Pb	Quarterly	1.5 µg/m³	1.5 µg/m³	1.5 µg/m³
NO_2	Annual	100 µg/m³	100 µg/m³	100 µg/m³
O_3	1-hour[5]	235 µg/m³	235 µg/m³	235 µg/m³
	8-hour[6]	157 µg/m³	157 µg/m³	157 µg/m³
PM_{10}	Annual	50 µg/m³	50 µg/m³	50 µg/m³
	24-hour[7]	150 µg/m³	150 µg/m³	150 µg/m³
$PM_{2.5}$	Annual	15 µg/m³	15 µg/m³	15 µg/m³
	24-hour[8]	65 µg/m³	65 µg/m³	65 µg/m³
SO_x	Annual	80 µg/m³	No standard	60 µg/m³
	24-hour	365 µg/m³	No standard	260 µg/m³
	3-hour	No standard	1300 µg/m³	1300 µg/m³

Sources: Clean Air Act, 42 U.S.C. 7401 et seq.: Official Compilation of the Rules and Regulations of the State of Florida; Title 62 - Department of Environmental Protection, Chapter 62-204 - Air Pollution Control, General Provisions; USEPA website http://www.epa.gov/airs/criteria.html

1. National standards (other than ozone, particulate matter, and those based on annual averages or annual arithmetic mean) are not to be exceeded more than once a year.
2. Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based upon a reference temperature of 25°C and a reference pressure of 760 mm of mercury; ppm refers to parts per million by volume.
3. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.
4. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.
5. The ozone 1-hour standard still applies to areas that were designated nonattainment when the ozone 8-hour standard was adopted in July 1997.
6. The ozone 8-hour standard is attained when the fourth highest 8-hour concentration in a year, averaged over three years, is equal to or less than the standard. This standard has not been implemented to date.
7. The PM_{10} 24-hour standard is attained when 99 percent of the daily concentrations, averaged over three years, are equal to or less than the standard.
8. The $PM_{2.5}$ 24-hour standard is attained when 98 percent of the daily concentrations, averaged over three years, are equal to or less than the standard. This standard has not been implemented to date.

Florida has adopted the NAAQS except for sulfur oxides (SO_x). EPA has set the annual and 24-hour standards for SO_x at 0.03 ppm (80 micrograms per cubic meter [$\mu g/m^3$]) and 0.14 ppm (365 $\mu g/m^3$) respectively. Florida has adopted the more stringent annual and 24-hour standards of 0.02 ppm (60 $\mu g/m^3$) and 0.01 ppm (260 $\mu g/m^3$) respectively. In addition, Florida has adopted the national secondary standard of 0.50 ppm (1300 $\mu g/m^3$)

The fundamental method by which the USEPA tracks compliance with the NAAQS is the designation of a particular region as "attainment," "nonattainment," or "unclassifiable." Areas meeting or having better air quality than the NAAQS are said to be in attainment. Areas that exceed the NAAQS are said to be in nonattainment. Areas that cannot be classified on the basis of available information as attainment or nonattainment are defined as unclassifiable and are treated as attainment areas. Attainment areas can be further classified as maintenance areas. Maintenance areas are areas that were previously nonattainment but have reduced pollutant concentrations below the standard and must maintain some of the nonattainment area plans to stay in compliance. Episodes of poor air quality, termed exceedences by the USEPA, are an indication that the federal air quality standard for a regulated pollutant was surpassed.

Literature describing the air quality over the open Gulf was not available. Information regarding the coastal areas of the northern and eastern Gulf indicates that most incidences of poor air quality are associated with large metropolitan areas (SAI et al., 1995). Thus, it is likely that the air quality improves as one moves out over the open Gulf.

Likely sources of emissions in the northern Gulf are petroleum platforms and vessels, commercial fishing vessels, refineries, recreational vessels, naval vessels, and intra-coastal barges. Cities along the northern Gulf such as Mobile, New Orleans, Baton Rouge, and Lake Charles have been associated with a recurring ozone problem for nearly 20 years (SAI et al., 1995). Exceedences occur during all seasons, with the majority (85 percent) occurring April through October.

3.1.2 Climate

While the eastern Gulf climate may be viewed as generally mild with only two seasons, climatic processes are more complex. Global circulation features such as the Atlantic subtropical gyre, the Icelandic flow, the Pacific high, and the Rocky Mountain low (FAMU, 1988) affect the seasonal climate of the eastern Gulf region. These may act directly or indirectly on air above the Gulf to cause seasonal shifts in climate.

A broad subtropical high-pressure band from a westerly extension of the Azores-Bermuda high pressure cell controls atmospheric circulation in the eastern Gulf region and is the primary influence of normal weather conditions of the area (SUSIO, 1973; MMS, 1990). Wind and wave behavior is also related to the seasonal changes in these atmospheric circulation patterns. Circulation of the atmosphere is generally clockwise spring through fall, while counterclockwise or anticyclonic motion predominates in the winter. Winter atmospheric circulation is governed primarily by atmospheric fronts that separate two distinctly different air masses, a cold dry air mass, and a warm, moist air mass. These fronts last several days, extend several thousand kilometers, and may be one of four types: 1) cold fronts, 2) warm fronts, 3) stationary fronts, or

4) occluded fronts. Cold and warm fronts are the most frequent, while stationary fronts are quite temporary, usually lasting less than 24 hours. Occluded fronts are not common in the Gulf.

Cloudiness and local weather are also heavily affected by diurnal heating and cooling patterns over bordering land areas (SUSIO, 1973). The near complete enclosure of the Gulf by land allows for the interaction of land and sea air masses of dissimilar temperatures, resulting in frequent atmospheric disturbances (MMS, 1990). Precipitation is primarily in the form of rain and drizzle; snow occurs rarely in the northern coastal areas. Rainfall is fairly uniform throughout the year along the coastal regions, with June, July, and August having the periods of highest precipitation. The annual average amount of precipitation from New Orleans, Louisiana, to Ft. Myers, Florida, is approximately 137 centimeters (cm) (MMS, 1990). Thunderstorms are a significant component in the region. Summer rains are often deposited during thunderstorms of short intense duration, while winter precipitation is often slow and continuous, frequently associated with the passing of frontal systems (MMS, 1990). Major storms are relatively rare in the eastern Gulf, but can have tremendous detrimental impact to coastal areas. Storm systems will be discussed in further detail.

Eastern Gulf coast average temperatures vary with latitude and exposure. Minor variations in air temperatures occur daily and seasonally over the open Gulf. The average temperature over the center of the Gulf is about 29°C in the summer, while winter temperatures average between 17°C and 23°C. In winter, temperature variations in the eastern Gulf depend on the frequency and strength of insertion of polar air masses from the north. These polar episodes have been documented (cited in FAMU, 1988) to occur at 3 to 10 day intervals between November and March. These encroachments of cold polar air sometimes bring strong northerly winds known as "northers." Severe freezes are known to occur in the northern Gulf coastal areas about once every five years and appear to follow the solar sun-spot cycle (FAMU, 1988).

The relative humidity over the Gulf is high throughout the year. Minimum humidities occur during the late fall and winter when cold, continental air masses bring dry air into the northern Gulf. Warm, humid air from southerly winds increases the humidity to highest levels during the spring and summer (SUSIO, 1973).

The mean sea level (MSL) pressure in the eastern Gulf ranges from 1018 millibars (mb) in September to 1021 mb in January. The lowest average monthly pressure takes place in the summer when the lighter warmer air of the equatorial trough slips northward. The highest pressure occurs during the winter as a result of the closeness and influence of heavier continental cold air (MMS, 1990). Departures from the mean daily pressure value occur infrequently, except during hurricanes and extratropical cyclones (SUSIO, 1973).

3.1.3 Storm Systems

Storm systems such as thunderstorms, tropical cyclones, and extratropical cyclones occur in the Gulf with varying frequency and under different atmospheric conditions. The most intense of these are tropical cyclones, which include tropical storms and hurricanes. Tropical cyclones are less recurrent than their winter counterparts (extratropical cyclones) but are more severe and generally slower moving. Most of the hurricanes and tropical storms influencing the eastern Gulf form in other areas, and there is normally some forewarning (FAMU, 1988). Hurricane season begins June 1 and lasts through November 30 (FAMU, 1988). Hurricanes affecting the eastern Gulf arrive from numerous directions. In general, June hurricanes are most likely to arrive from the south while the August and September storms are more likely to arrive from the southeast (FAMU, 1988).

Data analyzed over the last 100 years indicate that the Gulf experiences an average of 17.7 storm days annually with each having a mean duration of 4.8 days (FAMU, 1988). Researchers concluded that tropical cyclone tracks, motion, and intensity have an important role in the overall climatology of the Gulf (FAMU, 1988). Hurricanes cause direct loss of wildlife and habitat, destroy property, erode shorelines, and result in billions of dollars of economic losses (Mayfield, 1995).

Extratropical cyclones are another type of severe storm that occurs in the Gulf. These form in the middle and high latitudes on the fronts that divide distinct air masses. These storms, which may differ greatly in strength, arise chiefly during the winter months and may achieve wind velocities as great as 55-93 kilometers per hour (kph). The Gulf is an area of cyclone development during the cooler months due to the difference in temperatures of the warm air over Gulf waters and the cold continental air over the United States (MMS, 1990).

3.1.4 Ambient Noise

Ambient noise in the ocean may arise from natural sources: wind action on the sea surface, rain or hail striking the sea surface, seismic activity, various types of marine life, or from human activities such as industrial operations onshore, commercial (and military) ship traffic, seismic profiling for oil exploration, and oil drilling. A widely used ambient noise model, the Ambient Noise Directionality Estimation System (ANDES), was employed to derive estimates of ambient noise for the Gulf (Appendix D). Appendix H provides a basic explanation of sound properties and units of measure used in this discussion and in the Chapter 4 analysis.

Ambient noise sources may be continuous and persistent, or transient and intermittent. In open oceans, the primary persistent noise sources tend to be commercial shipping and wind action on the sea surface (Figure 3-2). Surface ships generate noise via a number of mechanisms, the most important being propeller blade cavitation. This broadband noise reaches a maximum source spectrum level in the band 40-100 Hz of 180 dB (re 1 microPascal) or more.

At any given time, there are approximately 20,000 large commercial vessels at sea worldwide. Since these sources' most significant noise component is below a few hundred Hertz, and since propagation is most favorable at those frequencies (particularly in deep water), surface ships can often be heard at distances greater than 100 kilometers. Thus, at many deep-water locations, it is not unusual for the low-frequency noise field to be influenced by contributions from tens or even hundreds of surface ships.

What is commonly known as wind noise is generated by a number of mechanisms related to wind. The interaction between capillary waves driven by local wind action on the sea surface is one mechanism that has been postulated. However, the clear correlation between the onset of white caps and a rapid increase in noise level suggests that the primary mechanism is related to the breaking of waves. This breaking process causes the formation of vast numbers of bubbles that oscillate at their formation and thereby produce sound.

Although wind noise is present at all frequencies, it tends to dominate above 250 Hz. At the higher frequencies, attenuation works against wind noise propagating to great distances. Thus, unlike shipping noise (Figure 3.2), wind noise tends to be locally generated and not particularly sensitive to environmental factors that affect propagation. The one notable exception to this rule is that shallow-water wind noise tends to be several dB higher than deep-water wind noise for comparable wind speeds. There is sufficient information on transient noise sources to identify areas in which these sources may be prevalent. Upper limits for these sources may be estimated.

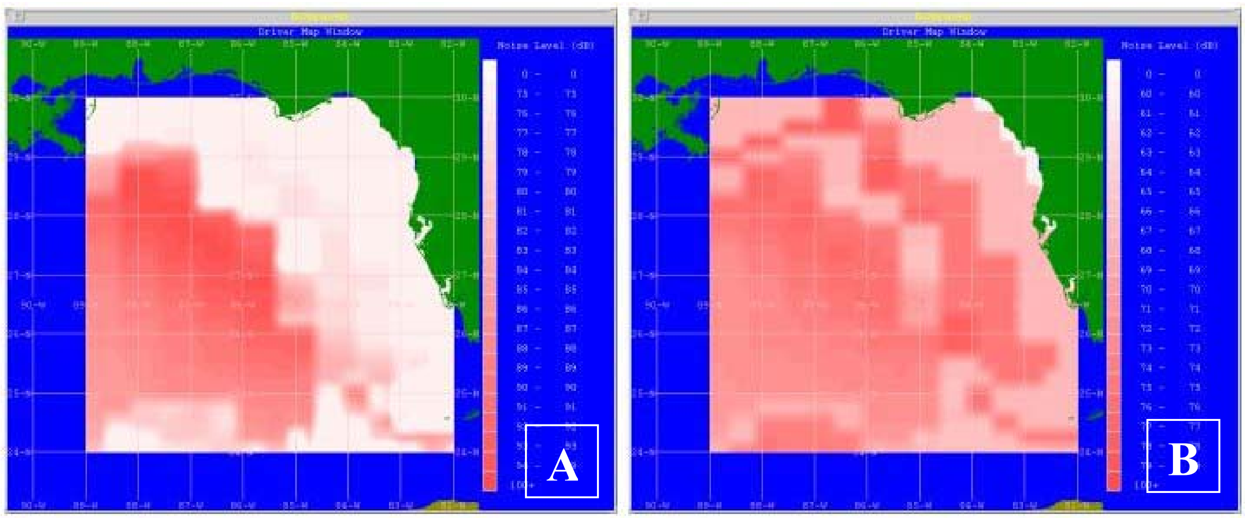


Figure 3-2. Typical Ambient Noise Levels from (A) Shipping (60-Hz) and (B) Wind (240-Hz)

Petroleum Industry

The petroleum industry has been actively prospecting and drilling in the Gulf of Mexico since the 1950s. Both activities are the source of considerable underwater sound. Yet despite this, little quantitative information is available concerning the noise levels generated by these activities. It is known that seismic exploration primarily employs very low frequency sources and that these exercises can easily dominate the low-frequency noise field at some range. Oil rigs, on the other hand, produce noise throughout the frequency domain. Recently, economic and political factors have not been favorable to offshore oil exploration and production. Nonetheless, oil production continues in the Gulf, particularly along the shelf off the coast of Louisiana and eastern Texas. This activity most likely can be detected acoustically in those areas.

Marine Animals

Many species of marine life are known to contribute to the underwater noise field over a very wide frequency envelope. These vocalizations range from low frequency grunts and moans to very high frequency chirps, whines, and clicks. The sound producing marine species tend to belong to one of three major classes: crustaceans (shellfish), marine mammals, and certain species of true fish. Each class includes several species that have been acoustically detected and investigated. The following subsections address the most prevalent among these.

Crustaceans

Among the crustaceans, the most prevalent noise makers are various types of snapping shrimp. Snapping shrimp are generally found in the more temperate latitudes, including the Gulf of Mexico. In these warmer waters, the occurrence of snapping shrimp is typically limited to water depths of less than 60 meters and will be most abundant in regions where the bottom sediments consist of rough boulders, cobbles, or coral rubble, or in regions where the bottom consists of shale or other loose rock structures. Conversely, sand and mud bottoms are not favorable habitats for snapping shrimp. In particular, the shelf off the western coast of Florida has numerous regions of coral that are favorable habitats for snapping shrimp.

Noise generated by snapping shrimp peaks in the frequency band of 3-10 kHz. Examples of measured noise levels indicate that the received noise level can be significant in this frequency band, easily exceeding wind noise by as much as 20 dB. However, due to propagation attenuation at high frequencies, the contribution of a bed of snapping shrimp to the total noise field strongly depends upon their proximity to the receiver.

Other crustaceans, such as other species of shrimp, crabs, sea urchins and barnacles, are also known to contribute to the noise field, particularly in warm waters. Most, if not all, produce noise in the same high-frequency band as the snapping shrimp; some produce sounds similar to that of snapping shrimp. However, there is very little known about the actual levels they produce.

Mammals

Many species of marine mammals are known to be significant sources of various types of underwater sounds. In the Gulf, clicks from sperm whales and various dolphins are measured in the 5-150 kHz range. The sounds generated by these mammals tend to be quite loud (at low frequencies, the source levels are equivalent to those of the biggest commercial ships). When present, these mammals also tend to be acoustically active, repeating their vocalization patterns at a rapid rate.

Fish

Many types of fish have been observed to make noise; among these one of the most common is the croaker or drumfish. Croaker-like noise has been observed in numerous shallow water locations and is often referred to as a chorus because of the number of individual fish that are simultaneously vocalizing. Peak levels (around 1 kHz) that are more than 30 dB above the background level are not unusual.

Noise from another type of fish (species unknown) “chorus” was observed in the evening, often lasting for several hours following sunset. The most significant contribution from this chorus was measured in the band from 400-4000 Hz with a peak usually around 2 kHz. Again, peak levels were often 30 dB above the background levels at the peak frequency. It is not clear whether either of these examples is pertinent to the Gulf of Mexico. At best, it suggests that fish can produce noise at significant levels in the mid to high frequencies, particularly in shallow water.

Rain

Rain produces noise in much the same manner as does wind. Countless water droplets striking the sea surface produce impulsive sound; however, it is the fluctuation of the bubble formed by the droplets rupturing the sea surface and encapsulating a volume of air that apparently is the dominant source of sound. Rain noise differs from wind noise in that its peak contribution to the field occurs at a slightly higher frequency, typically between 1-3 kHz. Even at moderate rain rates, the noise generated at these frequencies can easily exceed contributions from wind. While the rain noise mechanism has been well studied, actual measurements of rain noise differ by 10 dB or more for similar rain rates (Figure 3-3).

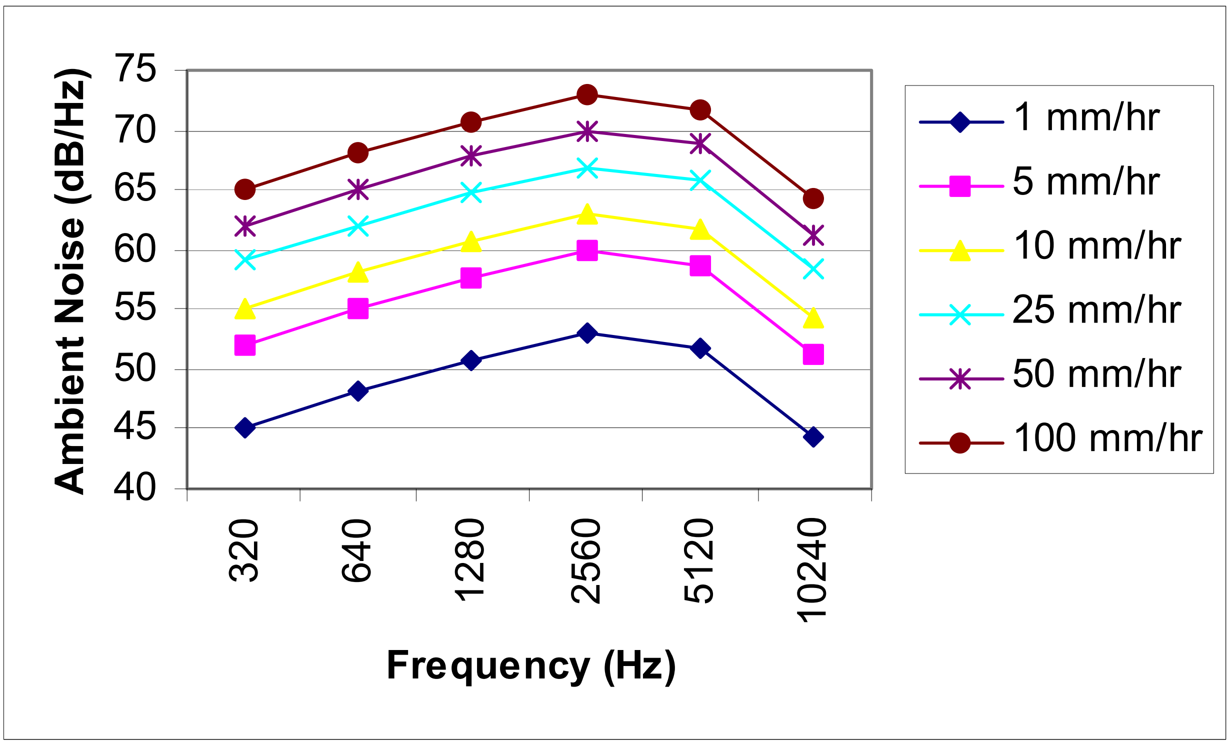


Figure 3-3. Ambient Noise Variation with Rain Rate (ANDES Noise Model, Renner, 1995)

Bounds on Ambient Noise

The lower bound on average noise level is defined at the low frequencies by shipping noise in regions outside the shipping lanes. At high frequencies, the lower bound is defined by wind noise at low wind speeds. From this lower bound, average noise levels increase as either the shipping density or the wind speed increases with the upper bound defined by areas of high shipping and under high wind conditions.

Intermittently, noise levels can significantly exceed the upper bound of average noise levels due to various factors. The passage of a surface ship very close to the receiver can raise low-frequency noise levels by 10 dB or more. The onset of rain raises high-frequency noise levels by 10 dB or more. Finally, marine life of various types can raise noise levels near 20 Hz (due to marine mammals), in the range of a few kiloHertz (due to crustaceans and fish), and in the tens to hundreds of kiloHertz (again due to marine mammals). While the occurrence of biologic noise is limited in time and location, when it is present it can produce noise levels that are as much as 30 dB greater than background levels. The spectra presented in Figure 3-4 illustrate the variability due to all of these potential noise sources (Appendix D).

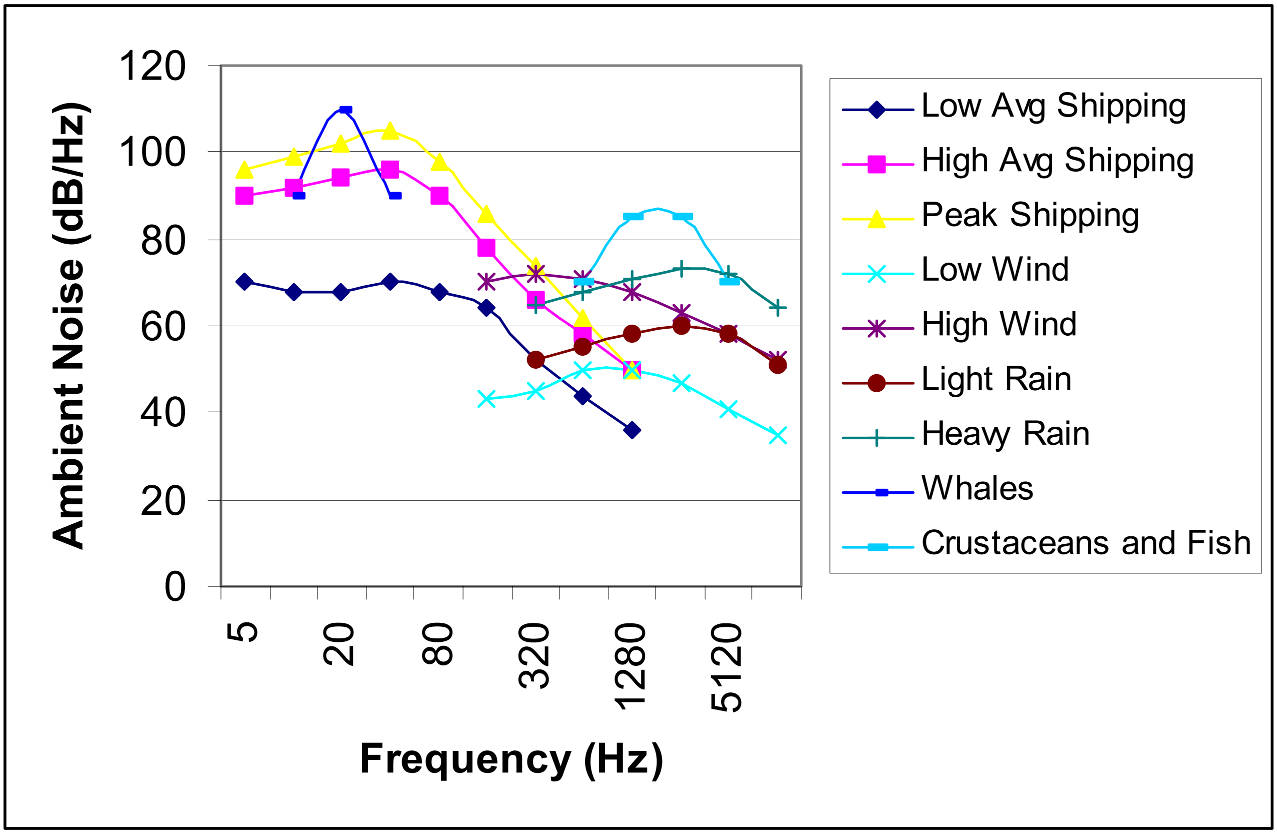


Figure 3-4. Ambient Noise Level Bounds in the Eglin Gulf Test and Training Range (ANDES Noise Model, Renner, 1995).

3.2 MARINE ENVIRONMENT

3.2.1 Physical Resources

The Gulf of Mexico, known to locals as simply the "Gulf," is a restricted oceanic basin, nearly surrounded by the United States, Mexico and Cuba. In the southeastern portion of the Gulf, the Yucatan Straits and the Florida Straits connect the Gulf with the Caribbean and western Atlantic Ocean, respectively (Dames and Moore, 1979) (Figure 3-5). The Gulf is characterized by a shallow and, in places, broad continental shelf, steep slopes leading from the shelf, two large deep water plains, and scattered regions where the bottom is somewhat higher (Weber et al., 1992). The average depth is over three-quarters of a mile and the maximum depths in the deep waters are over two miles. The continental shelf is widest along the eastern margin, called the West Florida Shelf; along the northwestern margin, called the Texas-Louisiana Shelf; and along the southern margin, called the Campeche Shelf (Dames and Moore, 1979).

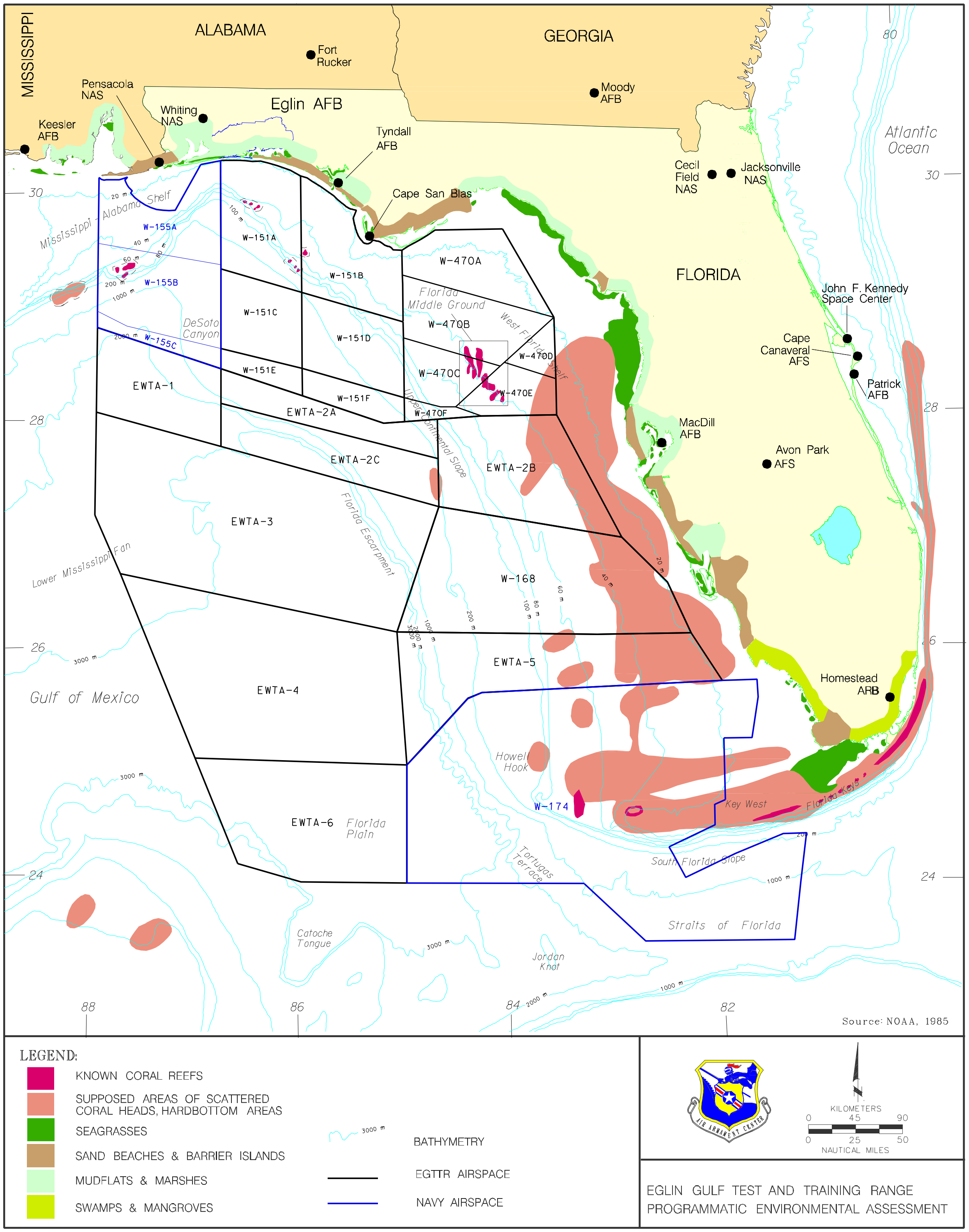


Figure 3-5. Eastern Gulf Resources and Habitats

Waves, Currents and Water Masses

Some basic qualities of waves in the southwest Florida shelf have been noted. For example, from September to February, waves tend to originate from the east and northeast, while from March through August, waves tend to come from the east and southeast. In general, waves from the west and northwest tend to have greater heights, especially during fall and winter (ESE et al., 1987). Measurements taken in the southeastern Gulf showed typical wave heights ranging from 0.7 meters to 2.5 meters, depending on the time of year and weather conditions. In general, offshore waves are larger than those near shore. The highest wave recorded between the years 1976 and 1985 was 10.7 meters (about 35 feet), during Tropical Storm Kate.

Several major currents affect the Gulf. The upper-layer transport system of the western North Atlantic is the primary influence of circulation in the Gulf. The Atlantic northeast trade winds drive the Caribbean Current, which is formed from the joining of the Equatorial Current and the Guiana Current. The Caribbean Current flows through the Yucatan Straits and becomes the Loop Current. After exiting through the Florida Straits, the Loop Current contributes to the formation of the Gulf Stream. This basic circulation pattern, modified by seasonal fluctuations in the northeast tradewinds, applies to the surface layers, with deeper layers following a similar but slightly modified pattern due to the influence of submarine topography (SUSIO, 1973).

There are at least five layers of water masses that make up Gulf waters: 1) Surface Mixed Layer, 2) Subtropical Underwater 3) Oxygen Minimum Layer, 4) Sub-Antarctic Intermediate Water, and 5) Gulf Basin Water (Pequegnat, 1983).

Tides

Compared to the Atlantic and Pacific coasts, Gulf coast tides are small and less developed, with a range usually less than 0.7 meter (ESE et al., 1987; Weber, 1992). Gulf tides may be diurnal (one high and one low daily); semi-diurnal (two highs and two low tides daily); or varying combinations of the two (Weber, 1992). Local fluctuations in tidal heights may result from strong winds, large storms and hurricanes (Weber, 1992). The southwest Florida shelf tidal regime is mixed, composed of diurnal and semi-diurnal components (ESE et al., 1987).

Chemical Resources

Gulf waters contain many dissolved ions, principally, chlorine, sodium, magnesium, calcium, potassium, bromine, boron, strontium, and fluorine and carbonate and sulfate ions (Petrucci, 1982). However, only six of these components make up 99 percent of the dissolved solids in the water: sodium, chlorine, magnesium, sulfur, potassium, and calcium (Millersville University, 1996). Table 3-2 identifies typical concentrations of various chemical constituents of the eastern Gulf waters.

Table 3-2. Chemical Composition of Seawater Typical of the Gulf of Mexico*

Components	Concentration (ppt)
Major	
Chloride	19.00
Sodium ion	10.50
Magnesium ion	1.35
Sulfate	0.89
Calcium	0.40
Potassium ion	0.39
Minor	
Bromide	0.065
Carbonate/Inorganic Carbon	0.028
Strontium	0.008
Borate	0.005
Silica	0.003
Fluoride	0.001
Aluminum ion	0.000005

* Other trace elements: nitrogen, iodine, phosphorus, iron, zinc, manganese, gold, organic carbon compounds
Source: Lerman, 1986

3.2.2 Biological Resources

This section gives a summary of the plankton community, invertebrates, fishes, marine and neotropical birds, marine mammals, threatened, endangered, and special status species, and special biological resources of the marine waters of the eastern Gulf.

Plankton Community

Plankton are free-floating microscopic organisms that include plant and animal species. The three general groups comprising plankton are bacterioplankton, phytoplankton and zooplankton. Plankton is essential to the Gulf food chain, ultimately affecting fish and marine mammals.

Invertebrates

Oceanic invertebrate fauna include benthic fauna associated with the sediments and free swimming pelagic animals. Benthic invertebrates include the infauna, which are animals living in the substrate (such as burrowing worms and mollusks), and the epifauna, which are animals that live on the substrate (such as mollusks, crustaceans, hydroids, sponges, and echinoderms). Benthic invertebrates are usually described in terms of species composition, density and faunal associations. At least 1,497 species of epibiota, (plants and animals living on the substrate) including mollusks (20 percent), crustaceans (19 percent), fishes (15 percent), algae (11 percent), cnidarians (10 percent), echinoderms (8 percent), sponges (6 percent), and others (11 percent) have been collected from live bottom stations on the Florida shelf, just below W-168. Over 90 species of sponges and 53 species of scleractinian coral have been identified (Phillips et al, 1990).

Fishes

The eastern Gulf provides a wide variety of resources for fishes to inhabit and utilize. These resources are dependent upon their physical and chemical environment, including variables such as salinity, temperature, depth, bottom type, primary productivity, oxygen content, turbidity, and currents. Table 3-3 illustrates the more common fishes of the eastern Gulf.

Table 3-3. Common Fishes of the Eastern Gulf of Mexico

Temperate	**Scientific Family Name**	**Common Name**
	Acipenseridae	Sturgeons
	Atherinidae	Silversides
	Clupeidae	Herring, menhaden
	Cyprinodontidae	Mummichogs, killifishes
	Engraulidae	Anchovies
	Exocoetidae	Flying fishes
	Percichthyidae	Striped bass
	Pomatomidae	Bluefish
Subtropical	**Scientific Name**	**Common Name**
	Albulidae	Bonefish
	Carangidae	Jacks
	Ephippidae	Spadefish
	Holocentridae	Squirrelfishes
	Istiophoridae	Marlins
	Labridae	Wrasses
	Lutjanidae	Snappers
	Mullidae	Goatfish
	Scaridae	Parrotfish
	Sciaenidae	Drums
	Scombridae	Mackerel, bonito, tunas
	Serranidae	Groupers
	Sparidae	Porgies
	Xiphiidae	Swordfish
Tropical	**Scientific Name**	**Common Name**
	Centropomidae	Snooks
	Chaetodontidae	Butterflyfish, angelfish
	Coryphaenidae	Dolphinfish
	Elopidae	Tarpon
	Gerreidae	Mojarras
	Lutjanidae	Snappers
	Pomacentridae	Damselfish
	Pomadasyidae	Grunts
	Rachycentridae	Cobia
	Sciaenidae	Drums
	Sphymidae	Hammerhead sharks
	Sphyraenidae	Barracudas

Fishes of the eastern Gulf may be characterized by where they live in the water column. Benthic and reef fishes live at the bottom of waters and around artificial or natural reef systems. Pelagic fishes, which spend most of their lives in the open waters of the Gulf, make seasonal, latitudinal migrations along the west coast of Florida. These migrations are caused by seasonal changes in temperature, movement of their food resources, and spawning instincts. King and Spanish mackerels leave their wintering areas in south Florida and move northward in the spring along the continental shelf. Both species spawn over the continental shelf from northwestern Florida to the northwestern Gulf off Texas. The shallow portion of the shelf at the high nutrient areas near river plumes is likely used for nursery areas (MMS, 1990).

High concentrations of profitable fish are typically found along the eastern Gulf, at the east Mississippi Delta, the Florida Big Bend Seagrass beds, the Florida Middle Ground, the mid-outer shelf, and DeSoto Canyon. These fish are targeted by fishermen, and many of the commercially important fish species in the Gulf are believed to be in decline due to overfishing.

Migratory and Nonmigratory Birds

The eastern Gulf is a migratory route for numerous bird species. Approximately two-thirds of the breeding bird species of the eastern United States migrate to Central and South America, Mexico, and the Caribbean (Keast and Morton, 1980). Some important resting areas for migratory birds include St. Andrew State Recreation Area, Gulf Islands National Seashore, St. Joseph Peninsula State Park, and St. George Island State Park (Duncan, 1994). Some of the migrant species of this region are summarized in Table 3-4 (Fisher, 1979; Fritts and Reynolds, 1981; Duncan, 1991). All migratory birds are protected under the Migratory Bird Treaty Act, originally passed in 1918 (USFWS, 1996).

Table 3-4. Migratory Birds Found in the Eastern Gulf of Mexico

Wading and Shore Birds	Land Birds and Birds of Prey	Waterfowl	Pelagic Birds
Upland sandpiper	Peregrine falcon	Blue-winged teal	Shearwaters
White-rumped sandpiper	Ruby-throated hummingbird		Storm petrels Boobies Tropic birds
Semipalmated sandpiper	Blackpoll warbler Chimney swift		Phalaropes Bridled terns Black terns
Eastern kingbird	Mourning doves		
Cattle egret			

Many nonmigratory (resident) birds are found in or near the eastern Gulf all year. They do not migrate to other geographical areas as the seasons change. The brown pelican, a bird familiar to everyone in the eastern Gulf, has been removed from the federal endangered species list in Florida, but remains a species of special concern (MMS, 1990; Florida Game and Freshwater Fish Commission, 1994). The double-crested cormorant (*Phalacrocorax auritus*), common throughout North America, is a marine bird that usually stays and breeds near the coast (Fritts and Reynolds, 1981; Udvardy, 1985). Laughing gulls (*Larus atricilla*) and royal terns (*Sterna maxima*) have been sighted in both the winter and summer seasons (Fritts and Reynolds, 1981). The frigatebirds (*Fregata magnificens*) may be observed along the coast and seldom go far from land. They can be seen at any time of the year and have been spotted over waters between 25 and 50 meters deep (Fritts and Reynolds, 1981; Duncan, 1991; Udvardy, 1985).

Marine Mammals

The eastern Gulf supports a variety of marine mammal species. All cetaceans (whales and dolphins) are afforded some degree of federal protection under the Marine Mammal Protection Act (MMPA), and several are listed under the Endangered Species Act (ESA). The most extensive data on cetacean population abundance come from the GulfCet II surveys that were conducted between 1996 and 1998 by Texas A&M University, the U.S. Minerals Management Service (MMS), and the National Marine Fisheries Service (NMFS) (Davis et al., 2000). The National Oceanic and Atmospheric Administration (NOAA) conducted a marine mammal survey in 1994 of the eastern Gulf. Species identification can be gathered from this data and from the Southeastern U.S. Marine Mammal Stranding Network (Odell, 1996). The lone sirenian, the West Indian manatee, will be discussed in the Endangered, Threatened and Special Status Species section. The abundance and density of cetacean populations in the northern Gulf has been estimated from NMFS aerial surveys (Table 3-5). Cetaceans (Table 3-6) are further identified according to their status of protection in the Gulf of Mexico.

Table 3-5. Cetacean Statistics from Surveys of the Continental Shelf and Slope (1996-98)

Species	Number of Groups	Mean Group Size	Individuals/ 100 km^2	Abundance Estimate
EPA CONTINENTAL SHELF				
Bottlenose dolphin	58	7.3	14.798	1,824
Atlantic spotted dolphin	8	31.8	8.890	1,096
Bottlenose dolphin/Atlantic spotted dolphin	5	3.8	0.665	820
Dwarf/pygmy sperm whale	1	1	0.081	10
EPA CONTINENTAL SLOPE				
Bryde's whale	2	4.0	0.035	25
Sperm whale	8	1.5	0.052	37
Dwarf/pygmy sperm whale	19	1.8	0.267	188
Cuvier's beaked whale	2	2	0.031	22
Mesoplodon spp.	5	2.2	0.084	59
Pygmy sperm whale	3	15	0.309	218
False killer whale	1	31	0.213	150
Short-finned pilot whale	1	33	0.227	160
Rough-toothed dolphin	1	34	0.234	165
Bottlenose dolphin	83	9.9	5.617	3,959
Risso's dolphin	31	8.8	1.869	1,317
Atlantic spotted dolphin	15	24.8	2.555	1,800
Pantropical spotted dolphin	43	67.4	19.369	13,649
Striped dolphin	7	66.7	3.119	2,198
Spinner dolphin	72	63.1	12.302	8,670
Clymene dolphin	5	97.4	3.253	2,292
Bottlenose dolphin/Atlantic spotted dolphin	5	8.2	0.282	199
Unidentified small whale	1	3.0	0.023	16

Source: Davis et al., 2000

Table 3-6. Marine Mammals Occurring within the Northeastern Gulf

Species	Status*	Areas of Occurrence
Atlantic Bottlenose Dolphin *Tursiops truncates*	MMPA	Bottlenose dolphins are commonly sighted in groups throughout the coastal, shelf, and slope waters of the ROI.
Atlantic Spotted Dolphin *Stenella frontalis*	MMPA	The diet of the Atlantic spotted dolphin consists of squid and fish from the surface and epipelagic zones of the Gulf.
Blainville's Beaked Whale *Mesoplodon densirostris*	MMPA	Blainville's beaked whales are difficult to distinguish from other beaked whales during surveys, but beaked whales in general were sighted in all seasons within the eastern Gulf.
Blue Whale *Balaenoptera musculus*	MMPA	Largest animal on earth. Rare visitor in U.S. Atlantic. Not expected to occur within ROI.
Bryde's whale *Balaenoptera brydei*	MMPA	The most common baleen whale in the Gulf. Most Gulf of Mexico sightings of the Bryde's whale have occurred during the spring and summer months along the edge of DeSoto Canyon.
Clymene Dolphin *Stenella clymene*	MMPA	Distribution in the Atlantic ranges from New Jersey to the Lesser Antilles, including the Gulf of Mexico. Clymene dolphins are primarily sighted outside the ROI.
Cuvier's Beaked Whale *Ziphius cavirostris*	MMPA	Perhaps the most common beaked whale in the Gulf, these animals have been sighted during all seasons within the eastern Gulf.
Dwarf Sperm Whale *Kogia simus*	MMPA	Dwarf sperm whales generally inhabit the deeper offshore water, feeding on squids, crustaceans, and fish.
False Killer Whale *Pseudorca crassidens*	MMPA	False killer whales have been sighted in the northern Gulf in the spring and summer during aerial and ship surveys.
Fin Whale *Balaenoptera physalus*	MMPA	Common in North Atlantic, but not expected to occur within ROI.
Fraser's Dolphin *Lagenodelphis hosei*	MMPA	This species is tropical in distribution and should be expected in pelagic waters of all oceans. It has been sighted in the northern Gulf, but not within the ROI.
Gervais' Beaked Whale *Mesoplodon europaeus*	MMPA	Information on Gulf of Mexico beaked whales in general indicates that they are deep-diving animals with a diet consisting of fish, squid, and deep-water benthic invertebrates. This species has been sighted within the eastern Gulf.
Humpback Whale *Megaptera novangliae*	MMPA	Common in North Atlantic, but not expected to occur within the ROI.
Killer Whale *Orcinus orca*	MMPA	Killer whales are found in all oceans of the world with local distribution ranging from the Atlantic pack ice to the Lesser Antilles, including the north, east and western Gulf.
Melon-Headed Whale *Peponocephala sp.*	MMPA	Distribution is worldwide tropical to warm-temperate waters including the Atlantic Ocean and Gulf of Mexico.
Minke Whale *Balaenoptera acutorostrata*	MMPA	Occurs in Atlantic, but not expected to occur within the ROI.
Northern Right Whale *Eubalaena glacialis*	MMPA	Occurs off Atlantic coast, but not expected to occur within the ROI.
Pantropical Spotted Dolphin *Stenella attenuata*	MMPA	Year-round inhabitants of the Gulf having been sighted during all seasons, primarily in waters greater than 200 meters.
Pygmy Killer Whale *Feresa sp.*	MMPA	Distribution in the Atlantic ranges from North Carolina to the Lesser Antilles, including the Gulf of Mexico. Sighted primarily outside the ROI.
Pygmy Sperm Whale *Kogia breviceps*	MMPA	Distribution in the Atlantic ranges from Nova Scotia to the Greater Antilles, including the northeastern and western Gulf of Mexico. Sightings have occurred in the northern Gulf primarily along the continental shelf edge and in deeper shelf waters during all seasons except winter.

Table 3-6. Marine Mammals Occurring within the Northeastern Gulf Cont'd

Species	Status*	Areas of Occurrence
Risso's Dolphin *Grampus griseus*	MMPA	Sightings in the Gulf occur along continental shelf and slope; this species is abundant within the eastern Gulf.
Rough-Toothed Dolphin *Steno bredanensis*	MMPA	Rough-toothed dolphins are expected to occur throughout the year in the Gulf. In 1998, 60+ rough-toothed dolphins stranded on Cape San Blas.
Sei Whale *Balaenoptera borealis*	MMPA	Occurs off Atlantic coast, but not expected to occur within the ROI.
Short-Finned Pilot Whale *Globicephala sp.*	MMPA	Distribution in the Atlantic ranges from New Jersey to Venezuela, including Gulf of Mexico. Short-finned pilot whales are more commonly observed in other parts of the Gulf.
Sperm Whale *Physeter macrocephalus*	MMPA	The most abundant of the federally listed endangered whales in the Gulf of Mexico. Areas of relatively high abundance west of W-155B and W-151.
Spinner Dolphin *Stenella longirostris*	MMPA	Distribution in the Atlantic ranges from eastern Newfoundland to the Lesser Antilles, including northern and eastern Gulf of Mexico waters. Sightings in the Gulf occur along continental shelf and slope.
Striped Dolphin *Stenella coeruleoalba*	MMPA	Striped dolphins are primarily found off deeper waters of the continental shelf and have been sighted in the northern Gulf during fall, winter, and spring.

MMPA = Protected under the Marine Mammal Protection Act

Cetaceans are potentially subject to harm from a variety of sources, including certain military activities, oil and gas exploration, dredging, commercial shipping, and commercial and recreational fishing. Noise and other disturbances from these activities can cause the animals to abandon areas, change migratory routes, or leave a feeding ground. Detonations related to oil platform removal have been shown to harm cetaceans within the area. Cetaceans are susceptible to auditory damage from explosive shock waves and from other negative effects of noise. Background noise from drilling platforms and ship traffic can affect cetaceans by masking intra-specific communication or interfering with acoustic detection of prey or predator (Tucker and Associates, 1990; Burrage, 1992; Weber et al., 1992).

Marine Mammal Strandings

The stranding of marine mammals occurs for numerous reasons with the vast majority of the causes leading up to individual incidents remaining unknown. Some of the natural causes of strandings include: illness, parasites, infant mortality, predation, and red tide. The identified anthropogenic causes of mortality and stranding include net fishing by-catch, intentional wounding, toxins, and noise. Information on the stranding of marine mammals within the Gulf of Mexico has been collected by both U.S. government agencies and private organizations for over twenty years. The most active organization in this effort is the Marine Mammal Stranding Network (MMSN), which is established, coordinated and authorized by NMFS and comprised primarily of volunteers in several states who aid in research and provide assistance to the rescue and reporting of stranded animals.

A review of stranding data from 1990 to 1999 indicated that 30 percent of strandings occurred near Galveston Bay while 8 percent of the strandings occurred along the Florida Panhandle. A further investigation shows that during this period one stranding per 1.7 miles of coastline occurred within the Florida Panhandle. The Gulf-wide average was one stranding per 2.0 miles. Cause and effect relationships for stranding events are not apparent from the information present in the stranding database. Seasonal fluctuations are observed, with winter and spring having a higher number of strandings than summer and fall. The reasons for this trend could vary from natural, anthropogenic, a function of changes in data gathering efforts, or a combination of these factors. Appendix I presents an analysis of stranding data obtained from the stranding network database for the years 1990 to 1999.

Threatened, Endangered, and Special Status Species

This section will discuss the threatened, endangered, and special status species. The Gulf of Mexico is an ecosystem that provides critical habitat for many threatened, endangered and special status species. There are eighteen federally listed species under the Endangered Species Act (ESA) that are known to live in the open ocean waters of the eastern Gulf. Five species of sea turtles (green, loggerhead, Kemp's ridley, hawksbill, and leatherback), and seven marine mammal species (right, sei, fin, humpback, sperm, and blue whales and the West Indian manatee) are included in that number. The Gulf of Mexico sturgeon is discussed though it is not known how far out in the Gulf they travel.

An endangered species is one that is in danger of extinction in a significant portion of its range or throughout all of its range. A threatened species is a species that is likely to become endangered in the future resulting from human impacts and degradation of habitat. Endangered or threatened species are published in the Federal Register by the United States Fish and Wildlife Service (USFWS) for potential listing as Endangered or Threatened. A species may either be a candidate, proposed, or listed. Species protected under the Florida Endangered Species Act of 1990 also receive consideration at Air Force bases when activities are being proposed and planned (U.S. Air Force, 1996a). The state of Florida lists the pillar coral (*Dendrogyra cylindrus*) as endangered (it does not occur within the ROI) and the brown pelican (*Pelecanus occidentalis*) as a species of special concern.

The ESA of 1973, as amended (16 U.S.C. §§ 1531-1544), provides a means whereby the habitats of endangered and threatened species may be conserved. The Act also sets a regulatory framework for the conservation of those species. Implementing regulations are found in Volume 50 of the Code of Federal Regulations (CFR). Under the ESA, it is prohibited to take any listed species. This includes harassment, harm, pursuit, hunting, shooting, wounding, killing, trapping, capture, collection, or any attempts at these activities. All cetaceans are protected by the Marine Mammal Protection Act (MMPA, 1972, amended 1988) administered by the NOAA/NMFS and USFWS. Offshore species are under the jurisdiction of the NMFS and coastal species are monitored by the USFWS (Patrick, 1996). A summary of federal and state listed species is presented in Table 3-7.

Table 3-7. Summary of Federal Listed and Candidate Species Known to Occur within the ROI

Species	Status*	Areas of occurrence
FISH		
Gulf sturgeon *Acipenser oyrinchus desotoi*	FT, SSC	Lives predominately in the northeastern Gulf of Mexico; may venture out to 20 miles. Moves inland to spawn. Within the ROI, spawning takes place in the Choctawhatchee River to the east of Eglin AFB and the Apalachicola River to the east of Tyndall AFB during April through June.
Dusky shark *Carcharinus obscurus*	C	One of the larger shark species of continental shelf waters; occurs in Atlantic and Pacific. Feeds on fish including other sharks, rays, squid, octopus and starfish.
Sand tiger shark *Odontaspis taurus*	C	In North America, the sand tiger ranges from the Gulf of Maine to Florida and the Gulf of Mexico. It is a popular aquarium shark, surviving up to 10 years in captivity.
Night shark *Carcharinus signatus*	C	Occurs in deep waters from Delaware to Brazil including the Gulf of Mexico. It feeds on fishes and shrimp and has no economic significance.
Speckled hind *Epinephelus drummondhayi*	C	Occurs from North Carolina and Bermuda to Florida. Reddish brown in coloration with light speckles.
Jewfish *Epinephelus itajara*	C	Occurs from Florida and northern Gulf through Caribbean to southeastern Brazil, west Africa, and parts of eastern Pacific. May grow to 700 pounds. Possession by anglers is illegal.
Warsaw grouper *Epinephelus nigritus*	C	Common from Massachusetts to Texas, with smaller individuals occurring around jetties and offshore platforms and adults preferring deeper, cooler waters.
Nassau grouper *Epinephelus striatus*	C	Occurs from Bermuda to North Carolina; rare and uncertain occurrence in Gulf.
Alabama shad *Alosa alabamae*	C	Occurrence is unknown east of Choctawhatchee Bay in the Florida panhandle.
REPTILES		
Atlantic green sea turtle *Chelonia mydas*	FE, SE	Inhabits open water and hard bottoms of marine environment. Nests within the ROI from May to August.
Hawksbill sea turtle *Eretmochelys imbricata*	FE, SE	Inhabits open water. Does not nest within ROI.
Kemp's Ridley sea turtle *Lepidochelys kempi*	FE, SE	Smallest and most endangered of the sea turtles. Inhabits open water. Does not nest within ROI, but does occur in ROI waters.
Leatherback sea turtle *Dermochelys coriacea*	FE, SE	Inhabits open water and hard bottoms of marine environment. Does not nest within ROI, but does occur within ROI waters.
Atlantic loggerhead sea turtle *Dermochelys coriacea*	FT, ST	Inhabits open water and hard bottoms of marine environment. Hatchlings often associated with *Sargassum* rafts. Nests within the ROI from April to October.
MAMMALS		
Manatee *Trichechus manatus*	FE, SE	Herbivorous aquatic mammals. Diet consists mainly of water hyacinth, hydrilla, turtle grass, manatee grass, and shoal grass. Usually occurs south of Suwannee River, but has been sighted in northwest Florida.
Sperm whale *Physeter macrocephalus*	FE, SE	The most abundant of the federally listed endangered whales in the Gulf of Mexico. Areas of relatively high abundance west of W-155B and W-151.
Blue whale *Balaenoptera musculus*	FE	Largest animal on earth. Rare visitor in U.S. Atlantic. Not expected to occur within the ROI.
Fin whale *Balaenoptera physalus*	FE, SE	Common in North Atlantic, but not expected to occur within the ROI.
Humpback whale *Megaptera novaeangliae*	FE, SE	Common in North Atlantic, but not expected to occur within the ROI.
Northern Right whale *Eubalaena glacialis*	FE	Most endangered of the large whales. Population probably declining. Occurs off Atlantic coast, but not expected to occur within the ROI.
Sei whale *Balaenoptera borealis*	FE, SE	Occurs off Atlantic coast, but not expected to occur within the ROI.

* FE = Federal endangered, FT = Federal threatened, C = Federal candidate, SE = State endangered, ST = State threatened SSC = State species of special concern,

Gulf Sturgeon

The USFWS and NMFS designated the Gulf sturgeon (*Acipenser oxyrhynchus desotoi)* as threatened under the ESA; listing became official on September 30, 1991. A special rule is in place to allow the taking of Gulf sturgeon for educational and scientific purposes, propagation or survival of the fish, zoological exhibition, and other conservation purposes consistent with the ESA (USFWS and Gulf States Marine Fisheries Commission, 1995).

The Gulf sturgeon migrates from salt water into large coastal rivers to spawn and spend the warm months (The Wordsworth Dictionary of Science and Technology, 1995). It lives predominately in the northeastern Gulf of Mexico, where it ranges from the Mississippi Delta east to the Suwannee River in Florida. The species is almost depleted throughout most of its range (U.S. Coast Guard, 1996). Spawning takes place in freshwater, such as the Choctawhatchee River to the west of Tyndall AFB and the Apalachicola River to the east of Tyndall AFB, during April through June (Paruka, 1996). No freshwater spawning areas exist for sturgeon around the Tyndall AFB area (Paruka, 1996). Little is known about the offshore distance the Gulf sturgeon travels, but analyses of stomach contents suggest that feeding occurs as far as 20 miles offshore (Page and Burr, 1991; U.S. Coast Guard, 1996). The biggest threats to Gulf sturgeon populations are oil exploration activities, shrimp trawls, dams, and waste disposal (Wooley and Crateau, 1985; MMS, 1990; Paruka, 1996).

Sea Turtles

Five species of sea turtles inhabit the waters in or near the eastern Gulf. Of the five species protected by state and federal governments, all but the loggerhead are classified as endangered. The loggerhead is classified as threatened by both the Florida and the federal governments (Patrick, 1996). The smallest species is the Kemp's ridley (75 to 100 pounds) and the largest is the leatherback (up to 2,000 pounds and eight feet long). Sea turtles spend their lives at sea and only come ashore to nest. It is theorized that young turtles, between the time they enter the sea as hatchlings and their appearance as subadults, spend their time drifting in ocean currents among seaweed and marine debris (Carr, 1986a, 1986b, 1987). The population numbers of sea turtles has been gravely reduced during the twentieth century due to illegal domestic harvesting of eggs and turtles in the United States and its territories as well as other important nesting areas around the world. Sea turtles are identified in Table 3-8 according to their status of federal protection in the Gulf of Mexico. Density and abundance estimates were derived from NMFS aerial surveys (Davis et al., 2000).

Table 3-8. Sea Turtle Statistics from Surveys of the Continental Shelf and Slope (1996-98)

Shelf	Number Sighted	Individuals/100 km^2	Abundance Estimate
Loggerhead			
Overall	84	4.077	503
Summer	39	3.891	480
Winter	45	4.253	524
Kemp's ridley	2	0.097	12
Leatherback	4	0.194	24
Unidentified	7	0.340	42
Slope	**n**	**D**	**N**
Loggerhead			
Overall	21	0.2	141
Summer	2	0.034	24
Winter	19	0.406	286
Leatherback			
Overall	25	0.238	168
Summer	19	0.327	230
Winter	6	0.128	90
Unidentified	5	0.048	34

Source: Davis et al., 2000

Manatees

The West Indian manatee (*Trichechus manatus*) is federally listed as endangered by the USFWS and also by the Florida Fish and Wildlife Conservation Commission (FWC) (Florida Game and Freshwater Fish Commission, 1994). In 1893, Florida passed a law to protect manatees, which were historically hunted for oil, meat, and leather (USFWS, 1990). In July 1978, the Florida Manatees Sanctuary Act established the entire state as a "refuge and sanctuary for the manatees" (USFWS, 1991). Manatees are herbivorous aquatic mammals; their diet consists mainly of water hyacinth, hydrilla, turtle grass (*Thalassia testidinum*), manatee grass (*Syringodium filiforme*), and shoal grass (*Haladule wrightii*) (USFWS, 1991; U.S. Coast Guard, 1996). They live in coastal regions including bays, rivers, salt marshes, seagrass meadows, and mangroves (USFWS, 1990). Although they usually occur in tropical waters, they have been sighted in northwest Florida. West Indian manatees rarely venture into deeper waters, but have been spotted as far offshore as the Dry Tortugas Islands (U. S. Coast Guard, 1996). For most of the year, they are found throughout south and central Florida, often in conjunction with sea grasses and vascular freshwater aquatic vegetation (MMS, 1990). The distributional range of the majority of West Indian manatees extends from the Suwannee River south to the Chassahowitzka River during summer and winter migrations (Rathburn et al., 1990). Incidental sightings outside of their normal range (north of the Suwannee River) and as far south as Sanibel Island have been documented (Rathburn et al., 1990). Seasonal movements result from the West Indian manatee's intolerance to cold. During cold fronts, they usually move into areas where there are warm-water refuges such as artesian springs and power-plant discharges. During the summer, their habitats are less defined as they have more freedom to move around in warmer waters and search for food (U.S. Coast Guard, 1996).

Birds

The brown pelican (*Pelecanus occidentalis carolinensis*) occurs within the coastal regions of the Gulf of Mexico and is listed as a species of special concern by the State of Florida (USFWS, 1996). It was formerly listed as endangered in October 1970 (USFWS, 1992). The brown pelican was faced with extinction because of the widespread use of DDT and its effects on the thinning of eggshells. The population has increased since the banning of DDT in 1972 (Udvardy, 1985) and removed from the Endangered Species List in 1985. Although they are coastal birds, they will sometimes travel 20 miles offshore to find feeding opportunities (Collazo and Klaas, 1986; Fritts et al., 1983).

Special Biological Resource Areas

Special Biological Resource Areas are offshore habitats that contain both unique flora and fauna. These may be areas that are important as feeding grounds, critical habitats, or principal places of productivity in the Gulf of Mexico. They are all unique ecosystems and support a large variety of species, many still unidentified. They can be found on the continental shelf, slope, and deep sea floor within the eastern Gulf. The eastern Gulf also contains many hard-bottom areas, which typically consist of a hard substrate of living and non-living carbonate reef structures. Although scattered regions of hard bottoms exist throughout the continental shelf and shallower slope areas of the eastern Gulf, the only hard-bottom area to be discussed will be the Florida Middle Grounds. Seagrass beds are another important habitat for numerous species that occur within the Gulf; however, they are not present in the waters of the eastern Gulf and will not be addressed in this section.

The Florida Middle Grounds

The Florida Middle Grounds, the principal hard-bottom in the eastern Gulf, is located approximately 100 miles west-northwest of Tampa (28^{o}15'-45' N: 84^{o} 00'-25' W) as shown in Figure 3-5. It rises from a depth of about 100 feet and its shallowest portion is approximately 75 feet deep. The most productive areas encompass 29,963 acres. It lies between three bodies of water: the Gulf Loop Current, west Florida estuarine waters, and the Florida Bay waters (Chew, 1955; Austin, 1970; Smith et al., 1975; USEPA, 1994). It is the most biologically developed live bottom in the eastern Gulf and is the northernmost extent of coral reefs in the Gulf (Bright and Jaap, 1976; Rezak and Bright, 1981). These live bottoms are able to support such a variety of species because of the intrusion of the Loop Current and its high organic productivity. The Florida Middle Grounds are similar to a typical Caribbean reef community; however, species may differ between the two communities. It is a habitat for as many as 197 species of fish. Invertebrates including hard and soft corals, sponges, algae, and anemones inhabit the area as well (Hopkins et al., 1977; Rezak and Bright, 1981). The Florida Middle Ground reefs are comprised of the hydrocoral *Millepora*, the scleractinians *Porites* and *Oculina*, the alcyonarian *Muricea*, and the scleractinian *Dichocoenia* (Hopkins, 1974). Other cnidarians that are present include the alcyonarians *Eunicea, Pseudopterogorgia, Plexaura* and *Plexaurella*, the scleractinians *Stephanocoenia, Scolymia, Agaricia, Helioseris, Madracis, Manicina, Mycetophyllia,* and *Solenastrea*, the actinarians *Condylactis* and *Stoichactis*, and the zoanthidean *Palythoa* (Smith et al., 1975). The Gulf of Mexico Fishery Management Council has designated the area as a Habitat of Particular Concern (HAPC) (50 CFR 638). Fishing the coral is prohibited except as authorized by permit issued under 50 CFR 638.4. Within this area, the use of bottom longlines, traps, pots, and bottom trawls is prohibited unless authorized by a permit from the NMFS (USEPA, 1994). It has been documented by Rezak and Bright (1981) that the Florida Middle Grounds are sensitive to environmental change as are most coral reef systems (Odum, 1971).

Sargassum Community

Sargassum, or Gulfweed, a dominant genus in shallow waters, is a free-floating brown algae that is present in the tropics and subtropics including the Gulf. The *Sargassum* mats drift in oceanic eddies, which have not broken off from over-mature plants. These mats provide an important niche for numerous species and support a community of animals found nowhere else. Fishes occupying the upper water column (0 to 200 meters) use *Sargassum* clumps for food while others lay their eggs in *Sargassum* (Adams, 1960; Bortone et al., 1977; Dooley, 1972; Smith, 1973). Between 1971 and 1976, fifteen families and forty species of fish were collected at sixty-two *Sargassum* locations within the eastern Gulf (Bortone et al., 1977). Sea turtle hatchlings also use *Sargassum* as a vehicle for passive migration and shelter (Collard and Ogren, 1990). The abundance of invertebrate fauna that inhabit the mats is an important food source for sea turtles (Carr and Meylan, 1980; Carr, 1987). The biomass of *Sargassum* has been decreasing in the Gulf and some believe it is due to human pollutant sources, such as oil spills and contaminant transport (Stoner, 1983). It has been shown that *Sargassum* can accumulate hydrocarbons and some toxic metals (Burns and Teal, 1973; Johnson and Braman, 1975). A decrease in this resource could have a devastating effect on the multitude of species that depend on it for survival.

Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act requires federal agencies to assess potential impacts to Essential Fish Habitat for commercial fisheries managed by the NOAA Fisheries. Essential Fish Habitat is described as those waters and substrate necessary for fish spawning, feeding, or growth to maturity. Some potential threats to essential fish habitat are certain fishing practices, marina construction, navigation projects, dredging, alteration of freshwater input into estuaries, and runoff. Many commercial species are migratory, moving from estuaries to open Gulf waters, or up and down the coast with the seasons. Numerous species pass through or occur in the region and thus the essential habitat of one commercial fish species or another at any given time of the year may fall within the EGTTR (Gulf of Mexico Fishery Management Council, 1998).

Essential fish habitat has been identified by the NMFS for several species within the EGTTR; these species and their habitat by life stage are presented in Table 3-9 below.

Table 3-9. Managed Species for Which Essential Fish Habitat has been Identified in the EGTTR

Species	Life Stages	Habitat
Black Grouper	Adult, juveniles/subadults, larvae, eggs (spawning area)	Hard bottom; shore to 150 m
Brown Shrimp	Adult	Soft bottom; estuarine dependent
Cobia	Adult, juveniles/subadults, larvae, eggs (spawning area)	Pelagic; drifting or stationary floating objects
Corals	All life stages	Hard bottom
Sargassum	All life stages	Pelagic
Dolphin (Mahi)	Adult, juveniles/subadults, larvae, eggs (spawning area)	Pelagic; floating objects
Gag Grouper	Adult	Hard bottom
Greater Amberjack	Adult, juveniles/subadults, larvae, eggs (spawning area)	Pelagic and epibenthic; reefs and wrecks; to 400 m
Gray Snapper	Adult	All bottom types; 0 to 130 m
Gray Triggerfish	Adult	Hard bottom
King Mackerel	Adult	Pelagic
Lesser Amberjack	Adult, juveniles/subadults, larvae, eggs (spawning area)	Pelagic
Lane Snapper	Adult, juveniles/subadults, larvae, eggs (spawning area)	Soft and hard bottom; 0 to 130 m
Little Tunny	Adult, juveniles/subadults, larvae, eggs (spawning area)	Pelagic
Pink Shrimp	Adult (spawning area)	Soft and hard bottom; inshore to 65 m
Red Drum	Adult (spawning area)	Soft bottom, oyster reefs, estuarine to 40 m
Red Grouper	Adult, juveniles/subadults, larvae, eggs (spawning area)	Hard bottom; 3 to 200 m
Red Snapper	Adult, juveniles/subadults, larvae, eggs (spawning area)	Hard bottom, pelagic
Scamp	Adult	Hard bottom
Stone Crab	Adult (spawning area)	Soft, hard or vegetated bottom
Spiny Lobster	Adult	Hard bottom
Spanish Mackerel	Adult, juveniles/subadults, larvae, eggs (spawning area)	Pelagic; inshore to 200 m
Tilefish	Adult (spawning)	Soft bottom, steep slopes; 80 to 540 m
Vermillion Snapper	Adult, juveniles/subadults, larvae, eggs (spawning area)	Hard bottom; 20 to 200 m
White Shrimp	Adult, juveniles/subadults, larvae, eggs (spawning area)	Soft bottom; inshore to 40 m
Yellowtail Snapper	Adult, juveniles/subadults, larvae, eggs (spawning area)	Hard bottom; 0 to 180 m

Source: Gulf of Mexico Fishery Management Council, 1998; NOAA Data Atlas, 1985

3.3 ANTHROPOGENIC ENVIRONMENT

The anthropogenic environment contains all presently occurring human activities that potentially affect the environmental quality of the Gulf of Mexico and, in particular, the region of influence. Some of the anthropogenic or man-made sources of disturbances to the environment other than EGTTR operations include commercial activity such as energy exploration and development (Section 3.3.1), commercial shipping and air traffic, the placement of artificial reefs, and recreation and tourism.

3.3.1 Commercial Activity

Energy Exploration and Development

Offshore oil and gas development in the Gulf of Mexico is accompanied by a large number of environmental concerns including air and water pollution, waste debris, habitat alteration, and noise. The discharge of drilling muds and produced waters and oil spills from offshore petroleum activities affects water quality and threatens wildlife. A typical exploratory well dumps between 5,000 and 30,000 barrels of fluids and 3,000 to 6,000 barrels of wet solids directly into the ocean. About 2,000 tons of dry solids (formation solids and fluid additives) are discharged over the life of a typical exploratory well. The total loading of particulate materials from all U.S. Gulf Outer Continental Shelf (OCS) operations in 1980 was estimated to be 1.6 x 10^6 tons, which was only 0.8 percent of the yearly average input of sediment from the Mississippi River, 2.1 x 10^8 tons/year (MMS, 1990). Air emissions from routine petroleum exploration, production, and transportation activities affect air quality. In 1985, the OCS platforms in the Gulf of Mexico emitted a total of 115,592 tons/year of NO_x and about 43,872 tons/year of total hydrocarbon content (THC) (USEPA, 1993). Platforms emit the highest amount of chemicals, followed by exploration vessels and pipeline vessels. A 1993 inventory showed that 173,000 tons/year of NO_x, 3,260 tons/year of volatile organic chemicals (VOC), and 36,700 tons/year of carbon monoxide (CO) were emitted from OCS operations (MMS, 1995). Emissions of chemical pollutants from OCS production activities are much higher than emissions from maritime industrial activities and recreational boating.

Marine debris from offshore operations threatens wildlife and washes up on beaches. Solid wastes produced by petroleum industry exploration and production operations are restricted from disposal into the ocean by regulations imposed by the Minerals Management Service, the U.S. Environmental Protection Agency and the Coast Guard's implementation of MARPOL 73/78 Annex V. Due to accidental or intentional dumping of industrial solid wastes, debris from offshore petroleum operations is a chronic problem on major recreational beaches in the western and central Gulf (MMS, 1996; Gulf of Mexico Program, 1994). Debris wash-up from petroleum operations on the west Florida coast is not a significant problem due to the lack of oil and gas platforms located in the eastern Gulf. Most of the solid waste generated by OCS operations is associated with galley operations and operational supplies such as shipping pallets, containers used for drilling muds and chemical additives (sacks, drums and buckets), and protective coverings used on mud sacks and drilling pipes (shrink wrap and pipe-thread protectors). Other solid wastes include production sands, salvaged and discarded tubular pipes, pipe scale, and tank-bottom sludge (MMS, 1990). Many drums that are washed up on Texas and Louisiana beaches contain hazardous materials, posing potential health hazards to beach users, marine resources, and wildlife. Marine debris, such as plastic rope, straps and netting can cause entanglement of birds, fish, sea turtles, and wildlife. Suffocation or starvation can occur through the ingestion of plastic bags, sheeting, six-pack rings, and Styrofoam particles. Debris wash-up from offshore petroleum operations affects beach use, aesthetics, and beach maintenance requirements.

Structural emplacement of drilling rigs (jack-ups, semi-submersibles, and drill ships), production platforms and pipelines disturbs some areas of the bottom directly beneath the structure. Jack-up rigs and semi-submersibles used in water depths less than 400 meters disturb about 1.5 hectares (3.7 acres) of bottom area. Conventional, fixed platforms that are installed in water depths less than 400 meters disturb 2 hectares. Dynamically positioned drill ships in water depths greater than 400 meters do not disturb bottom area. Tension leg platforms used in deep-water sites disturb approximately 5 hectares. Pipeline emplacement disturbs 0.32 hectare per kilometer of pipeline. It is assumed that 5,000 square meters of sediment is resuspended for each kilometer of pipeline trenched (MMS, 1996). The presence of pipelaying barges and service vessels associated with drilling rigs further disturbs the sediment by utilizing anchors. Some drill ships use dynamic positioning systems to remain in place and do not anchor. Service-vessel anchoring does not occur in water depths greater than 150 meters where vessels can tie up to a platform or buoy. The greatest disturbance from anchoring is from pipelaying barges, which use an array of eight 9,000 kilogram anchors to position the barge and move it forward along the pipeline route (MMS, 1996). Platform locations are shown in Figure 3-6.

Noise emissions from OCS oil and gas development arise from seismic geophysical surveying, construction and operation of offshore structures, helicopter and service-vessel traffic, and explosive removal of structures. These noise emissions may be transmitted through both air and water, and are intermittent with highly variable intensity levels and frequencies. Possible effects of underwater noise from industrial activities include auditory discomfort, hearing loss, interference in animal communication signals, and behavioral responses such as avoidance of an area. In water depths less than 400 meters, conventional multi-leg platforms anchored into the seafloor by steel pilings are dismantled by explosive severing of conductors and pilings. The technology most commonly used in the dismantling of platforms includes bulk explosives, shaped explosive charges, mechanical and abrasive cutters, and underwater arc cutters. The MMS requires severing at five meters below the seafloor to ensure that structural remains will not interfere with commercial fishing operations. This placement of explosives results in a decrease in the impulse and pressure forces released into the water column upon detonation. The explosive charges are usually 50 pounds or less, but may be as much as 200 pounds. Approximately 80 percent of the removals of conventional platforms occur through the use of explosives. Possible injury to biota from explosive use extends to 900 meters from the point of detonation and upward to the surface. The explosive removal of these structures may cause potential impacts to marine wildlife through exposure to chemical by-products, potential lethal and injurious incidental take, as well as harassment. Injury or death may occur as a direct result of the explosive blast (concussion) and resultant cavitation (NMFS, 1995). The incidental taking of small numbers of marine mammals has been authorized by the Marine Mammal Protection Act (MMPA) if regulations are issued that include requirements for monitoring and reporting. Consequently, the National Marine Fisheries Service has developed regulations governing the taking of bottlenose and spotted dolphins incidental to the removal of oil and gas drilling and production structures (NOAA, 1995).

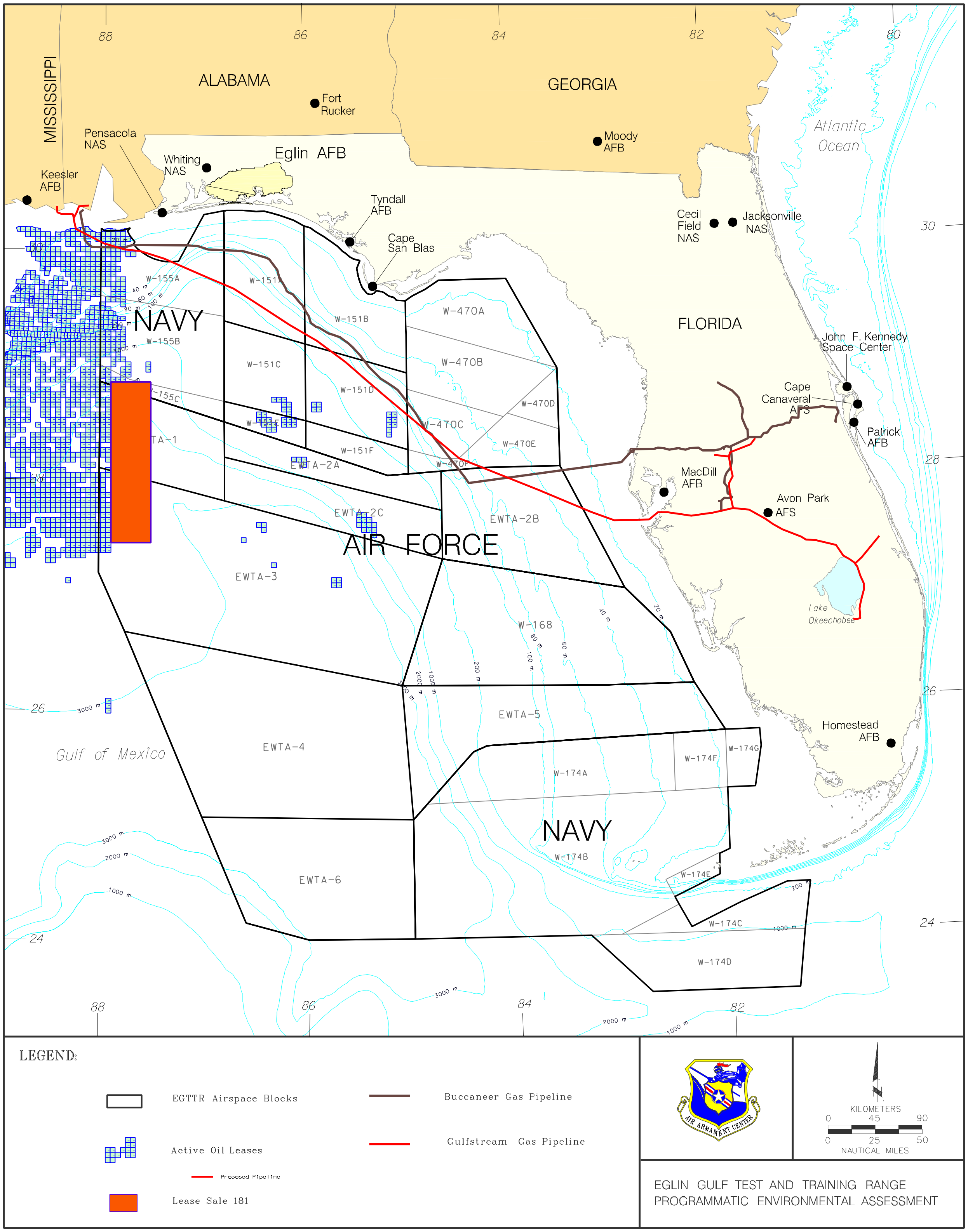


Figure 3-6. Petroleum Industry Activities in the Eastern Gulf

Aside from the environmental concerns, the expansion of the oil and gas industry into the eastern Gulf of Mexico increases the potential for conflicts with military testing and training missions. The addition of petroleum industry structures and personnel increases human safety constraints and would potentially impact or limit the ability of the military to use the Gulf of Mexico over-water airspace.

The closest area of future petroleum exploration is Eastern Lease Sale 181, approximately 100 miles south of Pensacola, Florida (Figure 3-6). The sale was held on December 5, 2001, and the bid evaluation process was completed on January 29, 2002. Lease Sale 181 is a deepwater area west of the EGTTR boundary, consisting of 95 lease blocks covering over a half million acres. Lease 181 is on the continental slope in water depths greater than 1600 meters.

Other Activities and Resources

Minerals Program

Minerals found on the coast and seabed include cobalt, manganese, sand and gravel, heavy minerals (e.g., titanium and chromium), and phosphorites. The Minerals Management Service (MMS) has identified sand, gravel, and shell resources as an area of potential commercial interest for beach nourishment and restoration materials (MMS, 1990). Shell is widely used throughout the southern United States as construction material in building roads and foundations (U.S. DOI, 1995).

Sulphur Mining

The sulphur industry has been established along the Louisiana and Texas Gulf coast since the 1920s. Sulphur is produced in salt domes, which are masses of salt that have forced up through overlying sediment (MMS, 1990). At present, sulphur is found in federal waters off Louisiana from two offshore mines, the Caminada mine and the Main Pass mine (MMS, 1996).

Municipal Waste Disposal

The Marine Protection, Research and Sanctuaries Act of 1972 (commonly known as the Ocean Dumping Act), as amended by the Ocean Dumping Ban Act of 1988, gives the Environmental Protection Agency the power to prohibit the transport of industrial waste for ocean dumping. Municipal trash or garbage is considered industrial waste under the Act (Amson, 1996). While the EPA does not permit the ocean dumping of trash, industrial waste and sewage sludge, certain materials such as fish waste and dredged material can be disposed of in the ocean under the permitting process (Gulf of Mexico Program, 1993). Dumping of materials in federal waters was not regulated or recorded before 1972, so it is difficult to ascertain the amount of municipal waste dumped during that period of time (Amson, 1996). The Rivers and Harbors Act required permits issued by the Army Corps of Engineers for dumping municipal trash in state waters before the initiation of the Ocean Dumping Act.

Utilities

Underwater utility lines, present in the west and central Gulf, are not yet present in the EGTTR. The closest utility infrastructure is one AT&T cable system that crosses the Straits of Florida. This cable begins at a terminal in West Palm Beach, Florida, and ends in Cancun, Mexico. The installation of the cable circumvents the Gulf of Mexico by placing the cable on the Atlantic side of Florida and turning west around the Florida peninsula where the cable crosses the Straits of Florida and the Yucatan Channel. A gas pipeline extending from Pascagoula, Mississippi to Palm Beach County, Florida is scheduled for completion in late 2002.

Commercial Shipping and Air Traffic

The following section discusses commercial air traffic and maritime transportation. Commercial air traffic uses established jet routes that cross portions of the EGTTR. However, commercial air traffic may enter the Warning Areas with permission from the controlling agency (Figure 3-7). The commercial air traffic issues are air quality, restricted access, and noise. Figure 3-8 depicts the preferred shipping routes of the maritime industry when crossing the eastern Gulf (NOAA, 1985). Relative intensity of use is indicated by the width of the routes, illustrating the low intensity of commercial shipping activity under the majority EGTTR airspace. Influences on the environment from the maritime shipping industry include air quality, water quality, marine debris, introduction of non-indigenous species, and noise.

The majority of oil spills from anthropogenic sources occur from the transportation of petroleum products and crude oil by tanker and barge movements. The heaviest volumes and routes, and resulting risks of import/export crude oil spills, are through the Florida Straits, Yucatan Straits, and at major oil terminals. The total contribution of petroleum products to the entire Gulf of Mexico (not just the ROI) from spills in both the petroleum and maritime industries is estimated to be about 0.089 million barrels (approximately 4 million gallons) per year, or 0.012 million metric tons annually (Mta). The majority of these oil spills occur from maritime operations, 0.07 million barrels (approximately 3 million gallons) per year (MMS, 1996).

Increased enforcement through monitoring and higher fines has forced ship operators to dispose of oily ballast water and tank washings at onshore facilities in accordance with in accordance with regulations (Carlton, 1996).

Annex V of the MARPOL treaty restricts the dumping of paper, garbage, food, plastic, metal, crockery, dunnage, and rags within 12 miles of the coastline. Plastic is strictly prohibited from dumping anywhere in the marine environment, U.S. lakes, rivers, and bays. U.S. law also regulates the distance from shore and the types of garbage that may be dumped in U.S. waters (Weber, 1992). Even though MARPOL restrictions are mandatory, high amounts of operational waste debris from offshore maritime and petroleum operations washes ashore in all Gulf states. Typical items are plastic sheeting, strapping bands, fluorescent light tubes, wooden crates, wooden pellets, glass light bulbs, hard hats, and metal drums. Plastic makes up over 60 percent of the debris that washes ashore on the nation's beaches. Florida typically reports the highest percentage Gulf-wide of trash is attributable to passenger cruise lines (Gulf of Mexico Program, 1993).

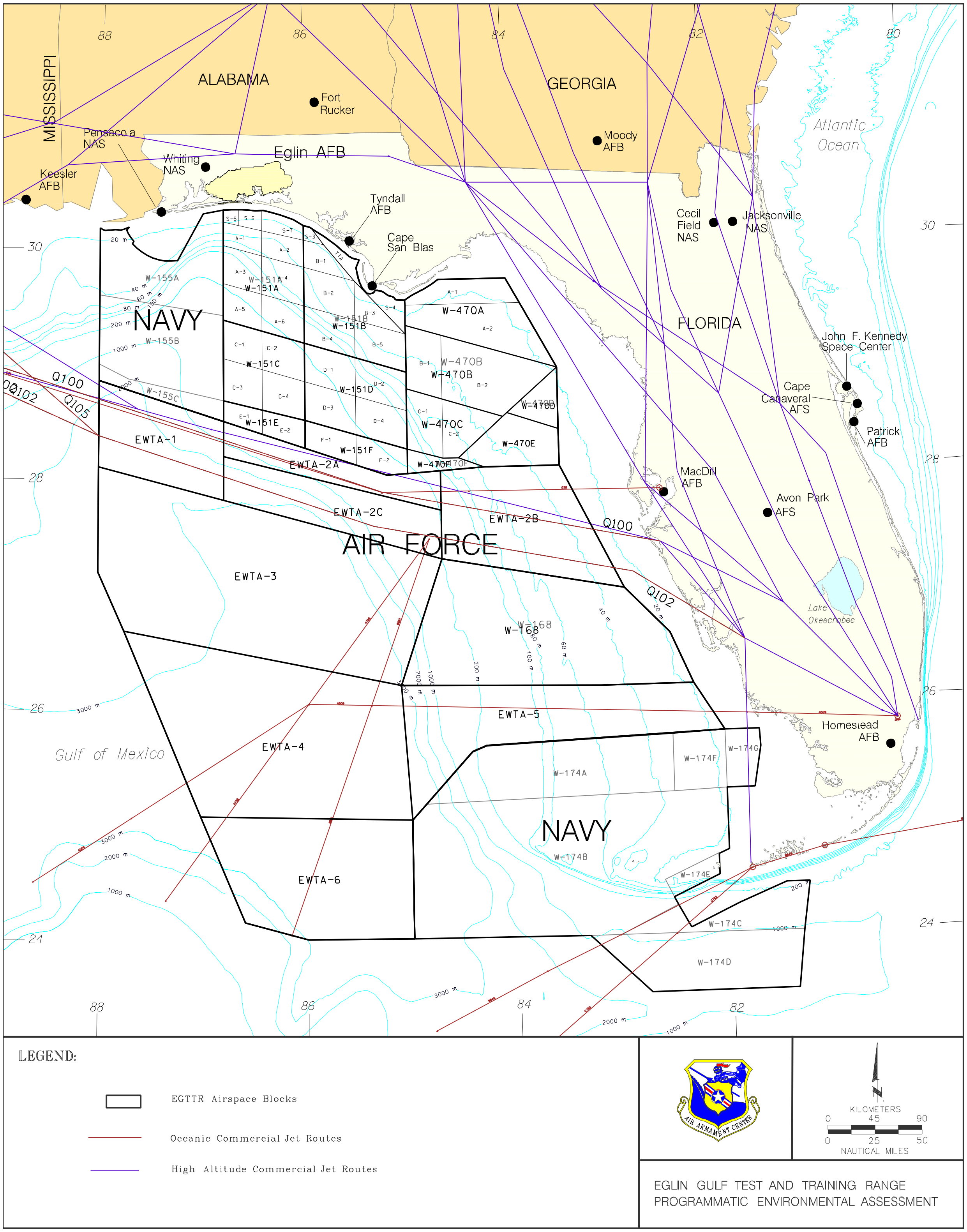


Figure 3-7. Jet Routes and Airways in the Eastern Gulf (U.S. DOC, 1985)

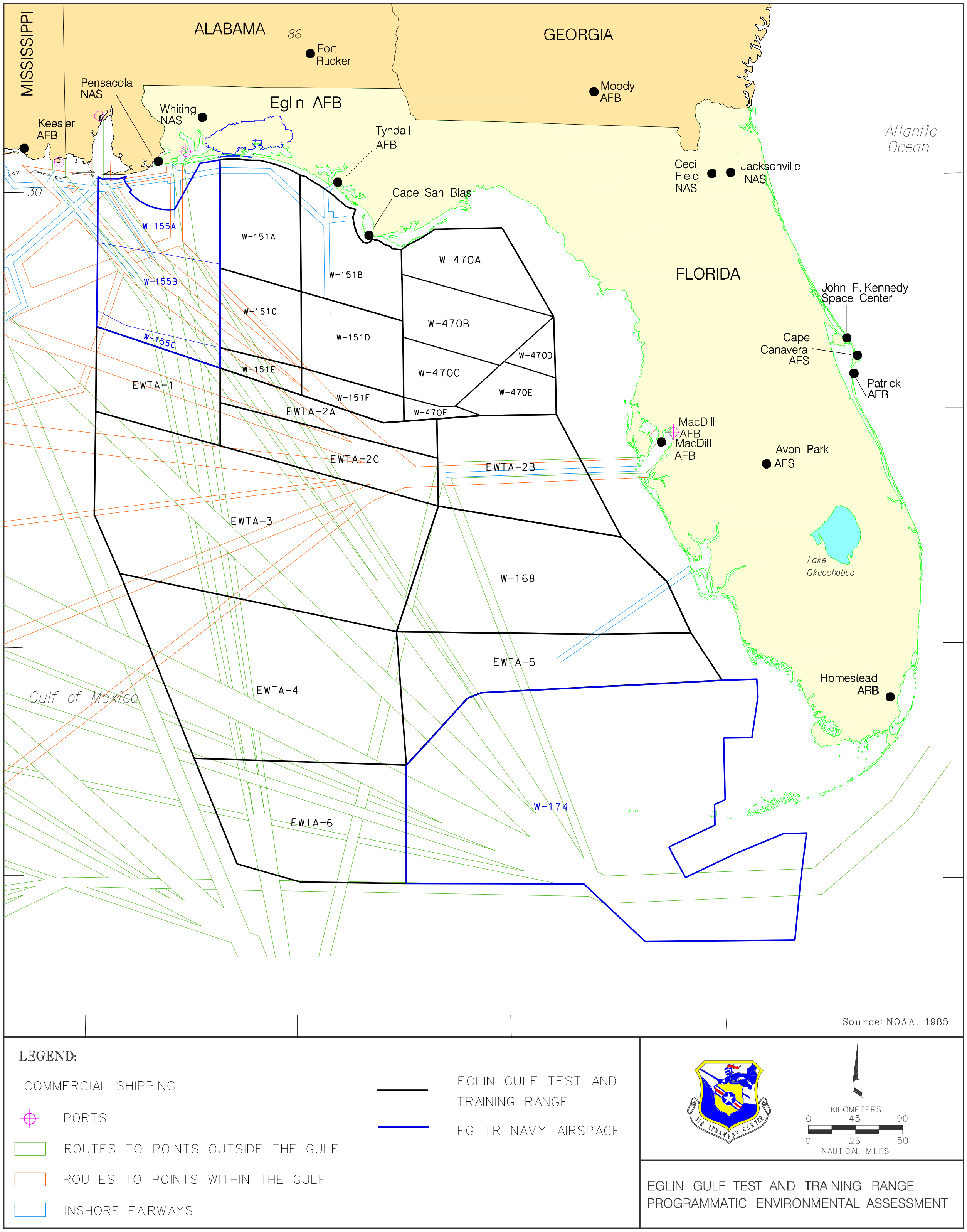


Figure 3-8. Shipping Routes Between Gulf Coastal Ports (U.S. DOC, 1985)

Foreign marine organisms have been introduced into American waters from maritime activities for over four centuries and continue to be introduced on a regular basis. Maritime vessels have the capacity for carrying small marine organisms in their ballast water and sediments, in seawater systems, and on their hulls.

3.3.2 Artificial Reefs

The disposal of materials on the ocean floor to enhance fishing success in U.S. coastal waters has been occurring for over a century. The U.S. Army Corps of Engineers (ACE) regulates artificial reef construction in U.S. waters through its Permits and Evaluation Branch. Regulatory authority has been given to the ACE through the Rivers and Harbors Act of 1899, the Outer Continental Shelf Lands Act of 1953, the National Environmental Policy Act of 1969, the Clean Water Act of 1972, and the Marine Protection Research and Sanctuaries Act of 1972 (Ocean Dumping Act). These regulations empower the ACE to prohibit the alteration or obstruction of navigable waters of the United States and waters over the continental shelf in territorial seas without a permit from the ACE. The ACE is required to assess the potential environmental impact of artificial reef projects before issuing a permit. The ACE is also empowered by the Clean Water Act and the Ocean Dumping Act to prohibit the discharge and transportation of dredged or fill material for the purposes of ocean dumping without first obtaining a permit. However, construction of fishing reefs is excluded from these regulations provided the nature of materials used to construct the reef is regulated by an appropriate state or federal agency. A general permit from the ACE is given to state agencies to regulate the placement of suitable materials in state management areas for the purpose of constructing artificial fishing reefs and fish attractors (GCMFC, 1993). Parties in Florida desiring to construct artificial reef material in the state management areas must submit an application to the Florida Department of Environmental Protection (FDEP). Individual counties planning on deploying artificial reef material outside of state management areas must obtain a permit from both the FDEP and the ACE. Artificial reef projects planned in federal waters must obtain a separate permit from the ACE (Maher, 1996; Spey, 1996).

All materials selected for construction of artificial reefs must be inspected by the ACE or designated agency before deployment. The following excerpt from the Army Corps of Engineers general permit outlines special conditions for selection and preparation of material to be deployed (U.S. Army Corps of Engineers, 1995):

"Materials authorized by this general permit include concrete and steel culverts, Army tanks and steel hulled or ferro cement vessels (without engines), construction-grade aluminum alloys and ferrous metals such as bridges, concrete blocks, slabs, natural limestone boulder size rocks, etc., and similar material. Materials are to be selected to avoid movement of reef materials caused by sea conditions or currents and are to be clean and free of asphalt, creosote, petroleum, other hydrocarbons, toxic residues, loose free floating material, or other deleterious substances. Such materials may be inspected by the Corps or their designee prior to placement. No automobile, truck, bus, or other vehicular tires may be used unless split and substantially embedded in concrete. Also prohibited are household appliances such as refrigerators, freezers, ranges, air conditioner units, washers, dryers and furniture, boat molds, dumpsters, PVC and fiberglass materials (unless specifically designed and constructed for reef or fish attractor purposes), trailers, vehicle bodies, fuel storage tanks, etc."

Several state and federal sources provide revenue for the development of Florida's public artificial reefs. Federal tax monies from the Sportfish Restoration tax base are collected and split among all fifty states based upon land and water area and the number of fishing license holders. This money is allocated to individual counties by the Department of Environmental Protection, Office of Fisheries Management and Assistant Services, for the actual construction of reefs. State funding sources include the sale of saltwater fishing licenses, the Florida Boating Improvement Program, the Florida Department of Transportation, and the Florida Aquatic Pollution Recovery Trust Fund. Using both federal and state funding sources, grants totaling 6.7 million dollars have been issued for the construction of artificial reefs in Florida. Portions of these state funds are allocated to individual counties for artificial reef projects. Individual counties may also fund their own artificial reef projects or receive donations from private fishing or diving clubs or individuals (Maher, 1995). Table 3-10 presents a summary of artificial reef materials in the Eglin Gulf Test and Training Range.

Table 3-10. Summary of Artificial Reef Materials (tons) Under the Eglin Gulf Test and Training Range

EGTTR Areas:		Concrete	Steel	Aluminum
W-151 A	**Total Reef Materials**	222	1,330	0
	1994/95 Amounts	0	0	0
W-151 B	**Total Reef Materials**	Insufficient Data	3,087	0
	1994/95 Amounts	0	0	0
W-151 C	**Total Reef Materials**	0	0	0
	1994/95 Amounts	0	0	0
W-151 D	**Total Reef Materials**	0	0	0
	1994/95 Amounts	0	0	0
W-151 S	**Total Reef Materials**	5,050	9,137	0
	1994/95 Amounts	0	865	0
W-155	**Total Reef Materials**	0	4,434	0
	1994/95 Amounts	0	0	0
W-470	**Total Reef Materials**	2,323	2,800	200
	1994/95 Amounts	442	0	0
W-168	**Total Reef Materials**	36,369	7,035	0
	1994/95 Amounts	450	480	0
W-174	**Total Reef Materials**	8,662	11,060	0
	1994/95 Amounts	0	0	0
EWTA-2	**Total Reef Materials**	29,751	4,364	0
	1994/95 Amounts	0	0	0
EWTA-5	**Total Reef Materials**	714	0	400
	1994/95 Amounts	0	0	0
Total	**Total Reef Materials**	**83,091**	**43,247**	**600**
	1994/95 Amounts	**892**	**1,345**	**0**

Note: Conservative estimates were made for artificial reef site based on limited available information. Material in artificial reef sites is underestimated and does not represent total amounts. Copper, zinc, lead and plastic, items that are deposited during EGTTR activities, were not deposited through artificial reef programs. Total Reef Materials represents known recorded amounts to date while 1994/95 Amounts represent those reef materials deposited during that time frame.

State Managed Reefs

The Florida Department of Environmental Protection (FDEP) obtained a permit from the Army Corps of Engineers in 1994 to manage three areas for deployment of artificial reefs off of the Florida panhandle. The coordinates in degrees (°) minutes (′) seconds (″) of the three state management areas are (Figure 3-9):

Escambia West Site:

30°07′00″;87°31′00″ X 30°07′00″;87°24′00″ X 29°60′00″;87°24′00″ X 29°60′00″;87°31′00″
surface area = 43.3 square miles

Escambia East Site:

30°07′00″; 87°12′50″ X 30°07′00″;86°60′00″ X 29°60′00″;86°60′00″ X 29°60′00″;87°12′50″
surface area = 77.4 square miles

Okaloosa Site:

30°10′00″;86°25′00″ X 30°10′00″;86°17′00″ X 30°02′00″;86°17′00″ X 30°02′00″;86°2500″
surface area = 56.7 square miles

Two deployments to date have occurred in the Escambia East site, which consists of five M-60 army tanks around a center coordinate and a 387-foot freighter. Deployment of 14 M-60 army tanks occurred in the Okaloosa site, as well as 250 tons of concrete culvert pipes.

Alabama currently has three general areas permitted by the Army Corps of Engineers (Figure 3-9). The first site was permitted in 1987 and encompasses 360 square miles off of Baldwin County, known as Don Kelly North General Permit Area. Don Kelly South General Permit area was permitted subsequently. In 1991, another general permit site known as the Hugh Swingle General Permit Area was established. Twelve deployments of artificial reef material have occurred since these areas became generally permitted.

County Managed Reefs

In a 1991 survey, 177 permitted reef sites were reported in Florida waters off of the west coast and federal waters adjacent to the state boundary (Figure 3-9). Permitted reef sites vary in size from a quarter mile to well over one mile in diameter (GCMFC, 1993). At least 441 deployments of material to build artificial reefs at permitted sites have occurred on the Gulf coast of Florida and in federal waters (Pybas, 1991; Maher, 1995). Approximately one quarter of these deployments have been funded, or partially supported, by state or federal grants (Maher, 1995). Volunteer reef coordinators, selected for each county, may serve on reef advisory boards, conduct site selection assessments, complete documentation necessary for permit or grant applications, obtain donations of suitable materials, conduct pre- and post- deployment assessments, and/or periodically monitor the reefs (GCMFC, 1993).

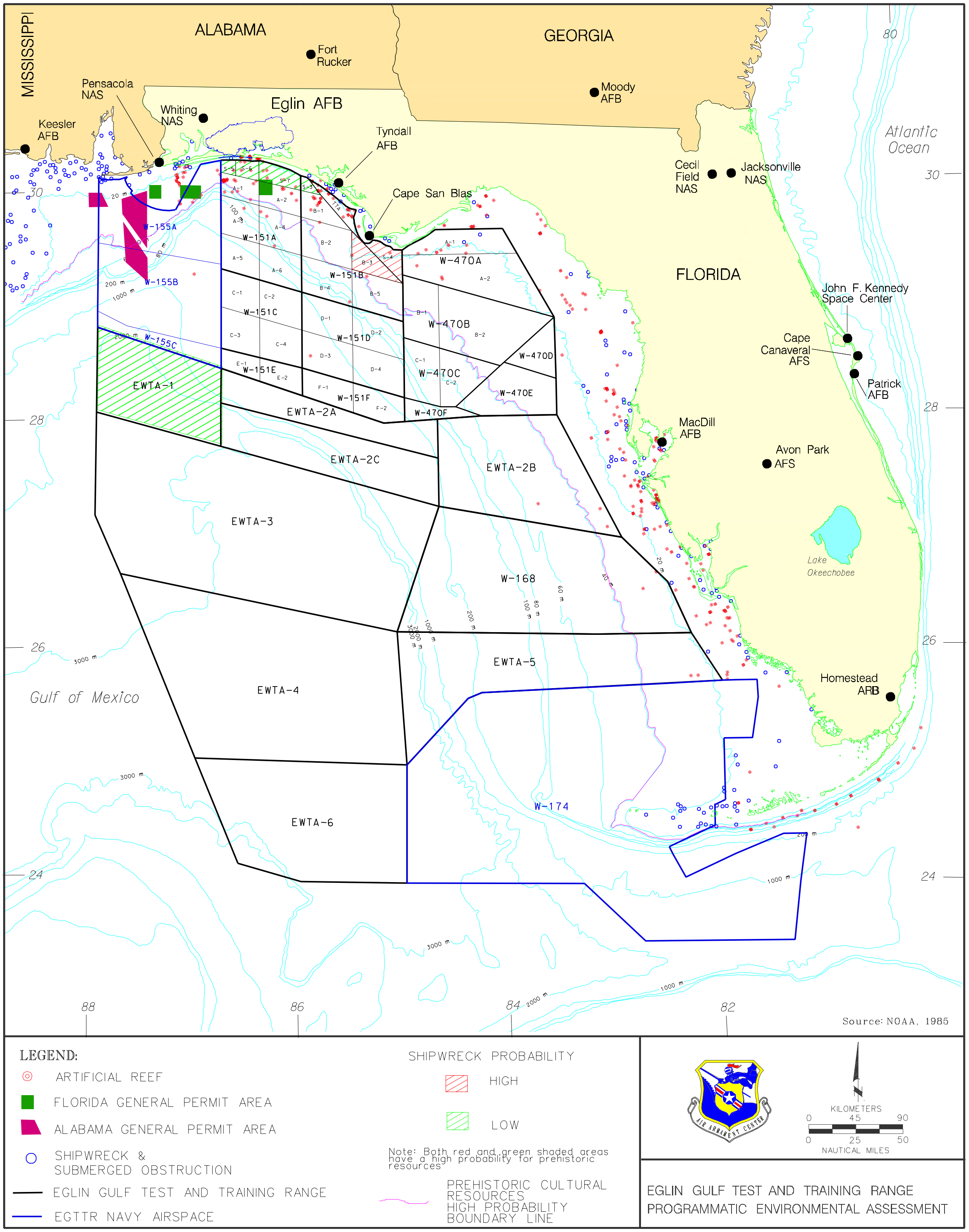


Figure 3-9. Artificial Reef Sites Off of West Florida (Pybas, 1991; Maher, 1995)

In 1998, Okaloosa County appealed to Eglin AFB for assistance in replenishing area artificial reefs that had been moved or covered up with sand as a result of the passing of Hurricane Opal. In response, Eglin furnished approximately 500 tons of tank turrets, assisted with funding, man-hours, and oversaw the deployment of 48 turrets to establish an artificial reef offshore of Destin. According to the county, Hurricane Opal affected approximately 90 percent of the area's artificial and natural reefs in 1995 (Fey, J. 1998). Other reefs created in the last five years include 1,310 tons of concrete culverts, a 70-ton Navy Landing Craft (LCM-8), over 35 acres of fish havens, several steel-hulled vessels, and pier rubble.

Rigs-to-Reefs

Formally adopted as federal policy by the MMS in 1985, Rigs-to-Reefs has become an important component and integral part of state artificial reef programs (GCMFC, 1993). Three permitted Rigs-to-Reefs sites exist off the west coast of Florida. An Exxon structure was placed off Franklin County in 1979. In 1982, a site off Escambia County was established by Tenneco. And most recently, a Chevron jacket was submerged southeast of Pensacola in the fall of 1993. Okaloosa and Bay counties are hoping to add obsolete petroleum structures to state waters as well. Okaloosa County has reserved a location 27.5 miles from the coast and in 354 feet of water for a future Rigs-to Reefs project (MMS, 1996).

3.3.3 Military Activities

Many of the Air Force and Navy activities occurring within the EGTTR involve the deposition into the marine environment of various materials, many of which are defined as pollutants under the Clean Water Act (CWA). The CWA states "any addition of any pollutant to the waters of the contiguous zone or the ocean within 12 nmi from any point source other than a vessel or other floating craft" requires a National Pollutant Discharge Elimination System (NPDES) permit. Therefore, military activities within 12 nmi of shore that contribute pollutants to EGTTR waters would require an NPDES permit under the CWA. A variety of substances are included in the definition of pollutants, including "munitions, chemical wastes, radioactive materials, and wrecked or discarded equipment" {33 USC 1362(6)}. At least one instance is known where a branch of the DoD was required to obtain an NPDES permit to drop ordnance in marine waters. In 1978, an NPDES permit was issued to the Navy for ordnance testing at the Atlantic Fleet Weapons Training Facility in Puerto Rico (456 US 305, 1982).

3.4 SOCIOECONOMIC ENVIRONMENT

The following sections describe socioeconomic conditions within the study region including commercial and recreational fisheries, commercial shipping, commercial air traffic, military activity, energy exploration and development, recreational activities, and cultural and historical regions.

The Gulf's diverse and productive ecosystem provides a variety of valuable resources and services, including transportation, recreation, fish and shellfish, and petroleum and minerals. The U.S. Coast Guard Eighth District, headquartered in New Orleans, covers 1,200 miles of U.S. coastline and 10,300 miles of inland navigable waterways. Some of its duties and responsibilities in the Gulf are waterways management, maritime safety, and environmental protection.

3.4.1 Recreation

The northern Gulf of Mexico coastal zone is one of the major recreational regions of the United States, particularly for marine fishing and beach activities. Its resources include coastal beaches, barrier islands, coral reefs, estuarine bay and sounds, river deltas, and tidal marshes. Many of these are held in trust for the public under federal, state, and local jurisdiction (i.e., parks, landmarks). Commercial facilities such as resorts and marinas are also primary areas for tourist activity.

Outdoor recreational activity in the Gulf is primarily located along the shoreline and is associated with accessible beach areas. Beaches are a major focal point for tourism as well as a primary source of recreational activity for residents.

3.4.2 Fishing

The Gulf waters are estimated to support more than one third of the nation's marine recreational fishing, with over 2.6 million anglers in 2000 who caught an estimated 149 million fish during more than 20 million individual fishing trips. Nearly 104 million of the fish were caught from private/rental boats, over 7 million were caught from charter boats and 33 million were caught from the shore (NMFS, 2001). Tourism-related dollars in the Gulf Coast states contribute an estimated $20 billion to the local economy each year (USEPA, 1994). Recreational fishing activities usually occur within three miles of the shoreline, with anglers fishing from shore or from private or charter boats. In Destin, Florida cobia fishing tournaments may occur in late March and April, and an annual billfishing tournament occurs in October. Cobia are fished from wrecks and artificial reefs beginning in late March. In 2000, there were 35,000 participants in the October billfishing tournament over the month long period. Table 3-11 shows the marine recreational fishing statistics for Gulf coast states in 2000.

Table 3-11. Marine Recreational Fishing Statistics for Gulf Coast States in 2000

State	No. of Fishermen	No. of Fishing Trips	No. of Fish Caught
Alabama	346, 885	1,096,852	7,471,949
Louisiana	699,540	3,653,903	39,219,520
Mississippi	223,280	1,060,902	4,910,520
West Florida	3,599,022	14,625,831	97,416,750

The Florida Gulf coast, and particularly southwest Florida, boasts diverse habitats that support several species of fish and invertebrates favored by tourist and resident fishermen (ESE et al. 1987). In 1988, estimates put recreational angling expenditures in the Gulf of Mexico at $6.5 billion and output at $10 billion, creating 187,000 jobs. Florida and Texas were by far the leaders among the five states. In west Florida, expenditures from sport fishing were $3.1 billion with an output of $4.2 million in 1988. Florida has 1,051 party and charter boats, more than all the other coastal states from Texas to North Carolina combined. Two thirds of these Florida boats operate from Gulf ports (USEPA, 1990). Registered boats (less than 5 net registered tons) reached 9,409 in 1992 and rose to 9,444 in 1993. Over 75 million pounds of fish were caught recreationally in 2000, with popular species being herring, seatrout, catfish, and flounder (Table 3-12) (NMFS, 2001).

Table 3-12. Estimated Total Number of Fish Caught by Marine Recreational Anglers in the Gulf of Mexico by Species Group, January -December 2000

SPECIES GROUP	THOUSAND POUNDS
Herrings	23,365
Spotted Seatrout	27,622
Saltwater Catfishes	8,941
Flounder	1,023
Red Drum	8,511
Sand Seatrout	5,934
Atlantic Croaker	5,935
Black Sea Bass	3,378
White Grunt	2,591
Red Snapper	2,182
Mullets	2,973
Kingfishes	2,411
King Mackerel	449
Bluefish	375
Spot	73
Other Fishes	53255
TOTAL	**149,018**

Source: Modified from NMFS, 2001

Species targeted by recreational anglers are generally the same targeted by the commercial fishing industry, and may be grouped as inshore, coastal pelagic, reef fishes, and offshore pelagics. Inshore species include red drum, spotted sea trout, snook, striped or black mullet, tarpon, pompano, black drum, and sheepshead. Most of these inshore species are primarily sought by recreational fishermen, with the exception of mullet and sea trout. Anglers seeking reef fishes capitalize on the abundance of larger predatory species such as snappers, groupers, grunts, porgies, barracudas, and jacks. Certain ornamental reef fishes such as angelfishes, butterflyfishes, damselfishes, gobies, and small seabass are sought for the aquarium industry. Billfish, dolphinfish and tuna are offshore pelagics, generally fished commercially. Invertebrate species fished in the northeast Gulf are scallops, oysters and blue crab, while lobster, stone crab and pink shrimp are fished in southwest Florida waters. Figure 3-10 illustrates known recreational fishing grounds for selected species.

Saltwater fishing activities, both commercial and recreational, are essential for the social and economic welfare of the citizens of the Gulf coast. Greene, Moss and Thunberg (1994) estimated the recreational reef fishery alone in Florida generates $385.6 million in total expenditures annually, approximately $12 million of which is derived from saltwater fishing license fees. Their study quantified the effects of declining catches, estimating a 20 percent reduction in average catch would reduce expenditures from saltwater anglers by $32.1 million. In 1988, the Sport Fishing Institute estimated resident and tourist sport fishermen from the five Gulf states spent $6.5 billion, generating a total economic output of $10 billion (MMS 1990).

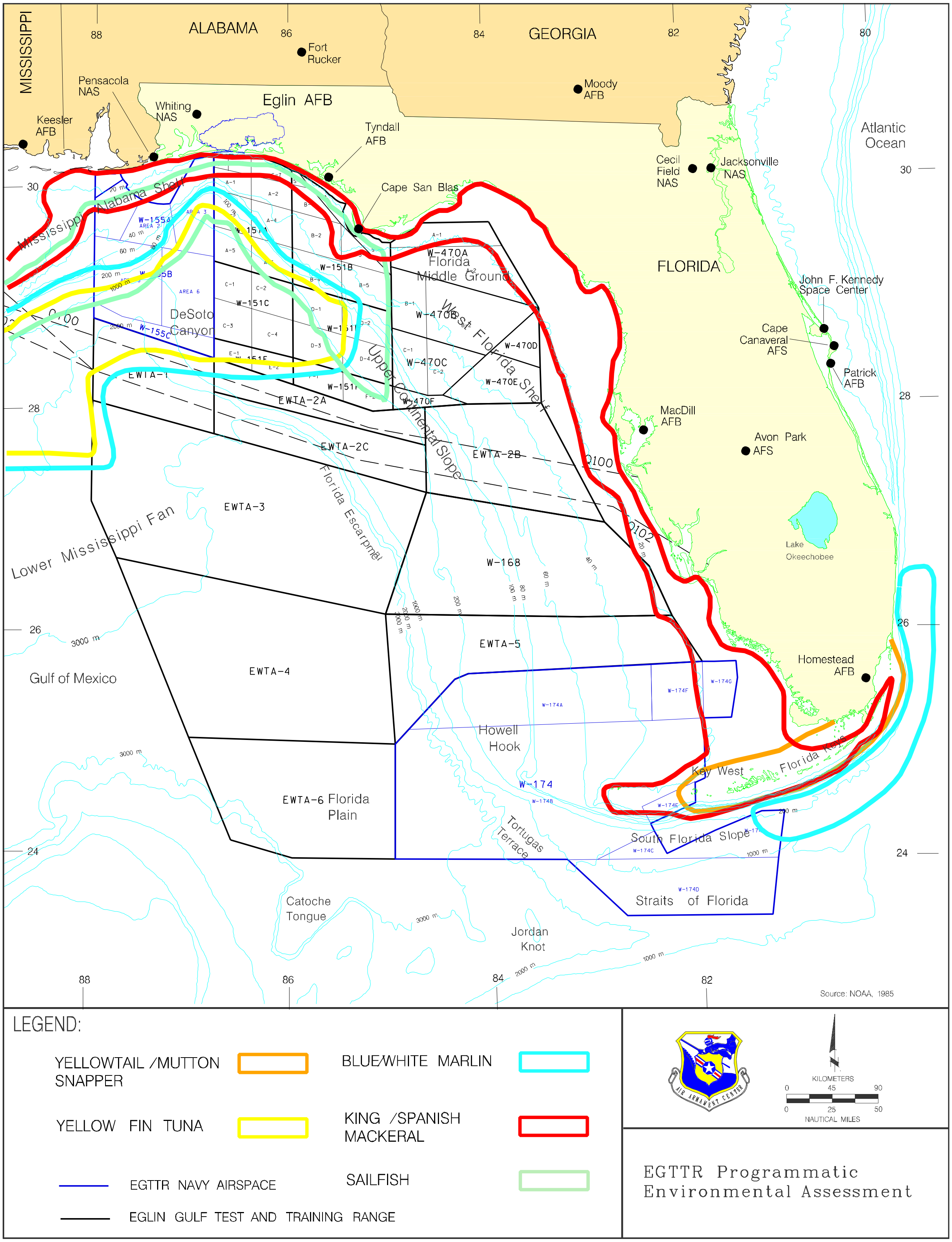


Figure 3-10. Known Recreational Fishing Areas of Selected Species within the Eastern Gulf

Recreational fishing activities also include fishing from charter boats that occasionally go into deeper waters. Party boats fish primarily over offshore hardbottom areas, wrecks, or artificial reefs for amberjack, barracuda, groupers, snapper, grunts, porgies, and sea basses. In addition, charter boats and party boats operating out of Key West frequently fish the Dry Tortugas area for grouper and snapper (ESE et al., 1987). In the Florida Keys alone, in 1984, there were 86 charter boats and 24 party boats compared to 215 charter boats and 24 party boats in operation on the entire west Florida coast. Ninety percent of all sport fishing in the Keys takes place via charter boat from December 15 to April, after which boat captains turn their focus to commercial fishing (SAIC, 1995).

Boating

Recreational boating interests include the use of sailboats, powerboats, and personal watercraft on freshwater lakes, inlets, estuaries, sounds, and in the Gulf. These watercraft activities lie almost entirely within three miles of the shoreline, limiting conflicts with military activities. A survey of the number of powerboats, sailboats and personal watercraft registered along the Florida Gulf coast shows the distribution of recreational boating activity along the shoreline (Table 3-13).

Table 3-13. Distribution of Recreational Watercraft Among Florida Gulf Coast Counties

County	All Boats	Powerboats		Sailboats		Personal Watercraft	
		Pleasure	Commercial	Pleasure	Commercial	Pleasure	Commercial
Bay	16,445	14,759	1,457	227	2	1,301	524
Escambia	16,783	15,977	487	314	5	1,060	77
Franklin	2,362	1,502	827	32	1	24	0
Gulf	2,376	2,112	259	5	0	28	8
Okaloosa	15,977	14,870	822	276	9	1,652	297
Santa Rosa	8,870	8,415	325	130	0	359	87
Walton	2,673	2,572	84	17	0	27	4
TOTAL	**65,486**	**60,207**	**4,261**	**1,001**	**17**	**4,451**	**997**

Source: Florida Department of Transportation, 1996

3.4.3 Commercial Fishing

The Gulf of Mexico is the single most important commercial fishing area in the United States (U.S. Department of Commerce, 1985). Commercial fishing in the Gulf of Mexico in 2000 produced over 1.79 billion pounds valued at over $990 million (NMFS, 2000). Florida's west coast ranked third among the Gulf states of Louisiana, Mississippi, Texas, and Alabama with over 75 million pounds valued at $156 million. The Gulf of Mexico is the single most important commercial fishing area in the United States (U.S. Department of Commerce, 1985). The major commercial ports and their dominant fisheries along the Gulf coast of Florida are Apalachicola (oysters/shrimp) with 10.3 million pounds valued at $11.4 million in 2000, Fort Myers (black mullet/shrimp) with 7.9 million pounds valued at $16.5 million in 2000, and Key West-Marathon (shrimp/lobster/king mackerel) with 16.9 million pounds valued at $50.6 million in 2000 (NMFS, 2001). Commercial fishing is generally concentrated along the coastline and extends west covering approximately one-half of the over water ROI.

Commercially Important Species

Commercial fisheries are a valuable industry in northwest Florida, worth over $3.5 million in 1997 from Gulf County alone (FDEP, 1998). The estimated number of fishing vessels operating in Florida waters decreased from 2,264 in 1992 to 2,128 in 1993 (Holliday and O'Bannon, 1995), yet the economic contribution from commercial fisheries in and adjacent to the ROI has increased over recent years. In 1995 the economic value was $176 million for 91.2 million pounds of total commercial fishery landings for the west coast of Florida. In 1994 the economic value was $171.4 million for 116.5 million pounds of total landings (Bennett, 1996). However, an even more dramatic difference in economic value is apparent from 1993 when the economic value was $153.5 million for 127.9 million pounds of total commercial fishery landings for the west coast of Florida (Newlin, 1994). The economic contribution from west coast Florida fisheries in 1995 certainly increased from over five years ago when in 1988 the economic value was $131.4 million for 143 million pounds of total commercial landings (USEPA, 1994).

Resources within the EGTTR are more economically important than fishery resources within the three-mile zone from the shoreline to range boundary, which is not considered part of the EGTTR. In 1993, commercial landings from 3 to 200 miles were 69 million pounds, which was 46 percent of total landings from the shoreline to 200 miles. However, the species landed in the EGTTR are more economically profitable. In 1993, the economic value of commercial fisheries from 3 to 200 miles was $106.8 million, which was 70 percent of the total value of all landings from the shoreline to 200 miles (Newlin, 1994).

The following sections describe the most commercially important species. Overall, the shrimp fishery, including pink shrimp, white shrimp, and brown shrimp is the most valuable to the Florida west coast. Other species that are valued over $1 million dollars a year are grouper and scamp, blue crab, striped mullet, and snappers (yellowtail and red) (Table 3-14).

Table 3-14. Commercially Important Fishes within the Eastern Gulf

Common Name	Scientific Name
Sandbar Shark	*Carcharhinus plumbeus*
Dolphinfish	*Coryphaeria hippurus*
Spotted Seatrout	*Cynoscion nebulosus*
Grouper	
Yellowedge Grouper	*Ephinephelus flavolimbatus*
Black Grouper	*Mycteroperca bonaci*
Gag Grouper	*Mycteroperca microlepis*
Scamp	*Mycteroperca phenax*
Yellowtail Snapper	*Ocyurus chysurus*
Shrimp	
Pink Shrimp	*Penaeus duorarum*
White Shrimp	*Penaeus setiferus*
Brown Shrimp	*Penaeus aztecus*
Cobia	*Rachycentron canadus*
King Mackerel	*Scomberomerus cavalla*
Spanish Mackerel	*Scomberomerus maculatus*
Amberjack	*Seriola dumerili*
Yellowfin Tuna	*Thunnus albacares*
Pompano	*Trachinotus carolinus*
Swordfish	*Xiphias gladius*

Source: FDEP, 1998

Shrimp (Pink, White, and Brown)

Total economic value of pink, white, and brown shrimp off of the west coast of Florida totaled $44.2 million in 1993. The commercial shrimp fishery is an important part of the fishing industry in west Florida, contributing 25 percent of the overall commercial fishery value. Pink shrimp dominate the shrimp resource off of the west Florida coast. Pink shrimp accounted for $39 million in 1995, which was 22 percent of the total commercial fishery value (Bennett, 1996). The offshore commercial shrimp fishery accounts for the most landings and has the highest value. In 1993, the value of shrimp landed between 3 and 200 miles off of Florida's west coast was $25.9 million, which was 78 percent of the total commercial fishery value for the year (Newlin, 1994). Major U.S. shrimp ports on the Florida Gulf coast are Pensacola, Apalachicola, Tampa, Fort Myers, and Key West (Upton et al., 1992).

There are a number of problems in the shrimp fishery today including an excessive number of vessels given available yields of shrimp and conflicts with other targeted fisheries. The Gulf of Mexico Fishery Management Council has closed areas in the eastern Gulf to shrimp trawling during the traditional trap fishing seasons for lobster and stone crab to lessen conflicts between these fisheries (MMS, 1996).

Groupers

Another valuable fishery for the west coast of Florida is the reef fishes, which include groupers and scamp. Eight species of grouper are commonly landed in commercial fishing operations off of the west coast of Florida. The species included in the EGTTR are black grouper, snowy grouper, warsaw grouper, yellowedge grouper, and the yellowfin grouper. In 1996, all groupers accounted for landings of 8.3 million pounds with a value of $17.5 million, which was 10 percent of the total commercial fishery value. This is down slightly from 1994, when landings of groupers totaled 88.4 million with a value of $19.4 million. The predominant species in the commercial fisheries landings was red grouper, which totaled 5.6 million pounds in 1995, with an economic value of $10.8 million, six percent of the total commercial fishery value (Bennett, 1996). The majority of grouper are caught offshore, where 97 percent of the economic value in 1993 for grouper was caught from 3 to 200 miles offshore (Newlin, 1994).

Snappers

Many different species of snappers are commercially sought in waters off of west Florida, including blackfin snapper, cubera snapper, dog snapper, lane snapper, mangrove snapper, mutton snapper, queen snapper, red snapper, schoolmaster snapper, silk snapper, and the yellowtail snapper. All snappers landed in 1995 totaled 2.8 million pounds and were valued at $5.8 million, or three percent of total commercial fisheries value. This was cut almost in half since 1994, where 4.9 million pounds of all snappers were landed, and the resource was valued at $9.6 million. Yellowtail snapper is the predominant species lending to commercial value of snapper species, where in 1995 landed yellowtail snapper was valued at $3.8 million from Florida west coast waters. Other economically important snapper species in 1995 were the red snapper, mangrove snapper, and the mutton snapper (Bennett, 1996). Most snappers are non-estuarine dependent, demersal fish associated with natural reefs, hard bottoms, and artificial reefs of the mid-outer continental shelf (USEPA, 1994). This preference in habitat excludes the snappers from the zero to three mile zone. Therefore, the snapper resource is entirely located inside of the EGTTR boundary.

Mariculture

Florida has a growing aquaculture industry, which reached $54 million in 1991 (USEPA, 1994). Interference of aquaculture practices from military activities in the EGTTR is minimal since most of the aquacultural activities are on land or near shore. There is a potential for offshore culturing of finfish in net pens associated with offshore oil and gas production platforms. A few projects have been initiated to assess the technological and economical feasibility of utilizing both active and inactive offshore production platforms for production of indigenous finfish in net pens surrounding the platform. Profits from production of highly marketable indigenous marine species that cannot be produced at most coastal aquaculture facilities may offset the high cost of operating an offshore aquaculture facility and circumvent high platform removal costs. The most promising species of marine finfish suited for this type of aquaculture in the Gulf are yellowtail snapper, ling, and mahi-mahi. These finfish can be grown to market size in one year in these offshore net pens (Millet, 1994).

3.4.4 Commercial Shipping

Seven of Florida's deepwater ports are located on the Gulf: Port of Pensacola, Port of Panama City, Port St. Joe, Port of St. Petersburg, Port of Tampa, Port Manatee, and Port of Key West. Approximately 45 percent of United States shipping tonnage passes through Gulf of Mexico ports. The Gulf of Mexico supports the second largest marine transport industry in the world. In 1999 there were more than 234,000 trips upbound and downbound in the Gulf Intercoastal Water Way. In 1999 over 109.6 million tons of commodities were shipped through the Gulf portion of the Intercoastal Waterway (U.S. Army Corps of Engineers, 1999). There are two deep water ports in the five county ROI: the Port of Pensacola in Escambia County and Port of Panama City USA in Walton County. Both of these ports are located along the Intracoastal Waterway.

The Port of Pensacola is northwest Florida's leading deep-water port and is located on the Gulf of Mexico at latitude 30 degrees, 24 minutes north, longitude 87 degrees, 13 minutes west (11 miles from sea buoy). The port offers stevedoring and marine terminal services for any description of bulk, break-bulk and unitized freight. Bagged agricultural products, forest products, asphalt, sulphur, lime, steel products, frozen and refrigerated foods and project cargos are a few of the many commodities frequently handled through the Port of Pensacola. For the third year in a row, the Port's operating revenues exceeded its operating expenses. The Port went from an operating deficit of $527,322 in FY 1996 to a surplus of nearly $613,000 in FY 1998—a gain of over a million dollars in two years. The momentum has continued with an operating surplus every year since. In FY 2000, the Port's operating surplus totaled an estimated $600,000. In FY 1998, the latest year for which figures are available, the port provided 588 total jobs, $11.8 million in wages, and $2.1 million in state and local taxes to Escambia and Santa Rosa counties (Port of Pensacola, 2001).

Port Panama City USA was established in 1967 and contains five deepwater berths, and intermodal transportation facilities. Foreign-Trade Zone #65 is also located at the port and provides financial advantages to importers and exporters in the international market. Port

Panama City is recognized as a Load Center for liner board and wood pulp. Other commodities shipped through the port include feed products, steel, machinery, and dry and liquid chemicals. Port Panama City handled over 0.9 million short tons of cargo in FY96/97 and is projected to handle 1.1 million tons in FY01/02 (Florida Ports Council, 2001).

The total dollar value of Florida's waterborne trade is presented in Figure 3-11.

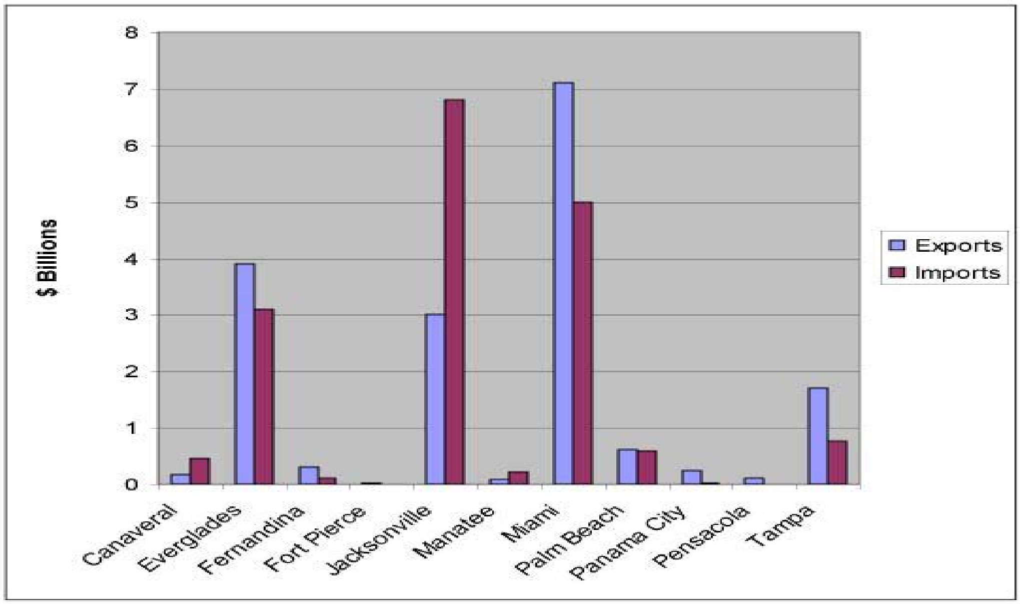


Figure 3-11. Dollar Value of Florida's Total Waterborne Trade (Florida Ports Council, 2001)

The Florida Seaport Transportation and Economic Development Council's latest five-year plan estimates that by 2005, 466,000 jobs, or 6.6 percent of all private sector employment will be attributable to seaport activities. In addition, by 2005, the seaports annual earnings are projected to increase by 68 percent to $11.1 billion; annual business sales are projected to increase by 61 percent to $36.8 billion, and annual state and local taxes will almost double, growing to $1.6 billion (FDOT, 2001).

3.4.5 Oil and Gas Production

The infrastructure for oil and gas production in the Gulf of Mexico is highly developed. This infrastructure includes oil refineries, petrochemical and gas processing plants, supply bases for offshore services, platform construction yards, pipeline yards, and other industry-related installations. Oil and gas refineries, natural gas plants, and petrochemical plants contribute little to the eastern Gulf of Mexico economy. Florida oil production peaked in the 1975-1980 period with just under 50 million barrels produced in 1978 (Florida Geological Survey, 1991). In 2000, oil production reached over 4.6 million barrels and over 605 million cubic feet of gas (Florida Geologic Survey, 2001). There are no active oil and gas producing wells within the Eglin AFB over water area. There are a number of oil and gas leases within this area.

3.4.6 Commercial Air Traffic

Figure 3-7 shows the network of jet routes and airways in the eastern Gulf. The existence of the Warning Areas in the northern EGTTR necessitates longer flight distances for commercial users. As a result of having to sometimes travel around the EGTTR Warning Areas, fuel costs to commercial users are significantly higher than what they normally would be (Draughon, 1996). However, commercial air traffic is allowed through W470 and W151 of the EGTTR during inclement weather. Most commercial flights traveling over the Gulf maintain altitudes between 29,000 and 41,000 feet. The exact number of flights using the various Gulf routes is not recorded; however, routes are most heavily used during the summer (Draughon, 1996). Air terminals statewide are relatively busy and provide a vital part of the Florida tourism economy. An estimated 21,518,096 visitors arrived by air to Florida in 1995 (Florida DOC, 1996). The purpose of the trip for air visitors surveyed was vacation (34.8 percent) or business (29.5 percent). Five Gulf counties, including Pinellas, Hillsborough, Sarasota, Monroe, and Bay were among the top ten destinations of air visitors surveyed in 1994 (Florida DOC, 1995). The regional economy of the Tampa Bay area is affected by business at Tampa International Airport. Tampa International Airport supported 6,040 jobs in 1995 and increased local income revenue by over $141 million. Purchases of local goods and services for 1995 by Tampa International Airport were over $161 million. Tampa International Airport contributed over $12 million in federal, state, and local government taxes in 1995 (Johnson, 1996).

3.4.7 Military Activity

In addition to Air Force operations at Eglin AFB, other Department of Defense activities occur along the Florida Gulf coast at the Naval Air Station in Pensacola (NASP), Tyndall AFB and Naval Surface Warfare Center Coastal Systems Station in Panama City, MacDill AFB in Tampa Bay, and the Naval Air Station, Key West. These military installations contribute significantly to the economy of the Florida Gulf coast. Direct impacts to local communities include creation of military and civilian jobs and the economic input from salaries, contracts awarded to outside government contractors, and money spent on sustaining operations. Indirect impacts such as increased local business and service jobs also boost the economy in the affected community.

NASP is home to the Chief of Naval Education and Training (CNET), the National Museum of Aviation, and the Navy Flight Demonstration Team Blue Angels. NASP employed 17,000 direct jobs through the second quarter of FY96. The jobs consisted of 10,706 military and 6,305 civilian jobs. Through the second quarter in FY96, the station increased local income in the Pensacola region by over $334 million. NASP spent, through the second quarter of FY96, over $189 million in local contracts, Navy Junior ROTC and tuition assistance programs, civilian training programs, and utilities.

Eglin AFB, which includes operations at Hurlburt Field, Duke, and other small fields, positively impacts the economy of the Fort Walton Beach area and surrounding communities. Over 21,000 direct jobs (16,612 military and 4,534 civilian jobs) are supported by Eglin AFB with total expenditures and payrolls exceeding $1.8 billion in 2001(Table 3-14). There are 38,747 retirees from the Army, Navy, Marine Corps, and Air Force in the area, who received $764 million in income in FY01. Table 3-15 displays Eglin AFB current and historical population, payroll, and expenditure data.

Table 3-15. Eglin AFB Personnel, Payrolls, and Expenditures, 1982-2001[e]

	1982 [1]	1990 [1]	1991 [2]	1999 [2(d)(e)(f)]	2000 [2]	2001 [2]
Personnel - Military						
Active Duty	10,569	8,544	9,377	7,562	7,615	8,249
Reservists[(a)]		1,509	1,336	1,278	1,281	1,274
Retirees		27,868	28,783	37,727	38,110	38,747
Students/Trainees		275	121	321	335	317
Active Duty Military Dependents		11,868	12,162	12,980	14,131	17,969
Personnel - Civilian						
Appropriated Fund	3,692	4,858	4,832	3,791	3,726	3,764
NAF/BX		845	987	1336	1,262	1,191
Contractors	1,240	1,156	1,129	2,691	3,057	4,285
Private Business On Base		105	45	44	53	55
Total Direct Employment[(b)]	15,501	15,783	16,491	15,745	16,048	17,861
Payrolls - Military ($)						
Active Duty	$186,225,700	$243,648,566	$241,555,783	$237,627,987	$249,088,868	$259,313,638
Living On Base	$71,436,200	$99,895,912	$101,453,429	$59,358,343	$64,844,670	$60,382,373
Living Off Base	$114,789,500	$143,752,654	$140,102,354	$178,269,644	$184,244,198	$198,931,265
Reservists [(a)]		$8,420,000	$8,430,000	$12,306,000	$12,463,000	$13,518,000
Students/Trainees				$6,648,586	$7,278,938	$7,018,720
Retirees	$90,252,400	$424,665,393	$458,917,145	$710,832,348	$731,052,000	$763,848,000
Payrolls - Civilian ($)						
Appropriated Fund	$99,568,600	$169,123,568	$186,336,708	$182,704,872	$184,717,907	$181,220,267
NAF/BX	$6,806,300	$4,734,711	$9,375,011	$16,618,330	$19,084,784	$18,723,803
Contractors		$30,040,042	$45,540,000	$177,437,764	$182,605,919	$199,331,429
Private Business On Base		$1,029,480	$727,609	$973,274	$1,338,127	$1,374,250
Total Direct Payrolls [(c)]	**$292,600,600**	**$456,996,367**	**$491,965,111**	**$634,316,813**	**$649,298,605**	**$680,500,107**
Expenditures ($)						
Construction	$7,932,200	$32,151,045	$34,481,000	$35,496,127	$32,244,114	$57,423,287
Services (local economic area contracts) [(g)]	$621,007,900	$244,554,635	$269,002,511	$70,495,364	$81,205,528	$78,951,325
BX/Commissary [(e)]		$753,000	$413,700	$2,434,529	$2,449,500	$2,802,413
Health	$11,903,600	$7,877,294	$6,871,902	$7,703,080	$8,807,673	8,525,401
Education	$5,451,600	$2,198,764	$2,258,541	$4,936,947	$4,921,622	6,034,583
TDY [(h)]		$2,965,502	$5,139,212	$3,957,456	$7,138,601	6,658,861
Other Materials, Equipment and Supplies				$15,788,685	$16,368,482	18,111,512
Total Expenditures	**$646,295,300**	**$290,500,240**	**$318,166,866**	**$140,812,188**	**$153,135,520**	**$178,507,382**

Notes: Blank entries represent data not reported.
(a) Assigned to the 919 Special Operations Wing at Duke Field
(b) Excludes reservists, retirees, and dependents
(c) Excludes retirees
(d) Numbers are not normalized to a constant base year dollars.
(e) Significant increases in personnel, pay, and expenditures for NAF/BX (FY90-FY92) resulted from construction projects that increased the Commissary by 76,500SF in 1991 and construction of a new 4500SF Convenience Store in 1992 (Source: Mr. Rackard, 96CEG/CER (882-3143 Ext. 207).
(f) Significant decreases in personnel and pay for Private Business On Base FY91 resulted from a correction to the way data were collected for the EIA. Prior to FY91, the personnel and pay for the Burger King was included with Private Business On Base in error as the data was included in the NAF/BX numbers; thus, double counting occurred (Source: FY91 EIA).
(g) Significant decrease in Service Contracts in FY99 resulted from a correction to the way data was collected for the EIA. Prior to FY99, the number used for Service Contracts included all contracts not just those from the local economic impact area (Source: FY99).
(h) Significant increase in TDY expenditures in FY91 resulted from a correction to the way data was collected for the EIA. Prior to FY91, Temporary Lodging Entitlement (TLE) was not included in the total TDY expenditures (Source: FY91).

Source: (1) Data extracted from Eglin 1995 Environmental Baseline Summary, (Eglin AFB Economic Impact Analysis's 1982-1990)
(2) Eglin AFB Economic Impact Analyses for FY91, FY99, FY00, and FY01

Tyndall AFB, located in Panama City, is home of the 325th Fighter Wing. Tyndall has 77 F-15 Eagle aircraft and two E-9A aircraft, and has five watercraft to recover its 142 assigned missiles and drones. The surrounding communities within a 50-mile radius of Tyndall comprise the local economic impact area. A total of 7,248 direct jobs were provided in FY95 by Tyndall AFB, and 2,567 indirect jobs were created in the community. Tyndall AFB increased the local payroll by $192 million through military and civilian jobs. Local service contracts totaled over $39 million in FY95, and construction activities put an additional $26 million into the local economy.

MacDill AFB is a major economic influence on the Tampa Bay Region. The 6th Air Base Wing is the host unit at MacDill, which recently has become home to a squadron of KC-135 tanker aircraft. MacDill AFB impacts the area in two main ways. The first way is the impact of base operations, which require local labor, goods, and services daily. The second way is the large number of retirees from all branches who have moved into the region and to whom MacDill provides services. The operations of MacDill AFB provided 30,981 direct, indirect, and induced jobs in FY95. The direct impact from these operations in FY95 was over $374 million that, combined with an indirect impact of $780 million, gave a total impact of $1.15 billion in the Tampa Bay Region. Retirees' payrolls had a total economic impact in the region of $1.45 billion, and supported 46,248 jobs in the region in FY95. The total impact reflects the spending patterns of the area retirees and the interaction with the economy that this creates.

Naval Air Station, Key West, is an air-to-air training base for military tactical aviation, Air Combat Maneuvering (ACM). Through the second quarter of FY96, the base employed about 1,600 military and 1,318 civilians. Naval Air Station, Key West, provided about $22 million in income to the community of Key West in FY95. Military personnel received most of the income, $18 million, compared to civilian personnel, $4.5 million, in FY95.

3.4.8 Cultural and Historical Regions

Eglin AFB airspace over the Gulf lies atop submerged prehistoric sites and historic resources such as shipwrecks. The protection of Gulf submerged cultural sites falls within federal and state (nine nmi into the Gulf) jurisdiction. The Exclusive Economic Zone (EEZ) extends 200 nmi from the shoreline and is under the jurisdiction of the U.S. Department of the Interior (USDI). Management plans have been developed for the cultural resources within the EEZ by the Outer Continental Shelf (OCS) Region and Minerals Management Service (MMS) of the USDI.

There are three main Acts that address submerged cultural resources: the National Historical Preservation Act (NHPA), the Abandoned Shipwreck Act, and the Florida Historical Resources Act. The NHPA (Section 106) of 1966, as amended, applies to submerged as well as terrestrial cultural resources. The Abandoned Shipwreck Act of 1987 gives the title and jurisdiction over historic shipwrecks to the federal government out to the EEZ. This applies even if the ship is within state waters. Before engaging in an activity that may negatively affect a shipwreck, this Act requires consideration of the effect the activity may have on a shipwreck, often also mandating preservation. The Florida Historical Resources Act protects sites on state-owned land and submerged land within the Gulf. Any excavation or disturbance of a site requires a permit or contract from the Division of Historical Resources, Bureau of Archaeological Research (U.S. Air Force, 1996b).

Submerged Resources Management

The Historic Preservation Plan (HPP) for Eglin AFB contains no guidance regarding the management of the resources within the over water ranges; however, Eglin Cultural Resources Division is responsible for identifying resources and impacts in the EGTTR. Two management plans were reviewed for relevant information.

For the northern areas of the over water ranges that overlie territorial waters, the state is in the process of developing *The Management Plan for Florida's Submerged Resource*s. It is currently in draft form and there is no timeframe for completion (Scott, pers. comm., 2001). When finalized, this document will provide guidance on the consultation and management procedures associated with submerged resources within state waters (equivalent to territorial waters). Consultation procedures cited in *The Management Plan for Florida's Submerged Resources* parallel NHPA Section 106 procedures with added emphasis on the protection of submerged resources through avoidance.

For the portions of the over water ranges situated outside state waters, the *Handbook for Archaeological Resource Protection* developed by the MMS/OCS, USDI, contains prehistoric and historic high-probability zones and guidelines for the identification of submerged cultural resources. These guidelines specify the investigation techniques required to identify potential historic and prehistoric resources in the high probability zones. In the absence of management direction specific to Eglin, a review of the identification procedures is useful.

Historic Shipwrecks

Shipwrecks within Eglin test areas were often the result of natural causes such as severe weather. Literature indicates that less than two percent of pre-20th century ships and less than 10 percent of all ships reported lost in the Gulf between 1500 and 1945 have known locations (MMS, 1990). Ships have been lost since the period of Spanish exploration until the modern age of shipping and commerce.

Spanish exploration and subsequent colonization began in 1508 and lasted for approximately two centuries, growing with a settlement and fort in Pensacola. The Spanish dominated maritime activities with galleons, frigates and various other light and heavy sailing craft. The French began to arrive shortly after, and their numbers increased until 1793. English and Spanish colonists displaced the French during the end of the eighteenth century (CEI, 1977). With the acquisition of Florida and Louisiana, the era of American commerce began and grew between 1830 and 1845, increasing ship traffic for the transport of cotton, lumber, and grain. Offshore in the vicinity of forts, there are numerous shipwrecks from the Civil War (1860-1865) that were used to guard harbor entrances and channels. Between the Civil War and the present, many ships that were used for such things as smuggling, defense, trade, and industry were lost in the Gulf (CEI, 1977; U.S. Air Force, 1996b). There are 271 known shipwrecks listed for the panhandle region of Florida, beginning with the sinking of a fleet of Spanish ships in 1553 and ending with the sinking of a hopper barge in 1986. Due to the sensitive nature of shipwrecks, the locations of known wrecks will not be included in this document.

A study was performed by Coastal Environments, Inc. (1977) that mapped the locations of known shipwrecks. A literature search of both shipwrecks and reported ship losses was combined with factors that are known to affect ship loss (reefs, straits, approaches to seaports, etc.). The results were used to determine areas that may have a high probability for shipwrecks. It was shown that shipwrecks tend to be clustered around navigational hazards and port entrances. Two-thirds of the wrecks were found within 1.5 kilometers of the coastline and 500 wrecks were found between 1.5 and 10 kilometers from the coastline of the northern Gulf (Coastal Environments, Inc., 1977). Texas A&M University performed a study for the MMS that identified approximately 3,500 potential shipwreck locations, thus expanding the database (Garrison et al., 1989). With the data generated from the studies, the MMS has identified high-probability zones for shipwrecks within the offshore area of Pensacola and Apalachicola-Cape San Blas (Garrison et al., 1989). Table 3-16 indicates the potential for shipwrecks within Eglin over-water areas.

Table 3-16. Probability for Cultural Resources within the EGTTR

Airspace Unit	Probability for Prehistoric Resources	Probability for Shipwrecks
S3	Low	High
S4	High	High
S5	Low	High
S6	Low	High
S7	Low	High
EWTA-1	Low	High
W151B3	High	High

Source: U.S. Air Force, 1996b

Eglin has documented the location of known shipwrecks within their over-water ranges (e.g., off the south coast of Cape San Blas), and this information has been given to the Federal Preservation Officer for management considerations. Presently, the Historic Preservation Plan for Eglin AFB does not have any information regarding the management of submerged resources. During the 1960s the U.S. National Park Service (NPS) began to investigate shipwrecks and document their conditions and locations.

Recently, the Submerged Cultural Resources Unit of the NPS began to survey the numerous wrecks in Dry Tortugas National Park. More than 200 known vessels can be found within the park. Florida has created a Management Plan for Submerged Cultural Resources, which provides submerged sites the same level of protection as terrestrial sites, guidance on the management of state owned submerged cultural resources, and a plan for managing state owned historic shipwrecks in accordance with the Abandoned Shipwreck Act.

Prehistoric Sites

Because of the gradual rise in sea level, submerged prehistoric sites may be present in the Gulf. Prehistoric peoples had a tendency to settle near and utilize water resources for food, etc. There was a maximum low sea stand around 16,000 BC to a high at 3,000 to 1,000 BC (Coastal Environments, Inc., 1982). There are two criteria that are used to determine the potential for submerged prehistoric sites: the presence of submerged geologic formations that would have a high probability of associated prehistoric sites and the known natural occurrences that would preserve a site, such as sedimentation and tidal movement. Geologic features in the eastern Gulf (karst topography, relict barrier islands with back barrier bays and lagoons, and coastal dune lakes) are used as indicators of cultural resources and have a high-probability of containing prehistoric sites. The shelf geomorphology across the eastern Gulf is relatively well preserved.

Off central and southern Florida, wave energy is relatively very low compared to coastal Alabama and the west Florida panhandle. Prehistoric site preservation in higher energy sites would likely be low (MMS, 1990). Sites that may exist in a high-probability zone may include Paleo-Indian, Archaic, and Early Gulf formational periods (U.S. Air Force, 1996b).

4. ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This section analyzes the potential environmental impacts of each alternative described in Chapter 2 on the affected environment resources described in Chapter 3. Eglin Air Force Base testing and training mission activities from FY95-99 constitute the baseline and Alternative 1: the No-Action Alternative. The Eglin Gulf Test and Training Range (EGTTR) airspace and the underlying water areas of the Gulf of Mexico constitute the study area for impacts analysis.

To facilitate analyses, each of the baseline activities and the affected environment resources have been condensed into more general mission and resource categories. Baseline mission activities are grouped as Air Operations and Ordnance Testing and Training. Specific mission activities associated with Air Operations and Ordnance Testing and Training are presented in Table 4-1.

Table 4-1. Baseline Mission Summary Categories

Mission Category	Activities
Air Operations	Air Operations Testing and Training
	Air to Air Combat / Onboard A/C Systems
	ECM / Electronic Systems Testing
Ordnance Testing and Training	Air to Air Missiles Testing
	Air to Air Guns / Ammunition Testing
	A/S Bombs and Missiles Testing
	Surface to Surface and Surface to Air Missiles Testing
	Air to Air Combat / Live Missiles Training
	Air to Air Combat / A/C Guns Training

Similarly, the affected environment resources have been grouped into five general resource categories:

- Physical Resources
- Biological Resources
- Threatened and Endangered Species
- Socioeconomic Resources
- Cultural Resources

For the purposes of analyses, an environmental consequence *Issue* is a general category of common ***Effector*** products, by-products, and/or emissions (pollutants) that may be collectively analyzed for potential impacts to the Affected Environment resources or ***Receptors***. Six broad categories of environmental consequence *Issues* have been identified for the Eglin Gulf Test and Training Range study area:

- Restricted Access
- Habitat Alteration
- Direct Physical Impacts
- Noise
- Debris
- Chemical Materials

The specific resources within each of these categories contain similar types of ***Receptors.*** Within each of these resource categories, the potential environmental impacts to ***Receptors*** within the EGTTR study area may be analyzed collectively. Specific resources associated with the Affected Environment categories are presented in Table 4-2. Additionally, following the discussion of mission categories and receptor impacts will be a set of comprehensive appendices including relevant and pertinent laws, regulations, and policies; management practices; detailed noise analyses; and marine mammal strandings.

Table 4-2. Affected Environment Resource Categories

Affected Environment	Specific Resources
Physical Resources	Air Quality Water Quality Noise • Physical Description
Biological Resources	Pelagic Environment Benthic Environment
Threatened, Endangered and Special Status Species	Marine Mammals and Sea Turtles
Socioeconomic Resources	Socioeconomic Environment • Commercial Shipping and Air Traffic • Commercial Fisheries • Employment • Tourist Economic Impact
Cultural Resources	Socioeconomic Environment • Cultural Resources

Effects to EGTTR study area resources are considered adverse if one or more of the following conditions would result from implementation of the alternatives:

- Loss or disturbance of individuals or populations of a federal or state listed threatened or endangered species (i.e. marine mammals and sea turtles). See Appendix A:
  - **16 USC 1531 to 1544-16 USC 1536(a);** 1997-Supp; Endangered Species Act 1973
  - **50 CFR Part 402;** 1996; Endangered Species Act - Interagency Cooperation
  - **50 CFR Part 450;** 1996; Endangered Species Exemption Process
  - **16 USC 1361 et seq. Public Law 92-574;** 1997-Supp; Marine Mammal Protection Act of 1972
- Substantial loss of individuals or populations of a federal candidate, regionally rare, or otherwise sensitive species of concern. See Appendix A:
  - **Air Force Instruction 32-7064;** 22-Jul-94; Integrated Natural Resources Management.

- Net degradation or loss of a sensitive habitat (a habitat is considered sensitive if it is regionally unique, declining, or designated as sensitive by resource agencies (i.e. the Florida Middle Grounds). See Appendix A:
    - **16 USC 1531 to 1544-16 USC 1536(a);** 1997-Supp; Endangered Species Act 1973
    - **50 CFR Part 402;** 1996; Endangered Species Act - Interagency Cooperation
    - **50 CFR Part 450;** 1996; Endangered Species Exemption Process
    - **Executive Order 13089;** 1998; Coral Reef Protection
- Increased risk to marine life and/or reduction in biodiversity or abundance. See Appendix A:
    - **42 USC 4321 et seq.;** 1969; National Environmental Policy Act of 1969.
- Increase in contaminant or pollutant concentrations greater than one percent of the background level in the Gulf of Mexico waters. See Appendix A:
    - **33 USC 1251 et seq.;** 1997-Supp; Clean Water Act.

The format structure of this section is developed in subsections that follow the four alternatives. Subsections are categorized by (1) mission category (Air Operations and Ordnance Testing and Training) and (2) the environmental *issues* followed by (3) identification and analysis of the affected resource(s). Potential issues, previously described in Chapter 2, are noise, restricted access, habitat alteration, debris, chemical materials, and direct physical impacts (DPI). The relationship of these issues to the mission categories and affected environment resources is displayed in a matrix table (Table 4-3).

Table 4-3. Environmental Consequence "Issues" Resulting from *Effector/Receptor* Associations

	MISSION ACTIVITY CATEGORIES	
RECEPTOR CATEGORIES	**Air Operations**	**Ordnance Testing and Training**
Physical Resources	Noise Chemical Materials	Habitat Alteration Debris Chemical Materials
Biological Resources	Noise Direct Physical Impact	Noise Debris Chemical Materials
Threatened and Endangered Species	Noise Direct Physical Impact	Noise Debris Chemical Materials
Socioeconomic Resources	Restricted Access Noise	Restricted Access Noise Debris Chemical Materials
Cultural Resources	Noise	Restricted Access Noise Debris

The following environmental consequences sections provide descriptions of the potential environmental impacts to the affected environmental resources within the Eglin Gulf Test and Training Range study area (Figure 4-1).

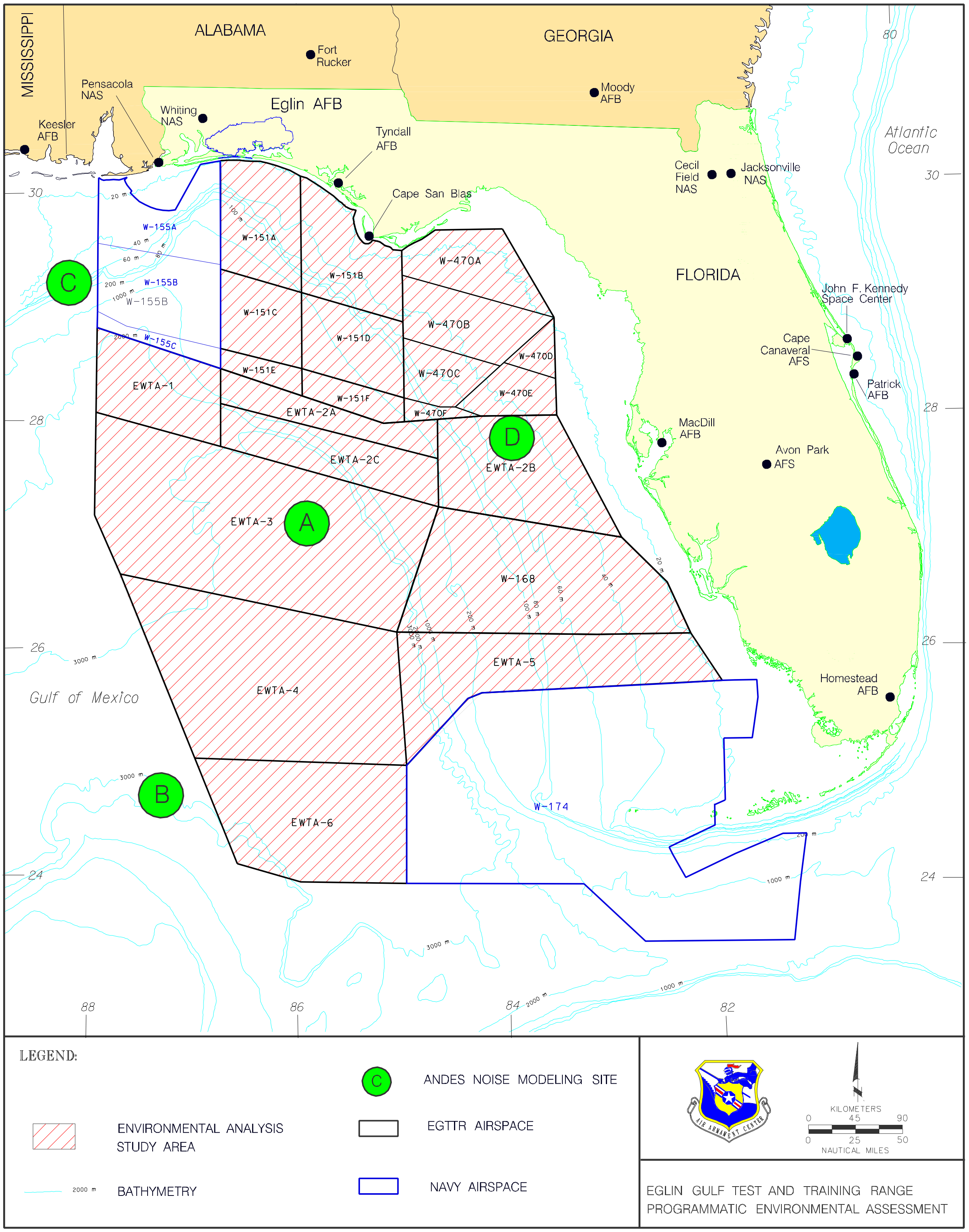


Figure 4-1. The Eglin Gulf Test and Training Range Study Area

4.2 ALTERNATIVE 1: NO ACTION ALTERNATIVE

4.2.1 Air Operations

Mission Description

Environmental consequences resulting from Air Operations within the EGTTR may include air emissions, fuel releases, and noise. Although other expendables, such as bombs, missiles, bullets, drones, chaff, flares, people, boats, and fuel bladders, etc., may have been released or deployed while performing Air Operation activities, these will be discussed in Section 4.2.2, Ordnance Testing and Training.

Table 4-4 indicates the issues arising from the baseline level of Air Operations activities that may potentially impact resources of the EGTTR study area. Noise is generated from subsonic and supersonic flights and can potentially impact marine animals. Direct physical impacts (DPI) of military aircraft with birds are a concern primarily from a human safety standpoint, but also from an environmental standpoint. However, all previous known bird strikes occurred within three miles of shore; therefore direct physical impacts from bird strikes are not a concern for the EGTTR Air Operation activities. Socioeconomic impacts may result when Air Operations testing and training activities mandate closure or restriction of certain air and water areas that the general public uses for fishing, transportation, or recreation. Cultural resource impacts are not anticipated because they are covered (buried) by sedimentation and tidal movement and protected beneath the bottom sediments. Those above the sea floor (i.e. shipwrecks) have been identified and are avoided. The issues of noise, chemical materials, and restricted access are discussed in the following sections.

Table 4-4. Potential Impacts from Baseline Air Operations

	ENVIRONMENTAL ISSUES					
RECEPTOR CATEGORIES	**Restricted Access**	**Noise**	**Habitat Alteration**	**Debris**	**Chemical Materials**	**Direct Physical Impact**
Physical Resources	-	-	-	-	o	-
Biological Resources	-	o	-	-	-	-
Threatened and Endangered Species	-	o	-	-	-	-
Socioeconomic Resources	o	o	-	-	-	-
Cultural Resources	-	-	-	-	-	-

Notes: o Potential Impact - No Potential Impact

Noise

Test and training missions conducted by Eglin AFB result in numerous flight activities in the EGTTR involving a variety of aircraft and missiles flying at a wide range of altitudes and traveling at speeds ranging from slow subsonic to supersonic. Subsonic and supersonic aircraft noise is basically continuous over the EGTTR while missions are in progress. The following discussions characterize and evaluate the potential environmental impacts associated with the above noise sources.

Data available to define and describe flight activities included aircraft types, operational times within specific elements of airspace, speeds and durations for supersonic events, and a range of altitudes flown. The lower ranges of the altitude blocks were emphasized to develop a conservative estimate of the noise produced.

It should be noted that subsonic events are measured using an A-weighted scale and supersonic events are measured using a C-weighted scale. The A-weighted scale places greater emphasis on those frequencies best heard by the human ear. The C-weighted scale gives nearly equal weight to most frequencies, and better reflects low-frequency sounds associated with impulsive noise events. Impulsive noise events are not only sensed by the ear, but also produce effects such as window rattle which influence human reaction to noise. The two metrics are not additive; therefore, they are reported separately.

Using the Air Force's MR_NMAP noise model (Lucas and Calamia, 1996), the uniformly distributed sound level resulting from aircraft operations in each specific airspace element was calculated. Based on an average utilization of each airspace element over the last five years, and operational performance data provided, the Onset Rate-Adjusted Monthly Day-Night Average Sound Level (L_{dnmr}) created by the indicated operations in each parcel is reflected in Table 4-5. Various missiles comprise less than .6% of the total of aircraft and missile sorties and, though not included in the noise analysis, are not sufficient in number to increase the results in Table 4-5.

Table 4-5. Noise Levels in EGTTR Airspace

Airspace	Airspace Area (km^2)	Total Sorties	L_{dnmr}
W-151A	7,668	20,567	61.8
W-151B	7,290	13,031	60.2
W-151C	5,779	9,803	60.1
W-151D	7,003	8,431	58.7
W-151S	2,745	3,410	54.6
W-155A	7,730	1,016	48.3
W-155B	9,038	955	47.4
W-168	28,573	140	27.0
W-470A	6,898	21,722	64.1
W-470B	7,346	20,310	63.7
W-470C	3,978	20,136	66.4
EWTA-1	24,207	15	18.8
EWTA-2	44,752	52	22.7
EWTA-3	42,344	27	20.6
EWTA-5	13,547	8	18.7

Source: Lucas and Calamia, 1996

Ambient background noise is normally estimated to have an average sound level of 35 to 40 dB. Therefore, in aircraft noise analyses, calculated values below 35 are normally reported only as "less than 35," since levels this low would be essentially undetectable over time. However, in this study, actual calculated values are shown for comparative purposes.

Supersonic Noise

Supersonic flight offshore is governed by AFI 13-201, Section 2.11 (Appendix A). Operations in each parcel of airspace were also used to estimate noise levels resulting from supersonic flight (sonic booms). Data supporting this assessment included aircraft types, minimum and maximum altitudes flown, Mach numbers associated with those altitudes, and the durations of those specific events. As with the evaluation of subsonic noise, emphasis was placed on the lower altitude regime to develop conservative estimates.

The airspace parcels considered in this study are used for two broad purposes. The first is air combat training. This training involves use of the airspace by individual or groups of opposing aircraft. They are usually widely separated and use a wide range of altitudes and power settings. However, these aircraft usually fly in the higher altitude ranges (20,000 feet above ground level [AGL] and above). These high altitudes significantly reduce the effects of sonic booms at the surface. The second major use of the airspace involves support for test and training activity that often requires supersonic flight, but at much lower altitudes and often of longer duration than that exhibited during air combat maneuvering. In order to consider all of these uses and develop a conservative estimate of noise resulting from sonic booms, the estimation technique used data developed by running the Air Force's PCBoom3 model (Plotkin, 1995). This single-event model was used to calculate boom footprints on the ground resulting from specific operations conducted by specific aircraft flying a range of trajectories at various speeds and altitudes. In this assessment of supersonic operations, noise values directly along the centerline of the aircraft's flight track ranged from a low of 2.2 pounds per square foot (psf) (108.8 CSEL) to a high of 26.9 psf (130.6 CSEL) (Plotkin, 1995), though psf's between 0.5 and 4.0 are typical for most supersonic flight operations.

These data were then applied using a methodology similar to that used by MR_NMAP to calculate estimated uniformly distributed C-weighted Day-Night Average Sound Levels (shown in L_{Cdn} or CDNL). These processes and their results are explained below. Table 4-6 summarizes data for the assessment performed for supersonic operations of all aircraft in the applicable airspace.

Table 4-6. Supersonic Noise Levels

Airspace	CDNL Value
W-151A	66.3
W-151B	64.6
W-151C	64.7
W-151D	63.1
W-155A	52.6
W-155B	51.6
W-168	28.8
W-470A	68.7
W-470B	68.1
W-470C	70.9
EWTA-1	23.4
EWTA-2	26.8
EWTA-3	24.6
EWTA-5	25.8

Source: Plotkin, 1995

Output from the PCBoom3 program includes information on ground locations of overpressures (in pounds per square foot), sound pressure levels (in dBP), and C-weighted sound exposure levels (CSEL). Collectively, these data enable calculation of CSEL values at incremental ground positions or distances along and on either side of the aircraft's flight track. With this information, the general methodology used by the MR_NMAP program can be employed to calculate uniformly distributed sound levels throughout the airspace. This is described in more detail in Appendix C.

Biological Resources

Marine species at the surface of the water would be exposed to supersonic noise and sonic booms. Due to their hearing sensitivity, cetaceans are of primary concern. Birds at the surface may be startled by supersonic noise but should not be significantly affected.

Air Force and NASA research studies have been examining the potential sonic boom impacts to the subsurface marine environment resulting from low-level supersonic flight. Data indicate that aircraft flights in the range of Mach 4.3 to 4.5 may produce sound waves that can penetrate the water's surface (Rochat and Sparrow, 1995). Some portion of the acoustic energy from this penetrating sound wave will be transmitted to the subsurface environment. Aircraft flights below Mach 4.0 generally produce sound waves that are reflected off the water's surface. Although the sound wave is reflected, some of the acoustic energy may still be capable of penetrating to depths as great as 125 meters below the surface.

Output from the PCBoom3 program includes information on ground locations of overpressures (in pounds per square foot), sound pressure levels (in dBP), and C-weighted sound exposure levels (CSEL). In this assessment of supersonic operations, noise values directly along the centerline of the aircraft's flight track ranged from a low of 2.2 pounds per square foot (psf) (108.8 CSEL) to a high of 26.9 psf (130.6 CSEL) (Plotkin, 1995). Within the W-470 areas, where the highest amount of supersonic activity, and therefore the highest number of sonic booms occurred, bottlenose dolphins are the dominant cetacean. The 26.9 psf generated at the waters surface along the center line of the aircraft flight path equates to less than 1 psi. Since 12 psi is the threshold for Level B harassment (temporary effects to hearing) for dolphins, supersonic noise from EGTTR missions is not likely to adversely impact dolphins or other biological resources.

Socioeconomic Resources

Evaluations of noise impacts to humans are typically discussed in terms of the percentage of the population that would be highly annoyed (disturbed) by the particular noise source. Little information is available to describe the potential population (transient) within the EGTTR at any given time who may experience annoyance due to aircraft activities.

Supersonic noise levels are of relative concern at the altitude blocks below 5,000 feet. Although no threshold criteria exist for areas over the EGTTR, if compared to similar altitude blocks of populated residential areas, approximately 18 percent of the given population would be annoyed. No conclusions can be made from these analyses due to the lack of EGTTR transient population data (population of shipboard individuals) for appropriate comparisons; however, Equation 4.1 does provide an indicator for future comparisons.

Percent of Population Highly Annoyed by C-Weighted Noise:

$$\%HA = \frac{100}{[1 + e^{(11.17 - 0.153 L_{cdn})}]}$$

Equation 4.1

Where: L_{cdn} is the Day-Night Average Sound Level in C-weighted dB.

All of the airspace supporting Eglin's activities in the EGTTR overlies the waters of the Gulf of Mexico. As such, there are no land use planning standards for assessing exposure to elevated noise levels. Furthermore, it is difficult to assess human annoyance from noise exposure since there is no established population present on the surface.

For planning purposes it may be useful to estimate changes in noise impacts resulting from changed use of the airspace. If it is assumed that specific elements of airspace would continue to support similar operations, (i.e., the same relative mix of aircraft types flying similar altitude patterns), it is possible to scale calculated noise levels from one level of operations to another, or to determine the maximum number of operations that could be conducted in the airspace without exceeding a specified noise level. While estimates of proportionality may be somewhat subjective, and it is recognized that scaling will not always yield the same precision as specific calculations, this method is a useful tool to estimate changes. Based on this analysis, noise from air operations within the EGTTR should not adversely impact socioeconomic resources.

Chemical Materials

Air Emissions

Mission generated air emissions were analyzed to enable comparison to National Ambient Air Quality Standards (NAAQS) (Section 3). Activities occurring in the airspace over the Gulf of Mexico that have the greatest potential to impact air quality are aircraft flight operations. In order to conservatively estimate the potential impact of these operations to ambient air quality, a "closed box assessment" was performed. The closed box assessment and results are described below.

The Closed Box Assessment

The closed box assessment provides a means to estimate maximum short-term impacts from aircraft emissions in a given element of airspace. Several assumptions are incorporated into this technique. First, it assumes that aircraft emissions are homogeneously mixed and contained within a defined volume of airspace through which the aircraft operate. For these assessments, this volume of air is described by the vertical boundaries of the airspace considered and an altitude of 3,000 feet above sea level (ASL).

Second, it is assumed that the calculated concentrations of criteria pollutants within the defined box resulting from aircraft operations are representative of the maximum resultant ground-level (i.e. sea level) concentrations. Because of these assumptions, the results of these calculations are expected to indicate somewhat higher air quality impacts than those that would result from a more structured dispersion model. However, the results do provide a maximum impact scenario for comparison with established ambient air quality standards.

For these assessments, it was assumed that aircraft operating in a specific airspace element operated randomly throughout the airspace. However, focus was placed on aircraft operating at or below 3,000 feet ASL. The ceiling of 3,000 feet was chosen as a conservative estimate of the average height of a stable temperature inversion common to the area. This type of inversion can significantly inhibit, if not effectively block, vertical mixing and widespread dispersion of some air pollutants. Such pollutants can be considered confined between the base of the inversion and the ground, or that portion of the lower atmosphere commonly termed the mixing layer. The mixing-layer height determines the vertical extent of the dispersion process for pollutant releases below the mixing height, while releases above this height are assumed to have no ground-level impacts.

To develop a one-hour worst case condition for the scenario, the estimated daily average number of sorties over the period of record (FY95-99) for those aircraft using a specific element of airspace below 3,000 feet ASL were calculated (approximately 10) and then all sorties were considered to be flown during the same one-hour time frame. Emissions for applicable pollutants were then summed.

To compare these calculated one-hour emissions contributions with the NAAQS, which are structured for various time frames, the one-hour emissions were converted to the appropriate time frames using suggested USEPA power-law conversion factors. For averaging times greater than one hour, the maximum concentration will generally be less than that one-hour value. The results of the "closed box assessment" for the Eglin test ranges are compared with the NAAQS in Table 4-7 (a and b). The comparison is limited to those criteria pollutants directly associated with aircraft emissions. Ozone is not included since it is not a direct emission. Ozone results from complex photochemical reactions involving other substances and sunlight. Due to the complexity of these reactions, and the specific environmental conditions necessary for ozone production, ozone levels are not estimated. However, as will be seen in all of the analyses performed to estimate air quality impacts resulting from Eglin operations, those substances considered as ozone precursors have concentrations at such low levels it is reasonable to assume that ozone resulting from these emissions would be of similarly small quantities.

Table 4-7a. Closed Box Assessment Results

Criteria Pollutant	Averaging Time	NAAQS	Eglin Water Test Area (EWTA) Blocks				W-151 Blocks				
			1	2	3	5	A	B	C	D	S
CO	1-hour	40 mg/m^3	7.31E-09	1.31E-08	4.68E-09	1.98E-08	2.79E-05	1.54E-05	1.34E-05	9.57E-06	2.58E-05
	8-hour	10 mg/m^3	5.12E-09	9.17E-09	3.28E-09	1.39E-08	1.95 E-05	1.08 E-05	9.38E-06	6.70E-06	1.81 E-05
NO_2	Annual	100 μg/m^3	6.70E-06	1.34E-05	8.00E-06	7.17E-06	8.58E-02	5.26E-02	5.37E-02	3.77E-02	3.30E-02
SO_2	3-hour	1300 μg/m^3	4.68E-07	1.27E-06	6.58E-07	1.09E-06	5.37E-03	3.43E-03	3.04E-03	2.12E-03	4.08E-03
	24-hour	365 μg/m^3	3.27E-07	8.87E-07	4.60E-07	7.60E-07	3.75E-03	2.39E-03	2.12E-03	1.48E-03	2.85E-03
	Annual	80 μg/m^3	1.21E-07	3.27E-07	1.70E-07	2.80E-07	1.38E-03	8.84E-04	7.83E-04	5.46E-04	1.05E-03
PM_{10}	24-hour	150 μg/m^3	2.56E-07	4.44E-07	3.23E-07	1.53E-07	4.01E-03	2.48E-03	2.63E-03	1.88E-03	1.14E-03
	Annual	50 μg/m^3	9.46E-08	1.64E-07	1.19E-07	5.63E-08	1.48E-03	9.16E-04	9.69E-04	6.93E-04	4.19E-04

Table 4-7b. Closed Box Assessment Results

Criteria Pollutant	Averaging Time	NAAQS	W-155A	W-155B	W-168 A/B/C	W-470A	W-470B	W-470C
CO	1-hour	40 mg/m^3	1.62E-06	1.08E-06	8.67E-08	2.41E-05	2.17E-05	3.94E-05
	8-hour	10 mg/m^3	1.13E-06	7.42E-07	6.07E-08	1.69E-05	1.52E-05	2.76E-05
NO_2	Annual	100 μg/m^3	4.30E-03	3.81E-03	6.72E-05	1.23E-01	1.10E-01	2.02E-01
SO_2	3-hour	1300 μg/m^3	2.95E-04	2.52E-04	8.09E-06	6.06E-03	5.30E-03	9.71E-03
	24-hour	365 μg/m^3	2.06E-04	1.76E-04	5.66E-06	4.23E-03	3.71E-03	6.79E-03
	Annual	80 μg/m^3	7.60E-05	6.51E-05	2.09E-06	1.56E-03	1.37E-03	2.50E-03
PM_{10}	24-hour	150 μg/m^3	2.92E-04	3.38E-04	1.65E-05	6.15E-03	5.63E-03	1.03E-02
	Annual	50 μg/m^3	1.08E-04	1.25E-04	6.10E-06	2.27E-03	2.08E-03	3.81E-03

Physical Resources

As shown in the analysis, due to the vast areas encompassed by these airspace elements, and the relatively few aircraft operations occurring below 3,000 feet, aircraft operations from Eglin AFB produce an almost insignificant impact on air quality over the Gulf of Mexico. The highest pollutant concentration (NO_2) contributed just 0.09 percent of the total National Ambient Air Quality Standard concentration for that pollutant. Therefore, no adverse air quality impacts to the physical/chemical, biological, or anthropogenic environments are anticipated.

Fuel Releases

Fuel release events may occur within EGTTR airspace during air-to-air refueling, testing or training involving full-scale or sub-scale drones that are downed into the water, and In-Flight Emergencies (IFE) in which fuel tanks are jettisoned from the aircraft. Table 4-8 and Table 4-9 report the average maximum annual usage of full-scale and sub-scale drones over the five-year baseline period and the estimated average number of IFEs, as well as estimated quantities of jet fuel released into the ROI.

Table 4-8. Estimated Volume of Fuel Released to ROI, Alternative 1

Drone Type	Quantity[1]	Average Fuel Amount (gallons/drone)	Total Fuel Released (gallons)
QF-4	21	1,030	21,630
QF-106[2]	35	735	25,725
BQM-34	20	40	800
MQM-107	23	30	690
		TOTAL	**48,845**

[1]The maximum yearly number of downed drones and sorties was used as the baseline to reflect the highest typical usage of the EGTTR.
[2]The QF-106 was replaced by the QF-4 in 1998.

Table 4-9. Estimated Fuel Release from In-flight Emergencies (IFEs)

Aircraft Type[1]	IFE Sorties which Released Fuel[2]	Average Released Fuel (gallons/sortie)[3]	Total Fuel Released (gallons)	Fuel (gal) Reaching Surface
F-15/F-15E	220	735	161,700	1,620
F-18	4	735	2,940	30
F-111[5]	2	735	1,470	20
F-117	.2	735	150	2
AC/MC/C-130[4]	.5	1,470	700	10
		TOTAL	**166,960**	**1,682**

Source: U.S. Air Force, 1996, 1998, 1998a, 2000, 2000a
[1]F-16s were also utilized, but do not have fuel jettisoning capability.
[2]IFE sorties estimated based on 1) 4.0% of total F-15 sorties underwent IFE; 0.3% of total AC/MC/C-130 sorties and 2) only 5% of IFE sorties released fuel.
[3]Modeled conditions for F-15: 5,000 feet altitude (minimum for IFE), speed of 400 knots, wind speeds of 2.51 knots, ejected fuel load of 735 gallons would result in only approximately one percent of fuel load landing on the surface, with 99 percent evaporation before fuel hits the ground (Fuel Jettison Simulation FJSIM 1.01, Continuum Dynamics, Inc).
[4]Average volume of fuel potentially released during an IFE is twice that of the F-15 or about 1,470 gallons.
[5]This aircraft has been retired and is no longer in Eglin AFB inventory.

Air-to-air refueling operations are typically conducted at higher altitudes ranging from 16,000 to 26,000 feet for receiving aircraft. Fuel dispensing aircraft are of three types (KC-135s, KC-10s or C-130s) that are fitted with instantaneous, automatic closure devices (poppet valves) to reduce fuel loss during transfers. Estimates of fuel losses during refueling events are on the order of one quart during normal transfers and one- to two-gallons or less during unplanned, emergency breakaways.

Since most drone target testing occurs at higher altitudes, a significant portion of the fuels and oils stored within the target drones volatize during descent if released. Table 4-8 presents fuel capacities for each drone category. Analyses in this section will assume that the maximum possible volume of fuels was introduced into EGTTR waters as a conservative scenario. The full-scale QF-106 and QF-4 drones contained significantly higher fuel volumes than either of the sub-scale drones. Total fuel released into the ROI environment from the maximum baseline level of drone use per year was estimated at 49,000 gallons. QF-106 drones are no longer in use, having been replaced by the QF-4.

During IFEs, pilots release fuel to lighten the aircraft, facilitating aircraft maneuverability and increasing chances for a safe return. Fuel is never released in the EGTTR at altitudes below 3,000 feet during IFEs and pilots typically release fuel gradually (i.e. 1-2,000 pounds of fuel per minute). Jet pilots do not track or collect data on jettison frequencies or volumes of fuel discarded; hence the number of IFE occurrences for F-15s is estimated to be approximately 2 - 4 percent (4 percent used in calculations) of all sorties flown. Assuming that 4 percent of all F-15/F-15E/F-18/F-111 sorties released an average amount of 735 gallons of fuel during an IFE, an estimated 167,000 gallons of fuel were deposited into the ROI environment from F-15s. Estimates of fuel ejected from IFEs for the AC/MC/C-130s are significantly lower due to a lower frequency of sorties and lower occurrence of IFEs (0.3 percent occurrence for all sorties), although the average volume of fuel potentially released during an IFE is twice that of the F-15. This results in an estimate of 700 gallons of fuel deposited into the environment from AC/MC/C-130 IFEs.

Fuel releases from IFEs and downed target drones may potentially impact air quality and water quality within the ROI. The descent of fuel through the atmosphere will cause a significant portion of fuel to evaporate into the air, while the remaining liquidized fuel will be deposited onto the surface of marine waters. Fuel evaporation may compromise air quality temporarily, but should quickly dissipate with atmospheric circulation. Air criteria for evaporated petroleum products are not presented as part of the NAAQS criteria; consequently, a threshold level for air contamination is not discussed. The primary contamination concern for fuel spills over Gulf of Mexico waters is the impact of residual petroleum products on biological resources within the water column.

Preliminary research describing the physiological effects of petroleum distillates on marine biological species including invertebrates and fish suggest that some liver, renal, neurological and pulmonary toxicological effects may occur (Pfaff et al., 1995; Davison et al., 1993; Stafford, 1989; Spain and Somerville, 1985). Bioaccumulation of JP-8 is not expected to occur within marine fish species, even under extended exposures (USDH & HS, 1993). Jet fuel is composed of various hydrocarbons in the form of alkanes and aromatics. Toxicity of these individual hydrocarbons has been reported on some species of fish, mussel larvae and marine worms (Table 4-10). As a worst-case scenario, a toxicity of 1 mg/L for jet fuel (considering all components) is considered in the following analysis.

Table 4-10. Toxicities of Hydrocarbons Constituting Jet Fuel

Compound	Aqueous Solubility (mg/L)	Toxicity (mg/L)	Persistence (half-life; days)
n-hexane[1]	9.5	LC_{50} = >100 (fish)	4
n-decane[1]	0.004	EC_{50} = >10 (mussel)	4
n-tetradecane[1]	2.82×10^{-4}	Not known	4
benzene[2]	1,780	LC_{50} = 5.8 - 46 (several fish species)	Not known
naphthalene[2]	32	LC_{50} = 1.24 – 150 (fish)	1.5
benzo(a)pyrene[2]	0.0037	LC_{50} = >1 (marine worms)	16

[1]alkanes [2]aromatics

LC = That concentration of material that is lethal to one-half (50%) of the test population of aquatic animals upon continuous exposure for 96 hours or less (40CFR116.3).

EC = That experimentally derived concentration of material in dilution water that is calculated to affect 50% of a test population during continuous exposure for a specified time (40CFR797.1300-1).

Source**:** Connell, 1996

The following analysis demonstrates that the amount of fuel deposited into the waters of the ROI during a baseline year from IFEs and drones (Tables 4-8 and 4-9) does not negatively impact water quality. The analysis assumes that the surface area underneath the EGTTR airspace (3.5×10^{11} m^2) is a confined box with a depth extending down to 0.5 m, creating a liquid volume of 1.7×10^{14} L which does not interact with other Gulf of Mexico waters. For the maximum baseline year, where estimated amounts of fuel are released as described in Table 4-9, 167,000 gallons of fuel are released from EGTTR aircraft operations. For the "closed box" illustration, this amounts to approximately 3 μg/L.

In reality, a significantly lesser fraction of fuel actually reaches the water surface in a baseline year, such that 167,000 gallons is a large overestimate. This is because a large fraction of the fuel is evaporated in the atmosphere as it descends to the surface. A computer simulation model indicates that at 5,000 feet altitude (minimum for IFE), an airplane speed of 400 knots, with wind speeds of 2.51 knots, a fuel load of 735 gallons ejected from an F-15 would result in only approximately 1 percent of fuel load landing on the surface, with 99 percent evaporation before fuel hits the ground (Fuel Jettison Simulation FJSIM 1.01, Continuum Dynamics, Inc.). Thus for a baseline total of 167,000 gallons released, the concentration would be .03 µg/L of petroleum product. Additionally, these petroleum products have short half-lives, and consequently do not persist in the marine environment for very long. Baseline levels of aircraft use and target drone use within the EGTTR airspace under Alternative 1 are not anticipated to significantly impact air or water quality in the EGTTR study area.

External fuel tanks are typically utilized as an auxiliary fuel source during long-range or high-performance missions. Nearly all training missions (and most testing missions) at Eglin AFB carry external fuel tanks. If a fuel tank jettison test is conducted, standard operating procedures require the tanks to be filled with water or remain empty during the test. Jettison of external tanks containing jet fuel only occurs in cases of extreme emergency or pilot error (e.g., during FY96 one F-15 aircraft erroneously jettisoned a 660-gallon external tank partially filled with fuel). External tanks are constructed of aluminum, have a capacity in excess of 600 gallons (e.g., F-15 tanks hold 660 gallons and F-16s may hold up to 670 gallons in wing and centerline tanks combined), and typically fragment on impact when jettisoned. Other than the one incident in FY96, there were no other fuel tank releases involving fuel. All other external fuel tanks released over the EGTTR during the baseline years (listed under the expendables column in Table 2-1) contained water or were empty.

Physical Resources

Temporary localized effects to air and water quality may result from fuel releases. Compromised air quality due to fuel contamination may occur temporarily, but should quickly dissipate with the evaporation and dispersion of the release. Naturally occurring air currents, wind velocity, and fast moving storm systems should minimize any potential long-term adverse impacts to air quality. The location of the test range in open water, Gulf diurnal tidal cycles, and high wave action caused by wind and storms should minimize the potential for adverse impacts. The physical characteristics of the fuel (e.g. volatility and solubility) should also help to minimize impacts to air and water quality. Adverse impacts from fuel releases to physical resources are not anticipated.

Biological Resources

Preliminary research describing the physiological effects of JP-8 and other petroleum distillates on biological species including invertebrates (soft shell clams), fish (salmon), and human subjects suggests that some liver, renal, neurological, and pulmonary toxicological effects may occur (Pfaff et al., 1995; Davison et al., 1993; Stafford, 1989; Spain and Somerville, 1985). However, the exact toxicological mechanism for these effects remains unknown and would benefit from further research. No evidence of mutagenic risk as a result of exposure has been documented to date. Data indicate that JP-8 is relatively nontoxic to humans through direct exposure (i.e., non-irritating to the eyes, and only slightly irritating to the skin).

Phytoplankton and zooplankton species have patchy distributions throughout the EGTTR study area waters. Effects from localized fuel releases, although potentially damaging to local populations, will have little or no effect on eastern Gulf plankton populations. Following a fuel release, fuel concentrations evaporate or are diluted through wave action, currents, and tides, resulting in minimal impacts to plankton communities. Fuel releases would not significantly impact invertebrate populations within the ROI. The volatile nature of JP-8, in conjunction with the location of the test ranges over deep, open waters and the weather and topography of the region tends to minimize any potential low-level adverse impacts that may occur to invertebrates as a result of fuel releases. Further, it has been suggested that exposure to JP-8 is not likely to result in adverse bioaccumulative effects (USDH &HS, 1993).

Habitat degradation within the water column that might adversely affect feeding, breeding, and spawning of fish is not anticipated from fuel releases. The releases would be localized and the fuel's fate in the water column would be short-term based on its volatility and non-persistent behavior. Additionally, JP-8 fuel's localized impacts to fish would be further reduced by the mobility of the fish species and their ability to move away from regions of degraded water quality.

Long-term bioaccumulation of petroleum contaminants in fish tissue, and in prey tissues, has potentially adverse impacts depending on the location, frequency, and historical record of fuel release events. Bioaccumulation of JP-8 is not expected to occur within marine fish species following extended exposures (USDH&HS, 1993). Due to the volatile nature of fuels, releases are likely to impact only a small area. Wind, wave action, and ocean currents further facilitate fuel dilution and dispersion, reducing the potential for adverse effects. In addition, fuel releases occur sporadically, triggered either by accident or aircraft emergency and do not result in large concentrations of fuel being released in one specific area. These factors minimize the potential adverse effects from fuel releases to fish populations and the Gulf fish community at large. In general, fuel releases should not significantly impact healthy stocks of widely-dispersed pelagic and benthic fish.

Fuel releases are not expected to directly impact marine birds and neotropical species. Indirect effects, such as toxic contamination of prey species, is not likely to occur as JP-8 fuel does not bioconcentrate up the food chain. Additionally, fuel releases are not expected to adversely affect marine mammal populations within the Gulf. Except in cases of a tank jettison, the tendency for marine mammals to avoid regions of reduced water quality, particularly waters having reduced visibility (Dohl et al., 1983), lessens the opportunity for direct exposure.

Indirect impacts to marine mammals from feeding are also expected to be negligible. Although marine mammals feed primarily on fish or planktonic species of the region, the limited exposure of prey species to fuel releases (see previous discussion of plankton communities and fishes) reduces the potential for contaminant bioaccumulation within marine mammal fatty tissues. Furthermore, because many JP-8 contaminants are volatile, their bioaccumulation potential within marine mammal species is not expected to be high (USDH&HS, 1993). Despite the negligible probability of adverse effects, preventative measures may be warranted to reduce the chance of any potentially damaging interactions. Avoiding migrating pods and areas known to have a high density of marine mammals will minimize the potential for adverse impacts.

Threatened and Endangered Species

Due to their limited numbers, species that are federally or state protected or identified as having special status warrant particular attention when assessing the potential for adverse effects created by a specific action. Because species abundances are already diminished, adverse impacts to one or more individuals may result in significant adverse effects to the remaining population at large. The mechanisms by which these impacts may potentially occur are similar to those previously described for fishes and marine mammals (i.e., degradation of habitat, direct exposure and toxicity, and increased potential for bioaccumulation of contaminants).

In contrast to EGTTR fuel releases, spills associated with other non-Air Force activities may result in significantly larger volume releases to the environment. For example, oil and other contaminant spills from offshore petroleum operations during a similar, one-year time frame (i.e., 1990) resulted in approximately 918,572 gallons (29,161 barrels) of diesel, oil, and other pollutants being released into the environment. Offshore spills during transportation result in an additional 2.8 million gallons (0.089 million barrels) of petroleum products being released into the environment. A comparison of Eglin AFB annual fuel releases to oil and fuel spills associated with petroleum operations (approximately 3.72 million gallons annually) indicates that Eglin testing and training operations are conservatively estimated to contribute less than 2 percent of oil/fuel contaminant volumes relative to petroleum operations. This comparison does not include petroleum contributions from commercial and recreational boating vessels.

In general, fuel release impacts are expected to have minimal or no effect on most resources within physical, biological, anthropogenic, or socioeconomic environments due to the extremely low incidence of recorded fuel release events and high rate of evaporation for JP-8. Localized degradations in water quality may temporarily affect the distribution of threatened and endangered species and fish populations. Cumulative effects are not expected for threatened and endangered species, fish populations, or commercial fisheries.

Restricted Access

The EGTTR is composed of Warning Areas 151, 168, 174, and 470 plus the individual Eglin Water Test Areas (EWTAs) 1 through 6. The Warning Areas and EWTAs only include the airspace. There are no restrictions on public or commercial use of the surface waters. The Warning Areas altitudes and activation periods are defined in FAA Handbook 7400.8B. These areas are restricted to DoD use except when the airspace controlling agency either authorizes joint use or turns the airspace back over to FAA control. The EWTAs are governed by a Letter of Agreement between Jacksonville, Houston, and Miami ARTC Centers, Training Air Wing Six (Navy Pensacola), and the Air Force Air Armament Center (Eglin AFB), and are only activated upon request. All requests must give at least two working days notice prior to activation. Once activated, they carry the same restrictions as any Warning Area plus those included in the Letter of Agreement. A Warning Area restricts all public and commercial use of the airspace due to the hazardous nature of military testing and training.

Airspace Restrictions

As stated above, all parts of the EGTTR, when activated, are Warning Areas that restrict all public and commercial use of this airspace. In general, the level of military activity in areas surrounding Eglin AFB is considered to be moderate. General aviation airfields have been identified and flight avoidance procedures have been effective in reducing the potential of any civilian-military aircraft interactions. Commercial air traffic routes generally follow the southern border of test areas W-168 and EWTA-3 and do not conflict with testing or training missions within the EGTTR. The airspace that does conflict with these commercial routes is activated on an average of two times per year. Closures must comply with the limitations as stated in the Letter of Agreement. These closures for operation above FL240, cannot exceed four hours and at or below FL240 the block of time is not to exceed 12 hours. There will also be a minimum of three hours between successive blocks to permit utilization of the airspace by nonparticipating aircraft. Based on previous mission activities within the EGTTR, restricted access should not impact socioeconomic resources.

4.2.2 Ordnance Testing and Training

Baseline Description

Ordnance testing and training involves a variety of activities employing the use of bombs, missiles, aircraft guns, small arms, drones, chaff, flares, rockets, N troop, smokes, and obscurants. Nearly all of the A/S Gunnery and small arms missions occurred in the W151 airspace blocks (A-D), while the majority of drones were downed in W-470. The number and distribution of items expended within the EGTTR are listed in Table 2-1. A brief description of all categories of expendables follows.

Bombs and Missiles

The majority of bombs dropped during test and training activities at Eglin Air Force Base are unguided, unpowered weapons. Some bomb types are laser-guided, allowing them to lock onto a target while in freefall. Others employ a variety of techniques to help guide them to their surface targets. It should also be noted that 3.5 percent of the total bombs released in the EGTTR contained live unfused warheads (5 live out of the 142 total bombs dropped), a higher number than is usual. All five live bombs were utilized as a result of having no inert substitute bombs (CBU-87) on hand in the inventory at the time of the test. Rather than delay the test one year and incur a substantial cost increase, live bombs were used. No permanent surface targets exist in the EGTTR, and since terminal effects are seldom a test objective, nearly all bombs are inertly released.

The primary explosive used in bomb technology is Tritonal, a mixture of 80 percent TNT and 20 percent aluminum. Other types of explosives include Minol (40 percent ammonium nitrate, 40 percent TNT, and 20 percent aluminum), Minol II (40 percent TNT, 40 percent ammonium nitrate, and 20 percent aluminum), and H-6 (45 percent RDX, 30 percent TNT, 20 percent aluminum, 5 percent D-2 wax, and 0.5 percent calcium chloride).

Most bomb types are constructed of hardened or cast steel, the thickness of which depends on the degree of fragmentation desired upon impact. The 2.75" (diameter) rockets (Army Aviation) have brass outer casings. All bombs released into the EGTTR are assumed to remain relatively intact without casing ruptures. Characteristics of bombs and missiles released over the EGTTR are presented in Table 4-11.

Table 4-11. Alternative 1 Bombs and Missiles Expended Over the EGTTR (FY95-99)

Ordnance	Class						Explosive	
Name	**Code**	**Weight (lbs)**	**Length (in.)**	**Diameter (in.)**	**Speed (mach)**	**Range (nm)**	**Weight (lbs)**	**Type/Composition**
Sparrow	AIM-7M	510	147	8	3.5	21.7	26 & 36	PBXN-3 and classified
Sidewinder	AIM-9M	195	113	5	2.0	8.7	7.4	PBXN-3
AMRAAM	AIM-120	345	144	7	4.0	26.9	49	RDX
Powered Standoff Weapon	AGM-130	2,980	156	15	Classified	12.9	535 and 945	Tritonal
Patriot	MIM-104	2,200	210	16	3.0	37.0	200	Classified
500 lbs GP Bomb	MK-82	500	66.15	10.75	Unpowered	N/A	192	Tritonal, Minol, or H-6
500 lbs GP Bomb	MK-82 SE	500	66.15	10.65	Unpowered	N/A	192	Tritonal, Minol, or H-6
2000 lbs GP Bomb	MK-84	2,000	129	18	Unpowered	N/A	945	H-6 or Tritonal
25 lbs Practice Bomb	BDU-33	25	22.9	4	Unpowered	N/A	0	None
Paveway I & II	GBU-10	2,562	172	15/18	Unpowered	N/A	535/945	Tritonal
Paveway I & II	GBU-12	800	129	11	Unpowered	N/A	192	Tritonal and PBXN-109
Rockeye II	MK 20	476	95	13	Unpowered	N/A	98.8	N/A
Navy Standard Block II	SM-2	1,100	175	13.5	N/A	40-90	N/A	N/A
N Troop rocket	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
AP/AM	CBU-58	818	86	16	Unpowered	N/A	N/A	N/A
CEM	CBU-87	961	92	17	Unpowered	N/A	N/A	N/A
Gator	CBU-89	710	92	17	Unpowered	N/A	N/A	N/A

Source: U.S. Air Force, 1996b
N/A = Not applicable or information not available

Missiles are categorized as Air Intercept Missiles (AIM), Air-to-Ground Missiles (AGM), or Surface-to-Air Missiles (SAM). Only 4.4 percent of the total missiles fired contained a live warhead during FY95 (17 live out of a total of 384 total missiles launched). A telemetry package for gathering data on missile performance was installed in place of the warhead in the remaining 367 missiles.

Chaff

Chaff is primarily used as a defense mechanism and is released from engaged aircraft. Discharge of chaff results in the release of millions of aluminum dipoles (short fibers similar in appearance to human hair) that create an electromagnetic cloud around the aircraft, shrouding the plane from enemy radar and defense systems.

There are two types of chaff: aluminum foil and aluminum-coated glass fiber. Although no longer manufactured, foil chaff is still found in inventory and used primarily by B-52 bombers. Foil and fiber are cut into dipoles ranging in length from 0.3 to over 2.0 inches. The foil dipoles are 0.45 mils thick and 6-8 mils wide. Glass-fiber dipoles are 1 mil in diameter.

Both types of chaff have a slip coating to minimize clumping of dipoles when ejected. The slip coating is a 1 percent solution of Neofat 18 (90 percent stearic acid and 10 percent palmitic acid) with naphtha as the solute. The naphtha volatilizes during the curing process. The older foil chaff is packaged in cardboard boxes, while the glass fiber chaff is packaged in plastic tubes. Historically, foil chaff contained lead imbedded in the cardboard packaging. Though this practice ended over 10 years ago, chaff with lead-containing packaging still exists in DoD inventory and may still be deployed in the EGTTR.

Chaff can be ejected from the aircraft either mechanically or pyrotechnically. Mechanically ejected, the cardboard box of dipoles is literally torn open by the air stream as it is released from the aircraft. Pyrotechnic ejection uses either propulsion derived from an enclosed explosive cartridge (aluminum-coated glass fiber method) or, as used with the foil dipoles, a small plastic cassette that has an internal pyrotechnic train with an initiator and explosive cord that fractures the case after ejection.

Environmental Effects from Chaff Deployment

The main chemical component of concern in chaff is aluminum. Due to the wide dispersion over enormous areas of the eastern Gulf, chaff dispersion would vary for each of the water ranges (W-155, W-151, W-470, NOVA 1, and NOVA 2, and W-168). A small portion of the chaff may dissolve over time. The assessment model assumes that the total annual amount of chaff used during the baseline was analyzed for effects to the eastern Gulf. Test results demonstrate that approximately 0.06 percent of the initial aluminum weight would dissolve in seawater (U.S. Air Force, 1996). Although no criteria exist for aluminum (Al) in oceanic waters such as the Gulf of Mexico, Al is a naturally occurring trace element (river input) in seawater and found at variable concentrations.

A Navy study (Block and Schiff, 1977) was conducted on the effects of chaff on various marine organisms from Chesapeake Bay waters. Under laboratory conditions, the organisms were exposed to higher concentrations of chaff than would have occurred with normal chaff use for training purposes. No effects to the organisms were noted. It was concluded that continued use of chaff at rates similar to those already used by the Navy would have no environmental effect on the Chesapeake ecosystem. The effects of oceanic circulation would further reduce the potential effects. This would further dilute concentrations by dispersing the chaff over larger areas.

A remote potential does exist for clumps of chaff to be mistaken as a food source and unintentionally ingested by aquatic organisms. However, the chances of this are unlikely, given the amounts of chaff deposited, and the wide dispersion of the clumps into individual fibers.

Similarly, regarding injury to biological resources, the Final Report on the *Environmental Effects of Self-Protection Chaff and Flares* (U.S. Air Force, 1997) evaluated the risk of injury from chaff debris. The study concluded that these components weigh so little that no injury would be anticipated if a person were to be struck. It may reasonably be assumed that no marine resources, such as marine mammals, fish, or sea turtles would be hurt. Therefore, no adverse effects to fishes, marine mammals, sea turtles, threatened or endangered species would result from chaff deployment over the eastern Gulf.

Flares

Flares are high temperature heat sources that are ejected from aircraft to confuse and divert enemy heat-seeking or heat-sensitive missiles. Flares are also used to illuminate surface areas during nighttime operations.

Flares are rectangular in shape and primarily consist of magnesium and Teflon™ (polytetrafluoroethylene). Flares are wrapped with an aluminum-filament-reinforced tape and packaged in an aluminum tube. The flare is ejected by means of an electrically controlled pyrotechnic impulse cartridge, which produces hot gases when activated. Burning for less than 10 seconds at approximately 2,800°C (5100° Fahrenheit), the flare is designed to be fully consumed before reaching the ground.

Surface and illumination flares are utilized in testing and training missions to illuminate an area that would otherwise be obscured by darkness, fog, or mist. Within the EGTTR, surface flares generally serve as nighttime illumination during paratroop activities, or as ocean surface markers during A/S Gunnery training. Only 32 illumination flares deployed with parachutes were used in 1998 for test purposes only. The surviving metal canisters (10 lbs) sink the parachute to the sea floor. Future testing of parachute flares is not anticipated in the EGTTR. Surface flares utilized during Eglin testing and training operations over the EGTTR include the MK-25 and MK-58 marine markers. The primary output of surface or illumination flares is light. Heat and debris in the form of spent casings, unconsumed fuel, and ash are considered minor expenditures when compared with the intensity and duration of light cast in the surrounding environment by the MK-25 and the MK-58 during use. Proper usage of the MK-25 and MK-58 ensures expenditure of all usable ignition material.

Environmental Effects from Flare Deployment

The type of flares typically used in training missions in the affected area is the MJU-7 flare. This flare weighs approximately 369 grams (g) (0.813 pounds) and is typically housed in a thin aluminum case that has an impulse cartridge and piston at one end and a felt spacer and plastic or aluminum cap at the other. The MJU-7 flare contains approximately 285 grams (0.628 pounds) of energetic material. This energetic material is referred to as the flare "pellet." The primary constituent of the pellet is magnesium (Mg), which is the energetic material. The pellet also contains minor compounds (polytetrafluoroethylene [or Teflon™] and fluoroelastomer) used to coat the pellet (U.S. Air Force, 1997). The actual percentages of the constituents vary among the flare manufacturers and are proprietary information [40 CFR 1502.22 (b)1]. When ignited, the flares burn at 2,800° C (5100° Fahrenheit) for approximately five seconds (U.S. Air Force, 1999).

The principle chemical element of concern regarding the use of the MJU-7 flare is magnesium, and therefore this assessment will focus on the potential impacts associated with the release of this chemical. For this assessment, it was assumed that the entire pellet weight (285 g) was comprised of magnesium. This represents an overestimate because there are other minor constituents present. Upon burning, the magnesium (as magnesium oxide) in the flare pellet may be deposited on marine waters, with the distribution of the products dependent on environmental factors such as wind direction and strength.

In order to analyze the impact of magnesium on the marine environment, the surface area beneath the airspaces were assumed to be a "closed box" with a depth extending down to one meter. The assessment model assumed that the annual quantity of magnesium potentially available from the flare would dissolve in the water. The model also assumed that the total quantity of magnesium from flares expended during the year was added to the seawater at one time.

The total amounts of magnesium added to the Gulf surface waters would be less than 1.40 μg/L (W-151) and 10.09 μg/L (W-470) and represents less than 0.0002 (W-151) and 0.0005 (W-470) percent of the background concentration (1.35 g/L) of Mg in the Gulf surface waters. Due to the fact that the extremely small amounts of magnesium introduced into the seawater would be significantly lower than natural concentrations naturally found in the Gulf, no adverse effects are anticipated to fishes, marine mammals, sea turtles, nor threatened or endangered species as a result of flare use over the eastern Gulf.

Drones

Drones are remotely piloted or automatically piloted target aircraft. Drones are categorized as either full-scale or sub-scale. Full-scale drones include QF-106s and QF-4s, while sub-scale drones include BQM-34s and MQM-107s. Drones (when destroyed) are predominantly composed of aluminum and petroleum products. During the timeframe of the baseline, the QF-106 was phased out and replaced with the QF-4. Fuel inputs into the environment were previously analyzed under Air Operations, Section 4.2.1. Drone debris is discussed under Debris section below.

Aircraft Guns

Aircraft guns or cannons fire shells in the 7.62 mm to 105 mm range. A shell is a hollow projectile containing explosive or incendiary material ignited by a fuze upon impact with the target or at some earlier point along the trajectory. The amount of high explosive (HE) varies with the size of the round. For example 20 mm rounds each have .0285 pounds of HE, while 105 mm shells have 4.7 pounds of HE. The projectile shell is made of aluminum, but on some rounds the aluminum surrounds an armor penetrator usually made of tungsten.

Small Arms

The conventional small arms cartridge consists of four major components: the bullet, the cartridge case, the propellant charge, and the primer (also known as the cap). The cartridges are classified by the bullet size (diameter) measured in hundredths or thousandths of an inch, or in millimeters, and by the type bullet the cartridge is loaded with. Small arms fired into the EGTTR include .50 Cal and 7.62 mm machine guns. Bullet component materials include steel, lead or an alloy of lead and antimony, and copper-zinc alloy. Only the lead projectile and its copper jacket enters the water; casings (steel) remain on the aircraft.

Smokes and Obscurants

Smokes and obscurants are used to confuse enemy defense systems and provide cover for offensive maneuvers. Smokes are designed to be effective in the visual, infrared, and microwave/millimeter (radar) regions of the electromagnetic spectrum. There are essentially five categories of smokes and obscurant:

- Petroleum (fog oil, diesel oil, and gasoline)
- Non-metals (white and red phosphorus)
- Metals (aluminum, brass, nickel-coated carbon fiber)
- Inert (carbon fiber, graphite, dust, kaolin)
- Miscellaneous (binder, potassium perchlorate, terephthalic acid)

Essentially all the above types of smokes and obscurant have been tested or used at Eglin Air Force Base at one time or another. Often, two or more categories of smokes/obscurant will be used simultaneously to generate greater amounts of coverage throughout several regions of the spectrum.

Smokes are released either through the use of a generator or explosives. Artillery, tank guns, mortars, smoke grenades, and aerial smoke systems are among the most common launching methods. Smoke grenades can be launched by hand or with a rifle/grenade launcher. Aerial smoke systems include smoke canisters.

The potential impacts to EGTTR resources from the use of ordnance, drones, chaff and flares, and smokes and obscurants are evaluated below in Table 4-12.

Table 4-12. Potential Impacts from Alternative 1 Ordnance Testing and Training Operations

	ENVIRONMENTAL ISSUES					
RECEPTOR CATEGORIES	Restricted Access	Noise	Habitat Alteration	Debris	Chemical Materials	Direct Physical Impact
Physical Resources	–	–	–	o	o	–
Biological Resources	–	o	–	o	–	o
Threatened and Endangered Species	–	o	–	–	–	o
Socioeconomic Resources	o	–	–	–	–	–
Cultural Resources	–	–	–	–	–	–

Notes: o = Potential Impact – = No Potential Impact

Debris

Eglin AFB testing and training operations result in the generation of a broad variety of expendable materials. Expendables may be downed target drones, discharged chaff and flares, or missiles, bombs, and other exploded/inert munition remains. The potential adverse effects of the types of debris deposited through EGTTR activities are not well understood. Debris can have negative impacts if ingested by marine animals, or an overall positive impact when providing suitable habitat for fish and invertebrates, as occurs with the placement of artificial reefs. Plastics introduced into the marine environment are documented to cause injury or death to marine mammals and sea turtles when ingested or through entanglement. It is possible that in some areas, large pieces of debris, such as from drones, could sink to the bottom and potentially damage habitat.

The Florida Middle Grounds, an important natural reef habitat in the northern Gulf, is protected by law and should be avoided. The use of bottom longlines, traps, pots, and bottom trawls is prohibited unless authorized by a permit from the NMFS (USEPA, 1994). The Florida Middle Grounds lie under the W-470C, W-470E and W-470D airspace. It is difficult to quantify effects to the coral reefs of the Florida Middle Ground since the debris dispersion patterns within this region are not known. The Florida Middle Grounds region is approximately 722,058 acres. The hard bottoms of the Florida Middle Ground comprise 2.3 percent of the area beneath the W-470C, W-470E and W-470D special use airspace and are at a depth of 130 feet. W-470C, W-470E and W-470D comprise approximately one third of the total airspace of W-470.

The weight of expendables distributed over the W-470 area is roughly 497,139 pounds (see Table 4-13). Assuming a linear fall from the ocean surface to the ocean floor, concentrated debris might place 0.005 lbs of debris every 1-acre in the Florida Middle Grounds. Over 20 years of similar activity would be required before even one tenth of a pound of steel would accumulate per acre. Also, the debris will not be damaging to the reefs as they decelerate after sinking through the water column. There is currently over 2,800 tons of steel material in the coastal artificial reef sites adjacent the Florida Middle Ground region (Maher, 1995). Comparatively, debris contributes a very small amount of debris within this region. Mission avoidance of the Florida Middle Grounds, particularly those activities deploying expendables, would provide the best assurance for habitat protection. Considering the above, no adverse effects to the Florida Middle Ground are anticipated.

Magnesium-thorium

Magnesium-thorium, a low-level radioactive metal and a component of the QF-4 engines, has been evaluated for potential environmental effects. The Nuclear Regulatory Commission concurred with the U.S. Air Force that the radioactivity of the metal is so low no environmental effects would be anticipated (Appendix J). Thus, it is considered to be a debris component. Each QF-4 drone contains 93 lbs of magnesium-thorium alloy or 0.3% of the total drone weight (U.S. ACE, 1994). Assuming the same percent 0.3% weight ratio, the QF-106 is estimated to contain approximately 70 lbs of magnesium-thorium alloy.

The amount and type of material were considered when analyzing potential impacts of debris from EGTTR activities. The total weight of all materials expended in the EGTTR during the baseline years was 1,507 tons (Table 4-13). The major expendables by weight were drones, followed by missiles and bombs. Drones, when destroyed, are primarily composed of aluminum since other components typically combust.

Table 4-13. Alternative 1 (Baseline) Expendables (lbs) Distributed over the EGTTR

Item	Airspace Block									TOTAL (TONS)
	W-151A	W-151B	W-151C	W-151D	W-151S	W-168	W-155	W-470	EWTA-2	
Bombs	401,000	65,000	51,000	16,000	16,000	0	0	2,000	0	**276**
Chaff	19,924	18,775	21,612	15,798	3,376	2,496	1,065	91,484	245	**87**
Drones	235,200	329,280	297,920	392,000	47,040	0	0	250,880	0	**776**
Flares	11,999	6,562	7,401	5,262	2,127	0	588	37,554	56	**36**
Guns	3,288	5,293	2,657	1,677	76	0	0	2691	152	**8**
105 mm	4,352	1,564	340	1,326	646	0	0	0	102	**4**
Missiles/ Rockets	100,000	133,000	101,000	131,000	4,000	0	0	113,000	0	**291**
Spheres	7	0	0	0	9	0	0	0	0	**.008**
Small Arms	51,633	1,460	1,460	254	975	0	0	0	0	**28**
Smokes	1,200	270	24	60	1,362	0	0	0	0	**1**
TOTAL (lbs)	**828,452**	**561,053**	**483,263**	**563,226**	**75,460**	**2,496**	**1,653**	**497,139**	**555**	**1507**

Bombs/missiles = average 1,000 lbs Drone weights listed in Table 4-14 Chaff weight = average .4 pounds
Flare weight = average .35 pounds 105 mm weight = 34 pounds Smoke weight = average 6 pounds

The debris composition of each ordnance type may contain a variety of individual metal, synthetic, and liquid materials. For purposes of analyses, focus will be given to the primary material makeup of each ordnance type. Marine debris generated from the deployment of bombs, 105 mm and smokes are primarily comprised of steel. Plastic is the main debris item resulting from chaff deployment. The primary component of guns, missiles, drones, calibration spheres, and flare cartridges contributing to marine debris is aluminum. Small arms may be comprised of varying compositions of copper, lead, and zinc. The NEW (net explosive weight) from bombs, guns and missiles, as well as the fuels from drones, have been analyzed in the Air Operations Chemical Materials section.

Table 4-14 summarizes the debris weight approximations that would occur under the maximum baseline scenario for each type of drone at the time destroyed. Marine expendables were composed primarily of aluminum and steel (Table 4-15), which once deposited on the bottom, should remain and undergo corrosion. Some pieces may be carried by currents, causing some minimal habitat alteration before becoming embedded in the sediments.

Table 4-14. Estimated Alternative 1 (Max Baseline) Debris Weights for Various Types of Drones

Drone Type	Number Destroyed	Empty Weight (lbs)	Total Estimated Debris (lbs)
Full-Scale Drone			
QF-4	21	32,000	672,000
QF-106	35	24,000	840,000
Subscale Drones			
BMQ-34	20	1,600	32,000
MQM-107	23	600	13,800
Totals:			**1,557,800 lbs (780 tons)**

Table 4-15. Alternative 1 (Max Baseline) Marine Debris (lbs) Composition within the EGTTR

EGTTR	W-151A	W-151B	W-151C	W-151D	W-151S	W-155	W-168	W-470	EWTA-2	TOTAL (TONS)
Plastic	8,051	11,224	9,668	11,268	1,512	50	33	9,952	11	**26**
Steel	72,458	101,017	87,014	101,408	13,610	449	298	89,570	100	**233**
Aluminum	326,060	454,575	391,565	456,335	61,246	2,022	1,339	403,063	450	**1,048**
Other*	5,072	7,071	6,091	7,099	953	31	21	6,270	7	**16**
TOTAL	411,640	573,886	494,339	576,109	77,321	2,552	1,690	508,855	568	**1,323**

*Other = Copper, zinc, lead, and magnesium-thorium.

During the baseline, the total weight of solid materials (debris) expended in the EGTTR by Eglin AFB activities was approximately 1,323 tons. Debris materials contributed from Eglin Air Force Base activities were significantly less than materials contributed from nonmilitary activities, such as state and county artificial reef enhancement programs.

The cumulative weight of artificial reef materials deposited within the EGTTR from various fishery enhancement projects totaled 129,175 tons, of which 18,826 tons and 5,323 tons were deposited in W-151 and W-470, respectively (Table 4-16). The materials used in artificial reefs are often similar to the materials found in ordnance, drones, and other expendables (aluminum, steel, and concrete). The total weight of artificial reef material placed in EGTTR waters during FY95 was 2,237 tons (Table 4-16). Artificial reefs were comprised primarily of concrete and steel and were located primarily in W-168 and EWTA-2.

Table 4-16. EGTTR Artificial Reef Materials and Alternative 1 Test and Training Mission Debris

EGTTR Areas:		Concrete (tons)	Steel (tons)	Aluminum (tons)	Plastic (tons)	Other (tons)	Total (tons)
W-151A:	**Artificial Reef (Total)**	222	1,330	0	4	0	**1,552**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	36	163	4	3	**206**
W-151 B:	**Artificial Reef (Total)**	*	3,087	0	6	0	**3,087**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	51	227	2	4	**287**
W-151 C:	**Artificial Reef (Total)**	0	0	0	5	0	**0**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	44	196	2	3	**247**
W-151 D:	**Artificial Reef (Total)**	0	0	0	6	0	**0**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	51	228	2	4	**288**
W-151 S:	**Artificial Reef (Total)**	5,050	9,137	0	1	0	**14,187**
	Reef FY95	0	865	0	0	0	**865**
	Eglin AFB FY95-99	0	7	31	1	0	**38**
W-155:	**Artificial Reef (Total)**	0	4,434	0	0	0	**4,434**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	0	1	0	0	**1**
W-470:	**Artificial Reef (Total)**	2,323	2,800	200	5	0	**5,323**
	Reef FY95	442	0	0	0	0	**442**
	Eglin AFB FY95-99	0	45	202	5	3	**249**
W-168:	**Artificial Reef (Total)**	36,369	7,035	0	0	0	**43,404**
	Reef FY95	450	480	0	0	0	**930**
	Eglin AFB FY95-99	0	0	1	0	0	**1**
W-174:	**Artificial Reef (Total)**	8,662	11,060	0	0	0	**19,722**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	0	0	0	0	**0**
EWTA-2:	**Artificial Reef (Total)**	29,751	4,364	0	0	0	**34,115**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	0	0	0	0	**0**
EWTA-5:	**Artificial Reef (Total)**	714	0	400	0	0	**1,114**
	Reef FY95	0	0	0	0	0	**0**
	Eglin AFB FY95-99	0	0	0	0	0	**0**
Total:	**Artificial Reef (Total)**	**83,091**	**43,247**	**600**	**0**	**0**	**126,938**
	Reef FY95	**892**	**1,345**	**0**	**0**	**0**	**2,237**
	Eglin AFB FY95-99	**0**	**233**	**1048**	**26**	**16**	**1323**

Note: Artificial Reef: Total amount of material deposited as of FY95 by state and county reef programs.
Reef FY95: Total amount of material deposited during FY95 by state and county reef programs.
Eglin AFB FY95-99: Maximum baseline amount of material contributed during FY95-99 by Eglin AFB mission activities. Other = Copper, lead, zinc, magnesium-thorium

The comparison of types and quantities of Eglin AFB mission activity debris to artificial reef material serves only as a general reference for future comparisons. Eglin AFB FY95-99 mission debris within the EGTTR represents 19 percent of the total artificial reef material deposited by various state and county reef enhancement programs during the same time period. In the short term, concrete, steel, and aluminum debris serve as a substrate for settling and encrusting organisms and thus provide structural heterogeneity to the bottom communities. The long term fate of such inert materials is relatively unknown beyond a slow corrosive process. However, it is not expected that debris would cause adverse impacts to biological resources.

Chemical Materials

Chemical materials are introduced into the marine environment through drones, gun ammunition, missiles, chaff and flares, and smokes and obscurants. Impacts to water quality and marine organisms could result. Fuel releases from drones were previously addressed under Air Operations.

NEW (Ordnance)

Explosive materials are used extensively over the EGTTR during ordnance testing and training activities as propellants, warhead components or in explosive ammunition rounds, such as the 40 mm and 105 mm. During FY95-99, including propellant amounts, a net explosive weight of 17,755 pounds was expended annually over the EGTTR as a result of test and training activities. Normal operational deployment of ordnance would result in the combustion of nearly all propellant and explosive. However, it is possible that a weapon that did not function as intended (e.g. a dud) may be released safely (arming function is disabled), thus some amount of explosive material may be introduced into the waters of the EGTTR. However, the toxicological effects of introduced explosives on the affected environment within the EGTTR are minimal. Assuming a typical dud rate of 5 percent, approximately 900 pounds of explosive material as contained in miscellaneous explosive rounds would be input into the waters of the EGTTR, primarily in W-151. W151 encompasses an area of over 8 million acres. Assuming an even distribution, the amount per acre would be negligible at .0001 pounds or 51 mg.

The net explosive weight (NEW) of materials expended or ignited during ordnance, smoke, and flares testing or training operations over the EGTTR during the baseline is presented in Table 4-17. The majority of ordnance (i.e., missiles, bombs, and guns) and smoke and flare testing occurred within W-151A. Guns accounted for the highest NEW values (16,597 pounds) of all ordnance categories. Flares were utilized at significantly higher rates than smokes within all test ranges, resulting in overall NEW values of 14,833 pounds (Table 4-20).

Most explosives used over the EGTTR are composed of TNT, HMX, PBX, or RDX. Aluminum and ammonium nitrate are compounds that are also used in the manufacturing of explosives. Detonation of explosives usually results in complete combustion of the original material and the emission of carbon dioxide, carbon, carbon monoxide, water, and nitrogen oxides. Although none of these chemicals are expected to have significant impacts on the affected environment, a series of calculations will estimate potential quantities of the primary detonation by-products into the EGTTR waters.

Table 4-17. Alternative 1 (Max Baseline) NEW Material (in pounds) Expended in the EGTTR

EGTTR	W-151A	W-151B	W-151C	W-151D	W-151S	W-155	W-470	TOTAL
Missiles	0.0	0.0	52.2	73.0	0.0	0.0	256.7	381.9
Bombs	2.0	0.6	793.9	0.6	0.0	0.0	0.0	797.1
Guns	7,175.1	3,931.3	3,298.3	2,192.2	0.0	0.0	0.0	16,596.9
NEW in Air	**7,177.1**	**3,931.9**	**4,144.4**	**2,265.8**	**0.0**	**0.0**	**256.7**	**17,775.9**
Flares	5,253.9	2,420.0	4,448.8	1,873.5	615.1	272.0	0.0	14,883.3
Smokes	175.3	0	0	0	0	0	0.0	175.3
NEW in Air	**5,429.2**	**2,420.0**	**4,448.8**	**1,873.5**	**615.1**	**272.0**	**0.0**	**15,058.6**
NEW EGTTR	**12,606.3**	**6,351.9**	**8,593.2**	**4,139.3**	**615.1**	**272.0**	**256.7**	**32,834.5**

Research has shown that if munitions function properly, full combustion of explosive materials will introduce one-billionth to one-millionth the total weight of raw explosive used during an *open air test* (above water) into the environment. The U.S. Army has developed emission factors (EF) for detonations of various explosives including RDX and TNT. The emission factor is the percentage weight of a chemical compound produced from the detonation of a given source amount of explosive. Explosive by-products with emission factors of 1 x 10^{-3} or less contribute extremely small amounts of material to the environment. Since a variety of ordnance has been detonated within the EGTTR containing multiple compositions of explosive materials, the emission factors for the primary detonation products of RDX will be used for calculating these estimates. Table 4-18 estimates the total number of pounds of explosive detonation products potentially produced during FY95 ordnance testing and training activities within the EGTTR.

Table 4-18. Alternative 1 (Max Baseline) Explosive Detonation Products (lbs) in the EGTTR

Detonation Products	EF	W-151A	W-151B	W-151C	W-151D	W-470	TOTAL
NEW as RDX		7177.1	3931.9	4144.4	2265.8	256.7	**17,775.90**
Carbon dioxide	0.57	4,090.95	2,241.18	2,362.31	1,291.51	146.32	**10,132.26**
Carbon monoxide	0.031	222.49	121.89	128.48	70.24	7.96	**551.05**
Nitrogen dioxide	0.0006	4.31	2.36	2.49	1.36	0.15	**10.67**
Nitrogen oxides (NO_x)	0.0009	6.46	3.54	3.73	2.04	0.23	**16.00**

Note: Due to specific rounding functions, totals may not exactly coincide with the sum or product of the rows and columns.

In order to evaluate a potential concentration of explosive detonation products added to the EGTTR waters during the baseline ordnance testing and training activities, an exercise incorporating the a similar treatment of the "closed box assessment" (as utilized in section 4.2 with emissions from aircraft) has been utilized.

The Closed Box Assessment

The "closed box assessment" provides a means to estimate maximum potential impacts from explosive detonation products within a given volume of EGTTR water range. Several assumptions are incorporated into this technique. First, it assumes that the explosive detonation products are identically mixed and contained within a defined volume of the EGTTR. For these assessments, the volume of each EGTTR water range is described by a depth boundary of approximately 50 feet (15.24 meters). This depth is defined by the maximum detonation depth of the 105 mm ordnance with the delayed fuse setting. The total area of each individual range within the EGTTR that was used in the model calculations is summarized in Table 4-5.

Second, as a means to estimate a worst-case scenario, it is assumed that the calculated concentrations of major explosive detonation products within the defined box result from a single detonation event. Although an unlikely scenario, the results demonstrate the extremely small quantities of explosive detonation products added to the waters of the EGTTR. Because of these assumptions, the results of these calculations represent higher water quality impacts than those that would result from a more structured dispersion model. However, the results do provide a maximum impact scenario for comparison.

Table 4-19 estimates the total concentration (micrograms per liter, µg/L, or parts per billion, ppb) of explosive detonation products potentially produced during baseline ordnance testing and training activities within the EGTTR. No criteria standards exist for these compounds in oceanic waters such as the Gulf of Mexico. Carbon compounds such as carbon dioxide and carbon monoxide (and their dissociation products) are associated to the carbonic acid system (carbon alkalinity) whose equilibrium concentrations control the water's alkalinity. The balance between the components of the carbon dioxide equilibria is controlled by the water's pH. The marine waters of the GOM exhibit a strong pH buffering capacity, such that additions of small amounts of acids or bases produce only extremely small changes in pH. Even a single addition of the total annual contributions of carbon dioxide (.00093 µg/L) and carbon monoxide (.00005 µg/L) would produce an immeasurable change in pH. Individual mission contributions would be distributed throughout the year and would therefore constitute an even more negligible impact.

Table 4-19. Alternative 1 Concentrations of Explosive Detonation Products* in the EGTTR

EGTTR	W-151A	W-151B	W-151C	W-151D	W-470	TOTAL
Volume (L)	**1.17E+14**	**1.04E+14**	**8.47E+13**	**1.06E+14**	**2.70E+14**	**4.92E+15**
Detonation Products	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**	**(µg/L)**
NEW as RDX	0.02780	0.01719	0.02220	0.00972	0.00043	0.00164
Carbon dioxide	0.01585	0.00980	0.01265	0.00554	0.00025	0.00093
Carbon monoxide	0.00086	0.00053	0.00069	0.00030	0.00001	0.00005
Nitrogen dioxide	0.00002	0.00001	0.00001	0.00001	0.00000	0.00000
Nitrogen oxides (NO_x)	0.00003	0.00002	0.00002	0.00001	0.00000	0.00000

* As represented by FY95 expenditures

Concentrations of organic and inorganic nitrogen compounds, including nitrogen dioxide and other generic nitrogen oxides, in marine waters are controlled primarily by biological factors. Within the upper water column photic zone of the above "closed box model" description, nitrogen compounds are assimilated during protein synthesis by phytoplankton and bacteria. Even a single addition of the total annual contributions of nitrogen dioxide (.000001 µg/L) and other generic nitrogen oxides (.000001 µg/L) would produce an immeasurable and insignificant change in the total organic and inorganic nitrogen balance of the EGTTR waters. Individual mission contributions would be distributed throughout the year and would therefore constitute even a more negligible impact.

Toxicity of TNT has been well documented. Classified as a possible human carcinogen (Group C by the EPA), exposure to TNT by humans and other mammals has resulted in pancytopenia, a blood disorder identified by decreased numbers of leukocytes, erythrocytes, and reticulocytes. Liver damage and anemia has also been reported by workers exposed to high levels of TNT. Long-term exposure to atmospheric concentrations of TNT can cause abnormalities in the blood, as well as skin discoloration and abdominal abnormalities.

Although some information is available, the toxicity of RDX, HMX, and the PBX class of explosives is not as well documented. Acute exposure in humans can cause dermatitis, nausea, and vomiting. Chronic exposure to RDX can cause insomnia, amnesia, and renal damage. RDX is classified as a Group C carcinogen; however, the only data indicating RDX may be carcinogenic are from a single study in which female mice showed hepatocellular adenomas and carcinomas following exposure to RDX (ATSDR, 1995). How this toxicity data relates to marine organisms is not clear.

Potential exposure of humans to these explosive chemicals is expected to be minimal; pilots are well protected in their aircraft, and water traffic is prohibited during test missions. Air exposure to these chemicals by marine mammals is expected to be minimal as well due to the limited amount of time these animals spend on the surface and the quick dispersion of chemical molecules by air currents. Exposure by marine mammals to these chemicals through water is also expected to be minimal (through wave action and tides) and Gulf currents quickly disperse the explosives molecules.

TNT concentrations of 5 mg/L and less have been shown to be toxic to tidepool copepods and oyster larvae, although TNT metabolites (the breakdown products) were not toxic at concentrations reaching 100 mg/L. TNT concentrations of 5 mg/L in the affected environment of the EGTTR would not be maintained for extended periods, as dispersion and degradation would occur. Exposure to TNT by biological resources is expected to be minimal.

Experiments that demonstrate the toxicity of explosive materials such as RDX, HMX, and PBX to aquatic vertebrates and invertebrates support the conclusion that prolonged exposure (greater than 48 hours) to high level doses of these chemicals (5-100 mg/L) will often produce toxic effects. These effects primarily manifest themselves as deformities or abnormalities rather than occurrences of death. Any exposure of marine vertebrates and invertebrates to these explosive chemicals in the EGTTR would be at low concentrations (0.00164 to 0.02780 μg/L) and for a short time period. Chemicals introduced would be quickly dispersed through wave action, currents, tidal action, and by storm systems, which frequently move through the area. Therefore, exposure to explosive chemicals not fully combusted during normal operations will have minimal to no adverse impacts on the affected environment.

Magnesium (Flares)

The fate of magnesium resulting from flare combustion may be examined in the same manner as explosive detonation products. The solubility of magnesium from flare ash residue was found to be 948 mg/L, as magnesium oxide (MgO), magnesium chloride ($MgCl_2$), and magnesium fluoride (MgF_2) from an initial solution of 1:20 solid to liquid (U.S. Air Force, 1996d). This study demonstrated that approximately 1.896 percent of the initial magnesium weight dissolved in seawater. The results were inconclusive concerning the remainder of the gases (carbon dioxide, carbon monoxide and nitrogen) released to the atmosphere or the insoluble residue from flare combustion. However, all of the ash should eventually dissolve given the volume of water in which it is deposited. Table 4-20 estimates the total pounds and resulting concentration (nanograms per Liter, ng/L or parts per trillion) of flare ash residue (magnesium) potentially produced during FY95-99 ordnance testing and training activities within the EGTTR.

Table 4-20. Alternative 1 Flare Ash Residue as Magnesium in the EGTTR

Flare Products	Percent	W-151A	W-151B	W-151C	W-151D	W-151S	W-155	TOTAL
Flare Net Weight	**100.00**	5,253.9	2,420.0	4,448.8	1,873.5	615.1	272.0	**14,883.3**
Magnesium (lbs) in water	1.90	99.8	46.0	8.5	35.6	11.7	5.2	**282.78**
Magnesium (ng/L) in water		.00039	.00020	.00005	.00015	.00002	.00001	**.00003**

Even addition of the total annual contributions of magnesium (.00003 ng/L) would produce an immeasurable and insignificant change in the total concentration of magnesium in the EGTTR waters. Although no criteria standards exist for magnesium in oceanic waters such as the Gulf of Mexico, magnesium is a major ion in sea water and found at a stable concentration of 1.294 parts per thousand (ppt) or $1.294x10^6$ µg/L (ppb). FY95 ordnance testing and training activities within the EGTTR represents only 2.3 x 10^{-6} percent of the GOM concentration of magnesium.

Aluminum (Chaff)

The fate of aluminum resulting from chaff deployment may be examined in the same manner as flare detonation products. The solubility of aluminum from a chaff leachability test was found to be 0.3 mg/L, as Al_2O_3 from an initial solution of 1:20 solid to liquid (U.S. Air Force, 1996d). This study demonstrated that approximately 0.0006 percent of the initial aluminum weight dissolved in seawater after 18 hours. Table 4-21 estimates the total pounds and resulting concentration (micrograms per liter, µg/L, or parts per billion, ppb) of ionic aluminum potentially produced during FY95 ordnance testing and training activities within the EGTTR.

Table 4-21. Alternative 1 Chaff Particles as Aluminum in the EGTTR

Chaff Products	W-151A	W-151B	W-151C	W-151D	W-151S	W-155	W-470	TOTAL
Aluminum (lbs) in water	73,024	4,125	3,616	3,562	1,508	723	84	**86,642**
Aluminum (µg/L) in water	.283	.0180	.0194	.0153	.00253	.00131	.00014	**.00778**

Even addition of the total annual contributions of aluminum (.00778 µg/L) from chaff deployments would produce an immeasurable and insignificant change in the total concentration of aluminum in the EGTTR waters. Although no criteria standards exist for aluminum in oceanic waters such as the Gulf of Mexico, aluminum is an element in seawater and found at variable concentrations averaging 5 µg/L (ppb). Baseline ordnance testing and training activities within the EGTTR represents only 1.56 x 10^{-3} percent of the GOM concentration of aluminum. Although the potential does exist for chaff to be mistaken as a food source and deliberately ingested by aquatic organisms, the insignificant concentrations of chaff from mission activities should not adversely impact natural, biological, or socioeconomic resources.

Restricted Access

In general, airspace control is the same for Ordnance Testing and Training as for Air Operations. Controlling agencies and procedures for requesting airspace have been previously discussed under Air Operations for this alternative. Specific items with regard to surface water restrictions that would be experienced with Ordnance Testing and Training are discussed below.

Surface Water Restrictions

There are no restrictions on public or commercial uses of the surface water under the Warning Areas unless this activity also requires airspace or other DoD activities are planned. These activities must then schedule through the controlling agency for that airspace. Other DoD activities primarily involve Navy operations utilizing surface waters for testing and training. Naval support vessels or helicopters may temporarily clear surface waters of any public or commercial traffic. If there is an activity that could be hazardous to public or commercial use of the surface, a Local Notice to Mariners (NOTMAR) notification will be made through the

U.S. Coast Guard Service stating the activity and potential hazards. But even with these notices, it is the responsibility of the testing/training activity to ensure that there is no surface traffic in the area. If there is, aircrews must wait until the area is clear or find another location in the EGTTR that is clear of traffic to pursue that activity. Due to the level of cooperation provided by local commercial and public users of the surface and the offshore nature of EGTTR waters, only one test in the past seven years was required to be rescheduled. Thus, restricted access should not impact socioeconomic resources.

Direct Physical Impacts

Potential impacts resulting from A/S test operations include direct physical impacts (DPI) resulting from ordnance. Although these test operations may potentially impact a variety of marine wildlife, the emphasis of the following discussions will be limited to marine mammals (dolphins and whales) and sea turtles. The Gulf sturgeon and the West Indian manatee are not expected to be in the offshore waters of the EGTTR and therefore are not discussed.

Direct physical impacts could result from inert bombs, A/S Gunnery ammunition, and shrapnel from live missiles falling into the water. Marine mammals and sea turtles swimming at the surface could potentially be injured or killed by projectiles and falling debris. Information is unavailable to determine the missile shrapnel dispersal patterns, and therefore the DPI from these munitions cannot be estimated. A/S Gunnery operations are evaluated in this section and may offer a worst-case scenario for evaluating DPI of EGTTR operations, mainly due to the comparatively large number of rounds expended. Some contained high explosive, but the majority did not. For simplicity, all rounds are considered in this evaluation to be inert projectiles.

Three key sources of information are necessary for estimating DPI impacts to marine species from A/S Gunnery operations: 1) the number of distinct firing or test events must be determined, 2) the zone of impact must be defined, and 3) the density of animals that could be potentially impacted must be determined. In conjunction with these three things, various assumptions were made to best characterize the A/S Gunnery missions and use of ordnance and small arms (.50 cal, 7.62mm, 20 mm, 25 mm, 40 mm, and 105 mm):

1) Since the number of rounds fired within a given test mission can vary, the primary assumption for analyses establishes that all firing will occur within a given and discrete time period and thus constitutes a single event. This premise establishes that potential impacts may only occur once within the given time period (Advanced Research Projects Agency, 1995). Thus an estimation of the number of "events," rather than the number of "rounds" was used as the primary mission criteria.

2) The estimation of test events is further defined by the approximated firing accuracy. Firing accuracy has been determined to occur within a 5 meter radius from the actual target flare.

The ***Event*** estimation is primarily based upon a *spatial* assumption that all ordnance firing did occur within a 5 meter radius target area. The second basic assumption supporting the ***Event*** estimation further defines the *temporal* criteria that all the ordnance firing has occurred within a limited time frame, with additional stipulations outlined below:

1) Continuous live firing with no pauses in excess of 10 minutes, using the same target location (all rounds and flares were within ½ mile), will constitute a single ***Event***.
2) Pauses between firings in excess of 10 minutes will indicate the end of one ***Event*** and the beginning of another.
3) Each of the 105 mm, 40 mm, and 25 mm rounds were not considered in the DPI analyses as the noise analyses constitute a far more conservative assessment for exploding rounds.
4) Each small caliber sortie, .50 cal or 7.62mm, is considered a single live fire ***Event***.

In summary, the A/S Gunnery operation activities have been estimated to constitute a total of **606 Events** for the Alternative 1 (FY95-99) baseline Ordnance Testing and Training missions. The process used for determining the total number of A/S Gunnery operations events follows the assumptions above and the calculations in Table 4-22.

Table 4-22. Alternative 1 A/S Gunnery/Small Arms Operations as *Events*

Activity Description of EGTTR Events	Percentage	Number
Small Arms .50 Cal Ball Events	16.3%	99
Small Arms 5.56 Linked Events	0.8%	5
Small Arms 7.62 mm Ball Events	82.8%	502
Total Baseline EGTTR A/S Gunnery/Small Caliber Events	100%	606

Source: Author Created

Information on the abundance and distribution of cetaceans and sea turtles within the EGTTR was derived from the GulfCet II surveys, which combined the efforts of the Minerals Management Service, Texas A&M University, National Marine Fisheries Service, and several other agencies and educational institutions.

Ships and aircraft were used to collect cetacean and sea turtle sighting data from 1996 to 1998. Abundance and density data from the aerial survey portion of the GulfCet study best reflect the abundance and density of cetaceans and sea turtles within the EGTTR given that the survey area overlaps approximately one-third of the EGTTR and nearly the entire continental shelf region of the EGTTR where military activity is highest. The survey area is known as the Minerals Management Service Eastern Planning Area and may be divided into continental shelf and continental slope regions. Most of the ordnance testing and training activities occur over the shelf region. The survey area of the shelf for GulfCet II is defined as 18.5 kilometers offshore to 100 meters deep between 88°10.0’West and 85°55.0’W and totals 12,326 km^2. The slope region is defined as waters 100-2,000 meters deep east of 88°10.0’W and north of 26°00.0’N and covers an area of 70,470 km^2 (Davis et al., 2000). Densities of individual marine mammal and sea turtle species are presented in Chapter 3.

Although most of the ordnance testing and training activities occur over the shelf region, for conservative impact assessments, the greatest species density estimate available for any given season (summer or winter), location (shelf or slope), or survey type (aerial or ship) was utilized. Here, densities have been totaled as cetaceans, T&E species, and sea turtles (Table 4-23).

Table 4-23. Alternative 1: DPI Metrics and Potential Impacts to Marine Species in the EGTTR

Species	Adjusted Density (#/km^2)	Impact Zone Area[1] (km^2)	Animals in Impact Zone (#)	Events Necessary to Impact 1 Animal[2] (#)	Impacts[3] (#/Yr.)
Cetaceans	4.326	0.000079	0.0003397	2,943	0.2059
T&E Cetaceans	0.011	0.000079	0.0000009	1,157,503	0.0005
Sea Turtles	0.869	0.000079	0.0000683	14,652	0.0414

Source: Author created.

1. Impact Zone Area based on 5 meter radius around target that would contain all A/S Gunnery impacts.
2. 50 cal., 7.62 mm, and 5.56 mm represent 606 events.
3. Number of potential impacts calculated by dividing the number of events it would take to impact one animal by the number of events that occurred.

It is important to note that there was a statistical decrease in the number of cetaceans over the continental shelf in the winter as compared to the summer (Davis et al., 2000). Thus, for A/S Gunnery operations over the continental shelf, the winter season would potentially have less impacts.

The impacts to marine mammals and sea turtles swimming at the surface that could potentially be injured or killed by projectiles and falling debris was determined to be an average of 0.2059 marine mammals and 0.0414 sea turtles per year. Thus, direct physical impacts are not likely to show significant adverse effects to biological resources.

Noise

Noise associated with the test and training mission operations within the Eglin Gulf Test and Training Range of the eastern Gulf of Mexico may result in potential environmental impacts to protected marine species. Two primary sources of noise have been identified as potential issues to be investigated. Noise associated with subsonic and supersonic aircraft flight represents one type of noise activity, and constitutes a continuous source of noise throughout the year. This type of noise activity has been previously analyzed in subsection 4.2, Air Operations and additional analysis is available in Appendix C.

This analysis will focus on the second source of noise, the underwater noise produced by the A/S Gunnery operations (i.e. gunship missions), particularly with regard to marine animals and sea turtles. The only noise source of concern from the gunship mission is the explosive shells. The noise analysis of ordnance testing and training applies solely to the gunship mission. This analysis will include: 1) a general description of the A/S Gunnery mission, 2) the methodology for estimating the number and frequency of explosive shells used, 3) a characterization of the potential noise from the explosive shells, and 4) the estimation of the noise impact area and the number of marine species potential exposed to the A/S Gunnery mission noise.

A/S Gunnery Operations

Prior to analyzing these potential noise impacts, it is first helpful to have an understanding of the gunship mission. The following description provides an example of a typical gunship mission.

Water ranges within the EGTTR that are typically used for the A/S Gunnery operations include W-151A, W-151B, W-151C, and W-151D (Figure 4-2). Based on baseline data, W-151A was the most frequently used water range due to its proximity to Hurlburt Field.

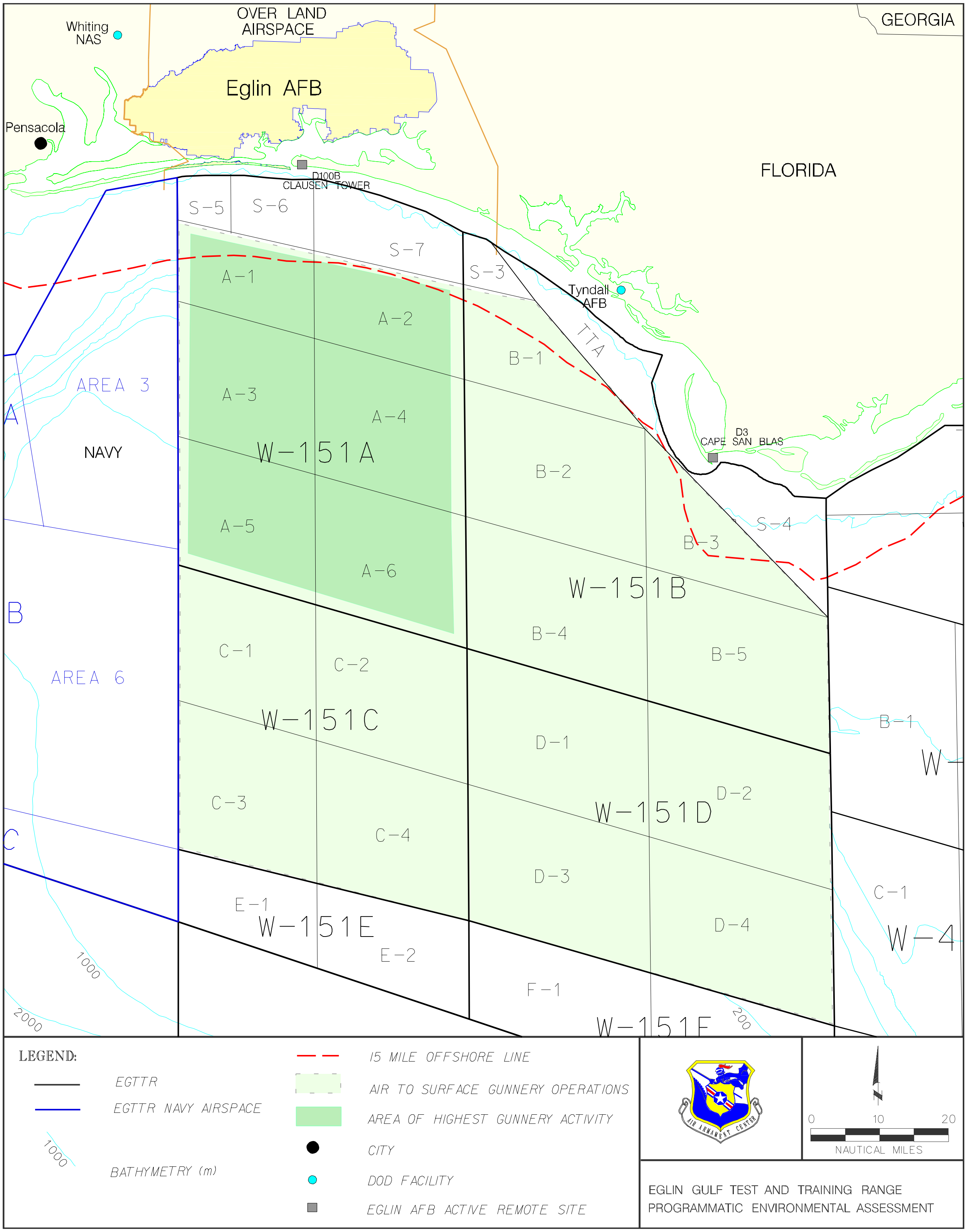


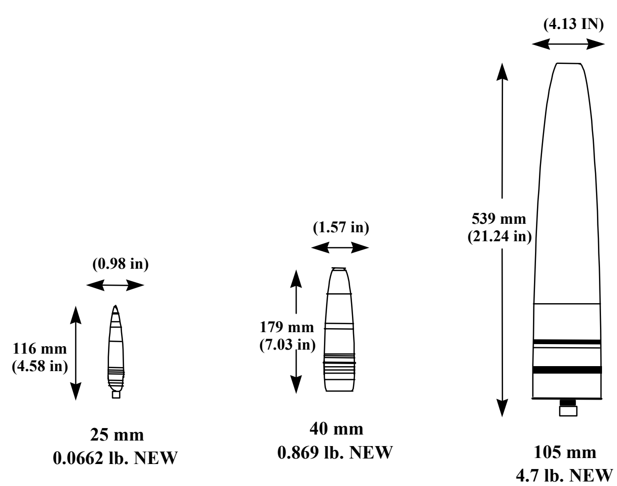
Figure 4-2. Primary Region for A/S Gunnery Missions in the EGTTR

Gunships normally transit from Hurlburt Field to the water ranges at a minimum of 4,000 feet above ground level (AGL). At a distance from the coast of at least 15 miles, the crews scan a five-mile radius around the potential impact area to ensure it is clear of surface craft. Scanning is accomplished using radar, all-light television (TV), infrared sensors (IR), and visual means. An alternative area would be selected if any whales, sea turtles, or vessels were detected within a five-mile search area. Once the scan is completed, Mk-25 flares are dropped and the firing sequence is initiated.

A typical gunship mission lasts approximately five hours without refueling and six hours when air-to-air refueling is accomplished. A typical mission includes:

- 30 minutes to take off and perform airborne sensor alignment; align electro-optical sensors (IR and TV) to heads-up display.
- 1½-2 hours of dry fire; this includes transitions time.
- 1½-2 hours of live fire; this time includes clearing the area and transiting to and from the range. Actual firing activities typically do not exceed 30 minutes.
- 1 hour air-to-air refueling, if and when performed.
- 30 minutes transition work (takeoffs, approaches, and landings—pattern work.)

The guns are fired during the live fire phase of the mission. The actual firing can last from 30 minutes to 1½ hours, but is typically completed in 30 minutes. Due to the variety of activities conducted, there is no set sequence of how the various guns are fired or how many bursts or rounds will be fired before switching to another gun. The number and type of A/S Gunnery munitions deployed during a mission would also vary with each type of mission flown. These munitions include marking flares and 25 mm, 40 mm, and 105 mm ammunition with HE contents (Figure 4-3).



Note: NEW = Net Explosive Weight

Figure 4-3. Projectiles of the A/S Operations in the EGTTR

Table 4-24 illustrates the distribution, quantities, and HE weight associated with the various gunship ordnance (105 mm, 40 mm, and 25 mm) deployed within the EGTTR during the baseline (FY95–99).

Table 4-24. Alternative 1 A/S Gunnery Expendables Deployed within the EGTTR

Ordnance	DODIC*	HE Content (lbs)	W-151A	W-151B	W-151C	W-151D	W151s	Total
105 mm FU	NA	4.7	128	46	10	39	19	**242**
40 mm	B549	.865	1,275	294	142	567	283	**2,561**
25 mm	B519	.0662	536	146	50	198	99	**1,029**
		Total	**1,788**	**335**	**51**	**653**	**401**	**3,832**

Source: Author created *DODIC = Department of Defense Identification Code NA = Not Available FU = Full Up

All guns are fired at a specific target in the water, predominately an Mk-25 flare. To establish the test target area, two Mk-25 flares are deployed into the center of a five nmi radius cleared area (visually clear of aircraft, ships, and marine species) on the water's surface of the EGTTR (Figure 4-4). Mk-25 flares were previously analyzed in the Chemical Materials section (page 4-29). The flare's burn time normally lasts 10 to 20 minutes, but could be much less if actually hit with one of the ordnance projectiles; however, some flares have burned as long as 40 minutes. Live fires are a continuous event with pauses during the firing usually well under a minute and rarely from 2 to 5 minutes. Firing pauses would only exceed 10 minutes if surface boat traffic caused the mission to relocate; aircraft, gun, or targeting system problems exist; or to deploy more flares. The A/S Gunnery missions have been further described by AFSOC as having a firing accuracy within a 5 meter area about the established flare target test area (Figure 4-4).

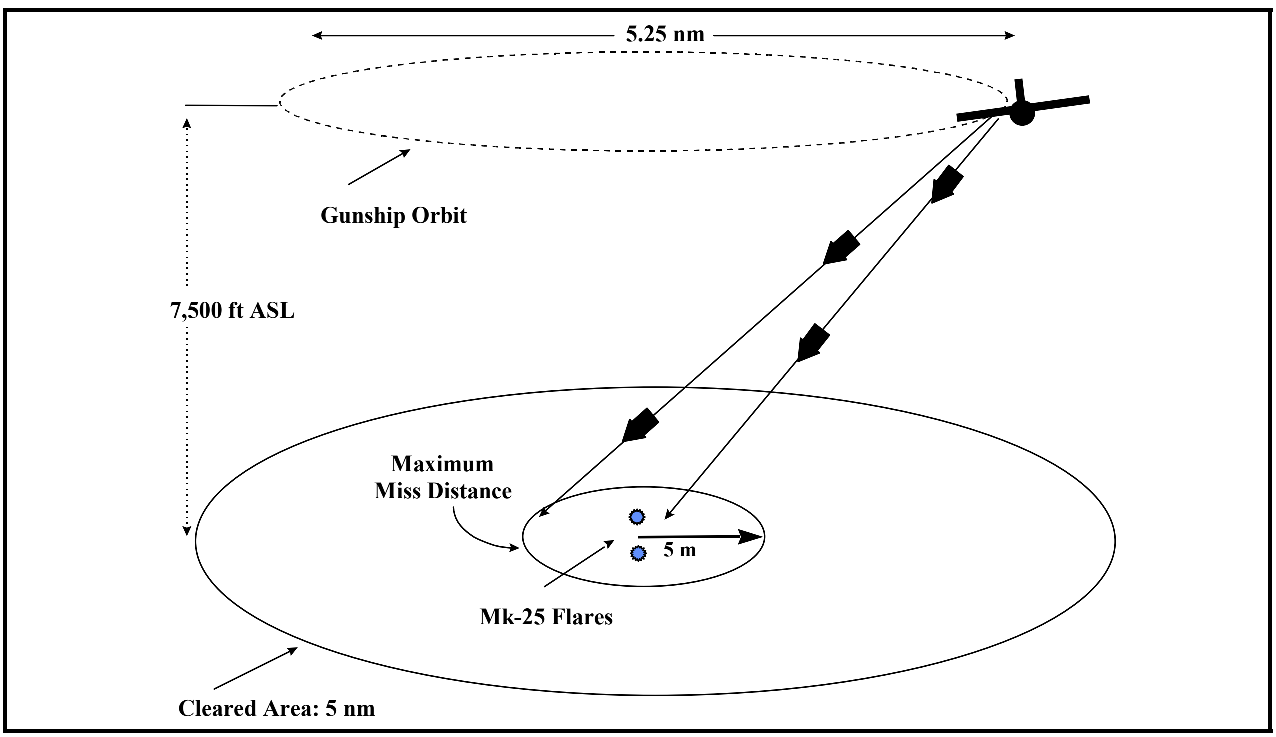


Figure 4-4. Typical A/S Gunnery Mission in the EGTTR

With this "typical" A/S Gunnery mission now described, three key sources of information are necessary for estimating potential noise impacts to marine resources: 1) the number of distinct firing or test events must be determined, 2) the zone of noise impacts must be defined, and 3) the density of animals that could be potentially exposed must be estimated.

For missions that contain more than one explosion, estimating the average number of animals exposed to a given noise level becomes complicated by the noise source and spatial and temporal distribution of animals. It should be noted that analyses are often further complicated by noise levels (thresholds) that depend on the duration or number of exposures (events) for each animal. The general case of moving animals, moving noise sources, and exposures of varying thresholds is difficult to solve analytically.

The methodology for estimating the number of firing events from gunnery missions is different when considering Noise impacts analysis versus Direct Physical Impacts. For the noise analyses, the number of events is synonymous with the quantity of rounds expended. When utilizing energy threshold metrics, as performed later in this section, one must consider that the energy released from multiple shots should be evaluated as an additive exposure, and therefore events must consider all shots fired. The estimated number of events for Alternative 1 A/S Gunnery testing is equivalent to the quantity of rounds expended and is listed in Table 4-25.

Table 4-25. Summary of Alternative 1 Daytime A/S Gunnery Testing Operations in the EGTTR

Test Area	Category	Expendable	Condition	Missions (#)	Events/Rounds (#)
W-151A	GUN	105 mm FU	LIVE	6	128
		25 mm	LIVE	1	1,275
		40 mm	LIVE	6	536
W-151B	GUN	105 mm FU	LIVE	2	46
		25 mm	LIVE	1	294
		40 mm	LIVE	1	146
W-151C	GUN	105 mm FU	LIVE	1	10
		25 mm	LIVE	1	142
		40 mm	LIVE	1	50
W-151D	GUN	105 mm FU	LIVE	2	39
		25 mm	LIVE	1	567
		40 mm	LIVE	2	198
W-151S	GUN	105 mm FU	LIVE	1	19
		25 mm	LIVE	1	283
		40 mm	LIVE	1	99
				28	**3,832**

Source: Author created

Note: The quantities of A/S Gunnery ordnance (105 mm, 40 mm, and 25 mm) were adjusted to reflect the most recent (09/01/99) AFSOC aircraft loading requirements. Typical number of expendables per mission for 105 mm is 20, for 40 mm is 96, and for 25 mm is 1,000.

Explosive Source Characterization

Now that the number of live fire events has been determined for the A/S Gunnery missions, it is necessary to estimate noise levels from the explosive shells (source characterization), as well as the loss of noise energy (transmission loss) over distance from the explosion source. The source characterization for an explosive shell is the estimated or measured noise level at the point of the detonation or underwater explosion. Transmission loss simply describes the loss of acoustic energy (or decrease in noise level) as the distance increases away from the source of the explosion. Without measurements ready available, underwater explosions are typically modeled in order to estimate their source characterization. As such, modeling was used to determine the source characterization for the A/S Gunnery ordnance as well.

There are several different metrics or units of measure utilized by those characterizing underwater noise, particularly when assessing potential impacts to marine mammals and sea turtles. A detailed summary and explanation of these metrics used in underwater noise characterization may be found in Appendix H. Some of the more recently used metrics for explosive source characterization include peak pressure, total energy flux density (EFD), and summation of the greatest 1/3 octave band (EFD). Peak pressure, along with several other energy metrics, has been derived through modeling to determine the source noise level for the explosive A/S Gunnery shells (Table 4-26). All of the source levels represent the noise modeled at a one meter distance from the point of underwater explosion. Peak pressure is in dB re 1 microPascal (μPa) units and Energy Flux Density (EFD) levels are in units of dB re 1 $\mu Pa^2 \cdot s$.

Table 4-26. Alternative 1 Explosive Shell Source Metric Levels

Expendable	Peak Pressure (dB)	Total Energy Flux Density	EFD in greatest 1/3 octave band > 10 Hz	EFD in greatest 1/3 octave band > 100 Hz
105 mm FU	272	234	223	223
40 mm	267	227	216	216
25 mm	260	216	204	204

Source: Author created

It should be noted that the use of peak pressure as a metric for estimating noise from small shots (small amount of explosive weight) potentially overestimates the actual measured acoustic energy and therefore may not be a good representative measure for noise impacts to marine mammals and sea turtles. As such, appropriate metrics and units of measure for assessing noise impacts to marine mammals and sea turtles are currently under debate. A comprehensive analysis utilizing the three different noise metrics described above are provided in Appendix E. For presentation purposes, the analyses to follow will focus on the total energy flux density metric of the greatest 1/3 octave band of hearing sensitivity for shelf cetaceans (i.e. primarily bottlenose dolphins). The analysis accounts for the release of pressure and energy into the atmosphere from rounds detonating at the surface. Use of this metric will enable a thorough impact analysis of Alternative 1 to assess underwater noise impacts to marine mammals and sea turtles, while also providing a meaningful metric for the comparison of all alternatives.

Zone of Influence (ZOI)

With known source levels of noise for each explosive A/S Gunnery shell, it is now possible to estimate the area of the Gulf of Mexico (zone of influence) and therefore the potential number of marine mammals and sea turtles exposed to the A/S Gunnery noise. Generally, a zone of influence (ZOI) describes the minimum region (of water) of the underwater explosion within which marine animals would be potentially exposed to a particular level of noise. For simplicity, ZOIs are often described as cylinders centered at the explosion with a constant radius over all depths.

The ZOI radius for a given underwater explosion depends on the noise metric and threshold selected. Thresholds employed to describe potential impacts to marine mammals and sea turtles are also the source of much scientific controversy and debate.

Over the last decade there has been considerable discussion within the scientific community regarding criteria to be used in determining when marine mammals are impacted by underwater noise. The debate has been continuous regarding the appropriate metrics and sound pressure levels to be used in judging degree of impacts. Controversy was ignited in the early 1990s by the Acoustic Thermometry of Ocean Climate (ATOC) project, designed to measure fluctuations in global temperatures in support of global warming research (CSI, 1995; ATOC, 2002). Due to concerns regarding potential impacts of high-level underwater noise sources to sensitive species protected by the Marine Mammal Protection Act, ATOC was delayed by the National Marine Fisheries Service until draft environmental impact statements were prepared (Buck, 1995). The debate captured the attention of Congress and led to the appointment of a special commission and publication of a special report by the National Research Council (NRC, 1994).

Congress reacted by promulgating amendments to the MMPA in 1994 that provided two levels of impact requiring permits (NOAA, 2002). Level A Harassment represents physical injury, which often leads to death of the animal. Level B Harassment represents changes in behavioral patterns. While there is general consensus in the scientific community on criteria for Level A Harassment, there is a wide range of interpretations and estimates of what represents Level B Harassment levels. The National Marine Fisheries Service (NMFS) has held a series of Acoustic Workshops in an attempt to gather information to support publishing guidance for estimating impacts of underwater noise and the number of resultant takes of protected species (NOAA/NMFS, 1998). Unfortunately, the leading authorities in the field have not been able to reach consensus on the technical issues.

In 2000, the NRC published an update to its 1994 report, but failed to bring any resolution to the debate (NRC, 2000). The report did call for clarification from Congress on its definition of Level B Harassment. The Natural Resources Defense Council also published a report on the subject in which they concur with NRC that the MMPA definitions of Level B Harassment require clarification (NRDC, 1999). The Department of Defense sought clarification from Congress as part of its Range Readiness and Preservation Initiative legislative package announced on 22 April 2002 (Denix, 2002). While endorsed by NMFS, the specific language clarifying definitions within MMPA was dropped early in the Committee review process. Major disagreements continue to the present day between scientists, regulators, environmental organizations, private citizens, industry, and the military over the effects of underwater noise on marine mammals.

Therefore, in order to cover the range of concerns expressed by interested parties, this assessment has focused on estimating the degree of acoustic exposure expected to occur as a result of the proposed actions and alternatives. Rather than attempting to determine the specific number of potential Level A and Level B takes, this report strives to estimate the potential number of protected species exposed to a range of noise levels using most commonly referenced metrics. The exposure data will be used to determine whether or not a consultation is required pursuant to the MMPA, and if so, to estimate the number of takes requiring permits based on methods recommended by NMFS. The metrics and range of sound pressure levels contained herein have been chosen in an effort to capture the more recently debated thresholds in scientific literature today, without preferentially selecting any single metric or criteria. The evaluation of impacts to marine mammals is best handled through the consultation process outlined under the Marine Mammal Protection Act and Endangered Species Act.

Methodology for Estimating Animal Exposure to Noise

The impact calculations for this section utilize marine mammal and sea turtle density estimates that have been derived from aerial surveys during the GulfCet II (1996-1997) surveys. In order to provide better species conservation and protection, the species density estimate data were adjusted to reflect more realistic encounters of these animals in their natural environment, and include considerations of: 1) temporal and spatial variations, 2) surface and submerged variations, 3) overall density estimate confidence, and 4) individual and group associations.

<u>Temporal and Spatial Variations:</u> The GulfCet II (1996-1997) aerial surveys have identified different density estimates of marine mammal and sea turtle between the winter and summer seasons, as well as between the shelf and slope geographic locations. Accordingly, the greatest species' density estimate available for any given season (winter or summer), location (shelf or slope), or survey type (aerial or ship) was utilized for conservative impact assessments.

<u>Surface and Submerged Variations:</u> The GulfCet II surveys focus on enumerating animals detected at the ocean surface, and therefore do not account for submerged animals or animals missed by the observer. As such, GulfCet II surveys do not provide a relative density estimate for the entire potential population of any given species, and are therefore negatively biased. To provide a more conservative impact analysis, density estimates have been adjusted to account for submerged individuals. The percent time that an animal is submerged versus at the surface was utilized to determine an adjusted density for each species. Percent time submerged for each species was obtained from Moore and Clarke (1998). Density estimates were adjusted to conservatively reflect the potential for undetected submerge animals.

<u>Density Estimate Confidence:</u> The abundance and density estimates of marine mammal and sea turtles resulting from the GulfCet II (1996-1997) aerial surveys were determined with an associated standard deviation and resulting coefficient of variation. Each of these analyses provides a measure of confidence about the resultant abundance and density estimate. These impact assessments for estimating protected species exposure utilize a methodology that incorporates the standard deviation in order to determine an upper confidence value for the density estimates. Similar methodologies have been employed by the National Marine Fisheries Service (NMFS), particularly at the Southeast Regional Office (SERO), to determine take assessments for biological opinions within this region. The standard deviation for each species abundance estimate was employed to increase the confidence of the analyses. Therefore, an

upper confidence value of two standard deviations (~ a 99% confidence level) was utilized to further adjust the density estimate for each species.

<u>Individual and Group Associations:</u> Since many marine mammals travel in groups or pods, impact assessments need to consider how this non-random distribution influences the calculations of potential impacts to a population. In some situations, the number of marine mammal groups (rather than individuals) may be the appropriate unit to consider potential risk. As an example, two hypothetical large test areas may be considered, one with 50 groups of 2 animals and the other with 2 groups of 50 animals. Further consider that within each large test area, a small zone of influence (ZOI) would be impacted. The risk of at least one group occurring within the ZOI would be much greater in the first case because there are many more groups to potentially encounter. Additionally, a group in the second case occurring in the ZOI would be easily detected, since large herds are highly visible. If only individual densities were compared, the two test areas would be considered equivalent, which is clearly not a valid case scenario. In situations such as this, the density of groups, along with mean group size, therefore may provide a more meaningful basis for calculating risk and, ultimately, estimating numbers of individuals potentially affected by the proposed actions (CHURCHILL FEIS) (U.S. Department of the Navy, 2000).

In the case of EGTTR where more than one explosion occurs, estimating the average number of animals exposed becomes complicated by source and animal spatial and temporal effects (see Appendix F). Often computations are further complicated by thresholds that depend on the duration or number of exposures for each animal. The general case of moving animals, moving sources, and exposure varying thresholds is difficult to solve analytically and Monte Carlo approaches are often used. Certain cases, however, can be solved analytically. The actual value of estimated number of affected (ENA) for the Appendix F Monte Carlo simulation is 0.127 animals. Based on Monte Carlo simulation, ENA values tend to be somewhat lower for random animal motion constrained to turns of ± 45° where a new turn is allowed every few seconds.

In the case of the EGTTR mission activities, however, the potential ENAs estimated from the Appendix F Monte Carlo simulation are less conservative than simply adjusting the individual density estimates to provide for a 99 percent confidence level as previously discussed. Therefore, the assessment using groups of animals are no more beneficial than just considering the likelihood of randomly encountering a single individual marine mammal. Additionally, these assessments have evaluated multiple shots as an additive energy exposure, and thus also provide a much more conservative assessment of potential animals affected. Similarly, as nearly all sea turtle sightings are solitary animals, individual densities are also appropriate for comparison.

Table 4-27 summarizes density estimates for marine mammals for the EGTTR test area and includes considerations of: 1) temporal and spatial variations, 2) surface and submerged variations, 3) individual and group associations, and 4) overall density estimate confidence. Similarly, Table 4-28 summarizes density estimates for sea turtles for the EGTTR test area. As a conservative approach for estimating marine mammal densities where temporal and spatial data were available, Continental Shelf data were utilized for the bottlenose dolphin, Atlantic spotted dolphin, and bottlenose dolphin/Atlantic spotted dolphin species, and Continental Slope data were used for the dwarf/pygmy whale. Similarly, the winter shelf density data were utilized for loggerhead sea turtles and the summer slope density data were utilized for leatherback sea turtles.

Table 4-27. Marine Mammal Densities for the ZOI Based on GulfCet II Surveys

Species	Individuals/ 100 km^2	Dive profile - % at surface	Mean Group Size	Groups/ km^2	Adjusted Density/km^2
Bryde's whale	.035	20	4	.0004	.007
Sperm whale	.052	10	1.5	.0034	.011
Dwarf/pygmy sperm whale	.267	20	1.8	.0074	.024
Cuvier's beaked whale	.031	10	2	.0016	.010
Mesoplodon spp.	.084	10	2.2	.0038	.019
Pygmy killer whale	.030	30	15	.0007	.027
False killer whale	.213	30	31	.0002	.026
Short-finned pilot whale	.227	30	33	.0002	.027
Rough-toothed dolphin	.234	30	34	.0002	.028
Bottlenose dolphin	14.798	30	7.3	.0690	.810
Risso's dolphin	1.87	30	8.8	.0070	.113
Atlantic spotted dolphin	8.89	30	31.8	.0090	.677
Pantropical spotted dolphin	19.369	30	67.4	.0095	1.077
Striped dolphin	3.119	30	66.7	.0015	.237
Spinner dolphin	12.302	30	63.1	.0064	.915
Clymene dolphin	3.253	30	97.4	.0011	.253
Bottlenose dolphin/Atlantic spotted dolphin	0.665	30	3.8	.002	.053
Unidentified whale	0.023	10	3.0	.002	.008
Totals	**65.74**				**4.326**

Source: Author created.

Table 4-28. Sea Turtle Densities for the ZOI based on GulfCet II surveys

Species	Individuals/ 100 km^2	Dive profile - % at surface	Mean Group Size	Groups/ km^2	Adjusted density/km^2
Loggerhead	4.253	10	1	.4253	.676
Leatherback	.327	10	1	.0327	.081
Kemps ridley	.097	10	1	.0100	.038
Unidentified chelonid	.340	10	1	.0340	.073
Totals	**5.017**				**.869**

Source: Author created.

Using the adjusted density estimate of each species, the ZOI of each type of round deployed, and the total number of events per year, an estimate of the potential number of animal exposed (harassed, injured, or killed) per year from noise were analyzed. Table 4-29 summarizes estimates for ZOI distances (radii) and the total number of marine mammals and sea turtles exposed to various noise thresholds for Alternative 1 A/S Gunnery ordnance (105 mm, 40 mm, and 25 mm). Estimates are provided over a range of noise threshold levels (160 dB re 1 $\mu Pa^2 \cdot s$ through 200 dB re 1 $\mu Pa^2 \cdot s$) utilizing the greatest 1/3 octave band energy flux density (EFD) metric.

Table 4-29. Range of ZOI (m) and Animals (#) Potentially Exposed for Alternative 1 A/S Gunnery

Expendable	160 dB	170 dB	180 dB	190 dB	200 dB
105 mm FU (m)	195	44.2	14	4.4	1.4
40 mm (m)	59.6	18.8	6.0	1.9	0.6
25 mm (m)	16.4	5.2	1.6	0.5	0.2
Marine Mammals (#)	184	12	1.2	0.12	0.01
Sea Turtles (#)	37	2.5	0.2	0.03	0.003
Total Animals (#)	221	14.5	1.4	0.15	0.013

Source: Author created

Current Permit Status

On April 9, 1998, the Air Force submitted a biological assessment to initiate a Section 7 consultation in order to resume limited daytime A/S Gunnery test missions in the Gulf (U.S. Air Force, 1998d). NMFS concluded the formal consultation with a biological opinion on December 17, 1998, which provided a "No Jeopardy" opinion ("not likely to adversely effect") for five listed sea turtle species, in addition to establishing an incidental take statement (sea turtles) for this action. Continuing with the Alternative 1 limited A/S Gunnery live fire during test mission activity was, and is still therefore legally permitted and requires the adherence to permit guidelines.

4.3 ALTERNATIVE 2

Alternative 2 is the authorization of Alternative 1, the baseline level of mission activities as captured. No changes from the baseline would occur under this alternative; thus environmental effects of Air Operations and Ordnance Testing and Training are the same as those described for Alternative 1.

4.4 ALTERNATIVE 3

Under Alternative 3, Nighttime A/S Gunnery Training would occur using the new 105 mm Training Round (TR) in addition to the Alternative 1 baseline level of activity, which includes limited daytime A/S Gunnery testing using the 105 mm Full Up (FU) round. An increase in A/S Gunnery activity would therefore occur, based on the fact that Alternative 1 represents only limited daytime A/S Gunnery test missions. Alternative 1 represents an annual baseline quantity of approximately 242 of the 105 mm FU rounds, while Alternative 3 would increase that quantity to 1,742 of the 105 mm rounds (242 FU and 1500 TR) to include nighttime operations. The number of 25 mm and 40 mm rounds expended would also increase compared to Alternative 1. All other Air Operations and Ordnance Testing and Training (non-A/S Gunnery) missions would be the same as those for Alternative 1. The anticipated Alternative 3 level of daytime testing and nighttime A/S Gunnery training activities are listed in Table 4-30.

Table 4-30. Summary of Alternative 3 A/S Gunnery Operations in the EGTTR

Test Area	Category	Expendable	Condition	Missions (#)	Events/Rounds (#)
W-151A	GUN	105 mm FU	LIVE	6	128
		105 mm TR	LIVE	45	902
		25 mm	LIVE	9	9,139
		40 mm	LIVE	108	10,347
W-151B	GUN	105 mm FU	LIVE	2	46
		105 mm TR	LIVE	13	255
		25 mm	LIVE	3	1,746
		40 mm	LIVE	32	3,169
W-151C	GUN	105 mm FU	LIVE	1	10
		105 mm TR	LIVE	9	197
		25 mm	LIVE	3	2,443
		40 mm	LIVE	25	2,352
W-151D	GUN	105 mm FU	LIVE	2	39
		105 mm TR	LIVE	7	133
		25 mm	LIVE	2	1,397
		40 mm	LIVE	18	1,781
W-151S	GUN	105 mm FU	LIVE	1	19
		105 mm TR	LIVE	1	13
		25 mm	LIVE	2	337
		40 mm	LIVE	2	181
		TOTAL		**291**	**34,634**

Source: Author created

Note: The quantities of A/S Gunnery ordnance (105 mm, 40 mm, and 25 mm) were adjusted to reflect the most recent (09/01/99) AFSOC aircraft loading requirements. Typical number of expendables per mission for 105 mm is 20, for 40 mm is 96, and for 25 mm is 1,000.

4.4.1 Air Operations

Under Alternative 3, the Alternative 1 baseline of 119,623 sorties would increase by only 263 sorties. Given the small increase in the number of sorties, air operation increases in subsonic and supersonic noise, chemical materials, and restricted access are negligible for Alternative 3. These increases are not likely to adversely impact biological or socioeconomic resources.

4.4.2 Ordnance Testing and Training

Debris

The types of rounds used in Alternative 3 (105 mm TR, 40 mm, and 25 mm) contribute extremely small amounts of debris compared to bombs, drones, and missiles/rockets, which make up the majority of the debris weight under Alternative 1 (Table 4-13). The addition of Alternative 3 rounds would increase the total amount of debris by a negligible amount and would not be expected to cause adverse effects to biological resources.

Chemical Materials

Concentrations of explosive detonation products in the EGTTR (Table 4-19) were extremely small for the Alternative 1 baseline level of activity (0.00778 μg/L or less). Under Alternative 3, the total number of items expended increases by only 30,802 items over the Alternative 1 baseline of over 1.8 million items. Given that Alternative 3 increases the number of items expended by less than 2 percent over Alternative 1, and the concentrations under Alternative 1 are already minute, the increase in chemical materials for ordnance testing and training under Alternative 3 is negligible. These extremely low concentrations of chemical materials are not expected to adversely impact biological resources.

Direct Physical Impacts (DPI)

As previously discussed (Alternative 1), the A/S Gunnery operations may potentially impact a variety of animal species at the ocean surface, but the emphasis of the discussion will focus on cetaceans and sea turtles, protected under the Endangered Species Act and Marine Mammal Protection Act. Alternative 3 represents an increase in the missions, number of expended items, and number of events. Subsequently, the potential for directly impacting an animal at the surface would potentially increase as well. DPI to marine mammals and sea turtles, however, is only determined from the small arms gun ammunition, excluding the 25 mm, 40 mm, and 105 mm rounds. As with Alternative 1, these rounds were not considered in the DPI analyses, as the noise analyses (below) constitute a far more conservative assessment for these exploding round types of ordnance. As such, the DPI to marine mammals and sea turtles under Alternative 3 would be the same as those determined for Alternative 1 (Table 4-23).

Noise

Alternative 3 includes nighttime A/S Gunnery training missions that use the new 105 mm TR round. This new 105 mm TR round contains approximately 0.3 pounds of high explosive (HE). The nighttime A/S Gunnery training missions are to be conducted in addition to the limited daytime A/S Gunnery testing missions, which use the 105 mm FU round (~4.7 pounds HE).

As reviewed in Alternative 1, there are several different metrics or units of measure utilized by those characterizing underwater noise, particularly when assessing potential impacts to marine mammals and sea turtles. A detailed summary and explanation of these metrics used in underwater noise characterization may be found in Appendix H. Some of the more recently used metrics for explosive source characterization include peak pressure, total energy flux density (EFD), and summation of the greatest 1/3 octave band (EFD). Peak pressure, along with several other energy metrics, has been derived through modeling for the explosive A/S Gunnery shells (Table 4-31). All of the source levels represent the noise modeled at a one-meter distance from the point of underwater explosion. Peak pressure is in dB re 1 μPa units and Energy Flux Density (EFD) levels are in units of dB re 1 $\mu Pa^2 \cdot s$.

Table 4-31. Alternative 3 Explosive Shell Noise Source Levels

Expendable	Peak Pressure (dB)	Total Energy Flux Density	EFD in greatest 1/3 octave band > 10 Hz	EFD in greatest 1/3 octave band > 100 Hz
105 mm TR	264	223	212	212
105 mm FU	272	234	223	223
40 mm	267	227	216	216
25 mm	260	216	204	204

Source: Author created. TR = Training Round; FU = Full Up

As noted in Alternative 1, the use of peak pressure as a metric for estimating noise from small shots (small amount of explosive weight) potentially overestimates the actual measured acoustic energy and therefore may not be a good representative measure for noise impacts to marine mammals and sea turtles. As such, appropriate metrics and units of measure for assessing noise impacts to marine mammals and sea turtles are currently under debate. A comprehensive analysis utilizing the three different noise metrics described above is provided in Appendix E. For presentation purposes, the analyses to follow will focus on the total energy flux density for the greatest 1/3 octave band metric. Use of this metric will enable a thorough impact analysis of Alternative 3 to assess underwater noise impacts to marine mammals and sea turtles, while also providing a meaningful metric for the comparison of all alternatives.

Table 4-32 summarizes estimates for ZOI distances (radii) and the total number of marine mammals and sea turtles exposed to various noise thresholds for Alternative 3 A/S Gunnery ordnance (daytime and nighttime 105 mm, 40 mm, and 25 mm). Estimates are provided over a range of noise threshold levels (160 dB re 1 $\mu Pa^2 \cdot s$ through 200 dB re 1 $\mu Pa^2 \cdot s$) utilizing the greatest 1/3 octave band energy flux density (EFD) metric.

Table 4-32. Range of ZOI in Meters (m) and Animals (#) Potentially Exposed for Alternative 3 A/S Gunnery

Expendable	160 dB	170 dB	180 dB	190 dB	200 dB
105 mm FU (m)	195	44.2	14	4.4	1.4
105 mm TR (m)	38	12	3.8	1.2	0.4
40 mm (m)	59.6	18.8	6.0	1.9	0.6
25 mm (m)	16.4	5.2	1.6	0.5	0.2
Marine Mammals (#)	1070	101	10.2	1.0	0.1
Sea Turtles (#)	215	20.2	2.1	0.2	0.02
Total Animals (#)	1285	121.2	12.3	1.2	0.12

Source: Author created.

Noise source levels for the 105 mm FU round and subsequent ZOI areas associated with the limited daytime A/S Gunnery missions remain the same for Alternative 3 as those defined in Alternative 1. The addition of nighttime A/S Gunnery testing missions (1,500 of the 105 mm TR rounds) to the existing daytime A/S Gunnery testing missions (242 of the 105 mm FU rounds) would increase the total impact area (for the 160 dB EFD threshold) from 28.9 km^2 under Alternative 1 to 35.7 km^2 under Alternative 3. This represents an increase of only 6.8 km^2, even though the number of events increases from 242 to 1,742 rounds.

However, there are complications associated with effective permit conditions at night (see Noise Summary). Appendix B explores the potential mitigations and management practices that could be implemented for Alternative 3.

4.5 ALTERNATIVE 4

Alternative 4 represents the same level of A/S Gunnery mission activity as Alternative 3, except 105 mm FU rounds (~4.7 lbs HE) would be used during the nighttime A/S Gunnery training missions instead of the 105 mm TR rounds (~0.3 lbs HE). The 105 mm FU would also continue to be used during the limited daytime A/S Gunnery test missions. All other Air Operations and Ordnance Testing and Training (non-A/S Gunnery) missions would be the same as those for Alternative 3. Alternative 4 therefore represents the same level (number of rounds) of day- and nighttime A/S Gunnery mission activity as described for Alternative 3. The anticipated Alternative 4 level of daytime testing and nighttime A/S Gunnery training activities (number and types of rounds) are listed in Table 4-33.

Table 4-33. Summary of Alternative 4 A/S Gunnery Operations in the EGTTR

Test Area	Category	Expendable	Condition	Missions (#)	Events/Rounds (#)
W-151A	GUN	105 mm HE	LIVE	51	1,030
		25 mm HE	LIVE	9	9,139
		40 mm HE	LIVE	108	10,347
W-151B	GUN	105 mm HE	LIVE	15	301
		25 mm HE	LIVE	3	1,746
		40 mm HE	LIVE	32	3,169
W-151C	GUN	105 mm HE	LIVE	10	207
		25 mm HE	LIVE	3	2,443
		40 mm HE	LIVE	25	2,352
W-151D	GUN	105 mm HE	LIVE	9	172
		25 mm HE	LIVE	2	1,397
		40 mm HE	LIVE	18	1,781
W-151S	GUN	105 mm HE	LIVE	2	32
		25 mm HE	LIVE	2	337
		40 mm HE	LIVE	2	181
		TOTAL		**291**	**34,634**

Source: Author created

Note: The quantities of A/S Gunnery ordnance (105 mm, 40 mm, and 25 mm) were adjusted to reflect the most recent (09/01/99) AFSOC aircraft loading requirements. Typical number of expendables per mission for 105 mm is 20, for 40 mm is 96, and for 25 mm is 1,000.

4.5.1 Air Operations

Similar to Alternative 3, Alternative 4 only increases the Alternative 1 baseline of 119,623 sorties by 263 sorties. Given the small increase in the number of sorties, air operation increases in subsonic and supersonic noise, chemical materials, and restricted access are negligible for Alternative 4. These increases are not likely to adversely impact biological or socioeconomic resources.

4.5.2 Ordnance Testing and Training

Debris

The types of rounds used in Alternative 4 (105 mm FU, 40 mm, and 25 mm) contribute extremely small amounts of debris compared to bombs, drones, and missiles/rockets, which make up the majority of the debris weight under Alternative 1 (Table 4-13). The addition of Alternative 4 rounds would increase the total amount of debris by a negligible amount and would not be expected to cause adverse effects to biological resources.

Chemical Materials

Concentrations of explosive detonation products in the EGTTR (Table 4-19) were extremely small for the Alternative 1 baseline level of activity (0.00778 μg/L or less). Under Alternative 4, the total number of items expended increases by only 30,802 items over the Alternative 1 baseline of over 1.8 million items. Given that Alternative 4 increases the number of items expended by less than 2 percent over Alternative 1, and the concentrations under Alternative 1 are already minute, the increase in chemical materials for ordnance testing and training under Alternative 4 is negligible. These extremely low concentrations of chemical materials are not expected to adversely impact biological resources.

Direct Physical Impacts (DPI)

Alternative 4 does not represent any increase in the number of missions, expended items, or the number of events compared to Alternative 3. Subsequently, the potential for direct physical impacts to animals at the sea surface would not increase. As such, the DPI to marine mammals and sea turtles under Alternative 4 would be the same as those determined for Alternatives 1 and 3 (Table 4-23).

Noise

Noise characteristics of the A/S Gunnery missions using the 105 mm FU round would be the same as previously discussed under Alternative 1; however, an increase in the number of sorties and therefore number of explosive shells and events would occur under Alternative 4. Source levels of noise for the 105 mm FU round have been previously described in Alternative 1 (Table 4-26).

Table 4-34 summarizes estimates for ZOI distances (radii) and the total number of marine mammals and sea turtles exposed to various noise thresholds for Alternative 4 A/S Gunnery ordnance (daytime and nighttime 105 mm, 40 mm, and 25 mm). Estimates are provided over a range of noise threshold levels (160 dB re 1 $\mu Pa^2 \cdot s$ through 200 dB re 1 $\mu Pa^2 \cdot s$) utilizing the greatest 1/3 octave band energy flux density (EFD) metric.

Table 4-34. Range of ZOI (m) and Animals (#) Potentially Impacted for Alternative 4 A/S Gunnery

Expendable	160 dB	170 dB	180 dB	190 dB	200 dB
105 mm FU (m)	195	44.2	14	4.4	1.4
40 mm (m)	59.6	18.8	6.0	1.9	0.6
25 mm (m)	16.4	5.2	1.6	0.5	0.2
Marine Mammals (#)	1,816	137	14	1.4	0.14
Sea Turtles (#)	365	28	2.8	0.3	0.03
Total Animals (#)	2,181	165	16.8	1.7	0.17

Source: Author created.

Noise source levels for the 105 mm FU round and subsequent ZOI areas associated with the limited daytime A/S Gunnery missions remain the same for Alternative 4 as those defined in Alternative 1 and Alternative 3. However, Alternative 4 represents an increase in the noise source levels for the 105 mm FU and subsequent ZOI areas for the nighttime A/S Gunnery missions as compared to Alternative 3. As such, Alternative 4 would result in an increase in the potential impacts to marine mammals and sea turtles. As an example, for nighttime A/S Gunnery missions only, the 160 dB EFD threshold encompasses a total impact area of approximately 6.8 km^2 for the 1,500 105 mm TR rounds used under Alternative 3, as compared to 179.2 km^2 for the 1,500 105 mm FU rounds used for Alternative 4.

Alternative 4 also implies potential complications associated with effective permit conditions at night (see Noise Summary). Appendix B explores the potential permit conditions and management practices that could be implemented for Alternative 4.

Noise Summary

Clearly, Alternative 4 presents the most potentially impactive alternative, given the increase in expendables using the maximum explosive weight (105 mm FU round), coupled with the fact that permit conditions or consultation measures for this alternative would be far less effective at night than the same measures conducted during daylight (Alternative 1).

Alternative 4 represents an increase in the noise source levels of the 105 mm full-up round over the 105 mm training round proposed for Alternative 3, and thus would result in an increase in potential impacts to marine mammals and sea turtles. For example, the 160 dB EFD threshold extends outward to only 38 meters using the 105 mm TR round (Alternative 3), whereas under Alternative 4 and Alternative 1, this same threshold for the 105 mm FU round would extend outward to a distance of 195 meters (Figure 4-5).

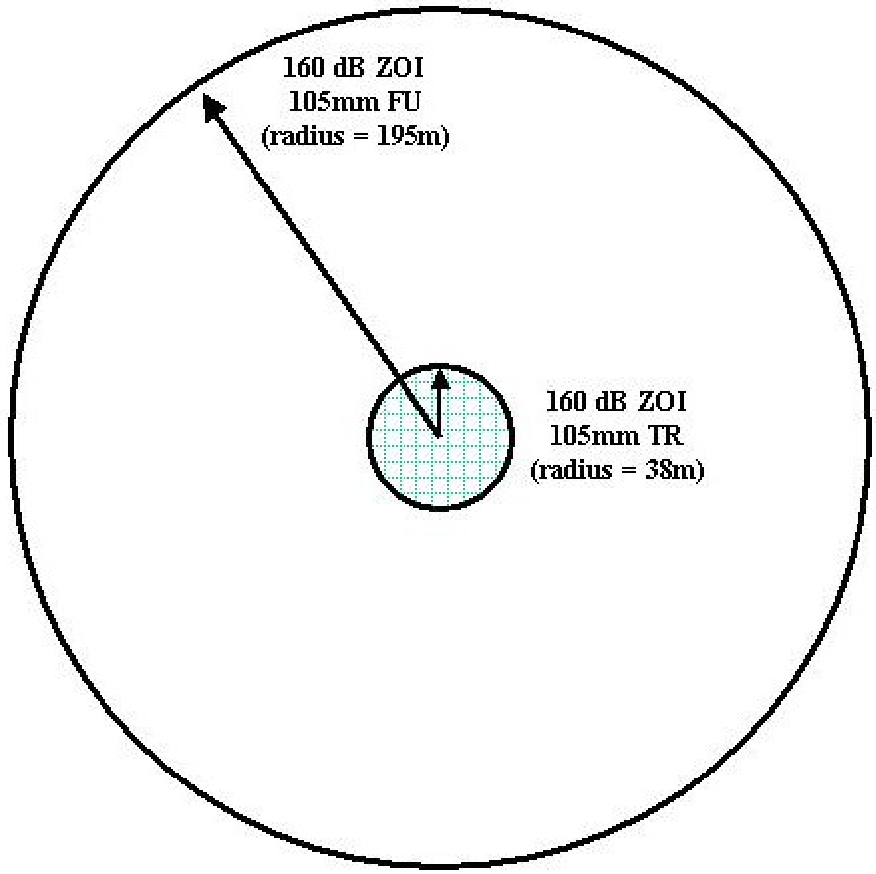


Figure 4-5. Illustration of ZOI Reduction Between Alternative 3 and 4 105 mm Rounds

Table 4-35 offers an additional comparison between Alternative 3 and Alternative 4, illustrating the reduction in impacts from utilizing the 105 mm TR round (Alternative 3) in place of the 105 mm FU round (Alternative 4), at the 160 dB threshold (other thresholds demonstrate similar reductions). Selection of Alternative 3, therefore, illustrates a reduction in risk to marine resource impacts as demonstrated by a 96 percent reduction in the ZOI and a 96 percent reduction in the potential number of animals impacted (Table 4-35). Other strategies, such as conducting mission activities in areas of the Gulf and/or during seasons (i.e. winter) where the observed marine mammal densities are statistically lower (as demonstrated by the GulfCet II surveys), would reduce potential impacts even further.

Table 4-35. Impact Reduction Using the 105 mm TR vs. the 105 mm FU Round

Threshold (dB)	Alternative 3 105 mm TR (~ 0.3 lbs HE)		Alternative 4 105 mm FU (~ 4.7 lbs HE)		Percent Reduction	
dB	**ZOI (km2)**	**Animals (#)**	**ZOI (km2)**	**Animals (#)**	**ZOI (%)**	**Animals (%)**
160	6.8	29.4	179.2	775.2	96	96

Source: Author created.

Compounding the increased source levels for Alternative 4 are the complications associated with implementing effective impact reduction strategies at night. Procedures such as seasonal considerations (e.g. fewer dolphins sighted within the northern Gulf during the winter), and ramping up from smaller munitions to larger munitions during a given mission would have greater importance in light of the fact that visual surveys to clear an area of marine mammals and sea turtles will be more difficult at night. However, gunships are equipped with infrared monitoring and night vision technologies and may be able to visually clear the area of protected species. Appendix B explores the potential permit conditions and management practices that could be implemented for nighttime A/S Gunnery activities. Under Alternative 4, impacts to cetaceans and sea turtles are estimated to potentially occur from noise generated from the 105 mm nighttime A/S Gunnery mission activity. Limited daytime A/S Gunnery, however, is a permitted activity with management practices in place to offset impacts, facilitated by surveying and clearing the area of marine mammals. The effectiveness of nighttime surveys is unproven, and therefore it cannot be assumed that nighttime A/S Gunnery impacts can be managed to the same degree as daytime impacts. Thus, noise from ordnance testing and training may impact biological resources during nighttime training activities.

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APPENDIX A

RELEVANT AND PERTINENT LAWS, REGULATIONS, AND POLICIES

RELEVANT AND PERTINENT LAWS, REGULATIONS, AND POLICIES

The Eglin Gulf Test and Training Range Programmatic Environmental Assessment was prepared with consideration and compliance of relevant and pertinent environmental laws, regulations, and policies. This section includes federal executive orders and laws; Department of Defense (DoD) directives and instructions; Air Force instructions (AFI) and policy directives; and Florida state statutes and administrative codes. This list has been compiled and limited to include the most relevant laws, regulations, and policies that are pertinent to the specific mission activities defined in this document. It is further recognized that additional laws and regulations may exist and will be included with subsequent updates.

General

42 USC 4321 et seq; 1969; National Environmental Policy Act of 1969 (NEPA); Requires that federal agencies (1) consider the consequences of an action on the environment before taking the action and (2) involve the public in the decision making process for major federal actions that significantly affect the quality of the human environment.

32 CFR 989; 2000; The Environmental Impact Analysis Process; This Instruction provides a framework for how the Air Force is to comply with NEPA and the CEQ regulations.

Executive Order 12372; 14-Jul-82; Intergovernmental Review of Federal Programs; Directs federal agencies to inform states of plans and actions, use state processes to obtain state views, accommodate state and local concerns, encourage state plans, and coordinate states' views.

Executive Order 12898; 11-Feb-94; Environmental Justice; Directs federal agencies to identify disproportionately high and adverse human health or environmental impacts resulting from programs, activities or policies on minority populations.

Executive Order 13148; 22-Apr-00; Greening the Government Through Leadership in Environmental Management. Directs heads of federal agencies to ensure all necessary actions are taken to integrate environmental accountability into agency day-to-day decision making and long-term planning processes, across agency missions, activities and functions.

Air Force Policy Directive 32-70; 20-Jul-94; Environmental Quality; Develops and implements the Air Force Environmental Quality Program composed of cleanup, compliance, conservation, and pollution prevention.

Air Force Instruction 32-7045; 1-Apr-94; Environmental Compliance and Assessment; Implements AFPD 32-70 by providing for an annual internal self-evaluation and program management system to ensure compliance with federal, state, local, DoD, and Air Force environmental laws and regulations.

Air Force Instruction 32-7062; 1-Apr-94; Air Force Comprehensive Planning; Implements AFPD 32-70 by establishing Air Force Comprehensive Planning Program for development of Air Force Installations, ensuring that natural, cultural, environmental, and social science factors are considered in planning and decision making.

Physical Resources

Air Quality

42 USC 7401 et seq.; 40 CFR Parts 50 & 51; 1996; Clean Air Act, National Ambient Air Quality Standards (CAA, NAAQS); Emission sources must comply with air quality standards and regulations established by federal, state, and local regulatory agencies.

Air Force Policy Directive 32-70; 20-Jul-94; Environmental Quality; Develops and implements the Air Force Environmental Quality Program composed of cleanup, compliance, conservation, and pollution prevention. Implements Clean Air Act.

Air Force Instruction 32-7040; 9-May-94; Air Quality Compliance; This AFI sets forth actions for bases to implement to achieve and maintain compliance with applicable standards for air quality compliance, and responsibilities for who is to implement them. Includes requirements for NEPA and RCRA as well as CAA.

F.S. Ch. 403, Part I; 1996; Florida Air and Water Pollution Control Act; Regulates air pollution within the state.

F.A.C. Chap. 62-204; 01-Oct-01; Florida State Implementation Plan, with Ambient Air Quality Standards and PSD Program; Establishes state air quality standards and requirements for maintaining compliance with NAAQS.

F.A.C. Chap. 62-212; 1996; Adopted Prevention of Significant Deterioration (PSD) permit program, designed to control the impact of economic growth on areas that are already in attainment.

Executive Order 12088, Federal Compliance with Pollution Control Standards.

Airspace Use

49 USC 106 & Subtitle VII; 1997-Supp; Federal Aviation Act of 1958 (FAA); Created the FAA and establishes administrator with responsibility of ensuring aircraft safety and efficient utilization of the National Airspace System.

14 CFR Part 71; 1997; Federal Aviation Regulation (FAR); Defines federal air routes, controlled airspace, and flight locations for reporting position.

14 CFR Part 73; 1997; Federal Aviation Regulation (SFAR No. 53); Defines and prescribes requirements for special use airspace.

14 CFR Part 91; 1997; Federal Aviation Regulation (FAR); Governs the operation of aircraft within the United States, including the waters within three nmi of the U.S. Coast. In addition, certain rules apply to persons operating in airspace between three and 12 nmi from the U.S. coast.

AFI 11-201; 2000; Air Operations. Implements aircraft rules and procedures applicable to air operations at Eglin AFB, including auxiliary airfields, land test areas and the EGTTR. September 8.

AFI 13-201; 2001; Air Force Airspace Management; This instruction implements AFPD 13-2, *Air Traffic Control, Airspace, Airfield, and Range Management* and DoD Directive 5030.19, DoD Responsibilities on Federal Aviation and National Airspace System Matters, 22 June 1989. Guidance and procedures for concerning special use airspace (SUA); planning, use, acquisition and management of airspace used for supporting Air Force flight operations; and managing and reducing adverse public reactions to flight operations are also covered. Section 2.11 establishes guidelines for overwater supersonic flight.

Land Resources

16 USC 670a to 670o; 1997-Supp; Sikes Act, Conservation Programs on Military Reservations; DoD, in a cooperative plan with DOI and State, opens Air Force bases to outdoor recreation, provides the state with a share of profits from sale of resources (timber), and conserves and rehabilitates wildlife, fish, and game on each reservation. The Air Force is to manage the natural resources of its reservations to provide for sustained multipurpose use and public use

16 USC 1451 to 1465; 1997-Supp; Coastal Zone Management Act of 1972 (CZMA); Federal agency activities in coastal zones should be consistent with state management plans to preserve and protect coastal zones. Lands for which the federal government has sole discretion or holds in trust are excluded from the coastal zone.

USC 1701 et seq., (Public Law 94-579; 1997-Supp; Federal Land Policy and Management Act of 1976 (FLPMA); Provides that the Secretary of Interior shall develop land use plans for public lands within BLM jurisdiction to protect scientific, scenic, historical, ecological, environmental, and archeological values and to accommodate needs for minerals, food, and timber.

16 USC 3501 to 3510; 1997-Supp; Coastal Barrier Resources Act (CBRA); Limits federal expenditure for activities on areas within the Coastal Barrier Resources System. An exception is for military activities essential to national security, after the federal agency consults with the Secretary of the Interior.

Air Force Instruction 13-212v1, v2, v3; 2001; *Range Planning and Operation (v1), Range Construction and Maintenance (v2), and SAFE-RANGE Program Methodology (v3).* Implements, in conjunction with AFI 13-201, AFPD 13-2, *Air Traffic Control, Airspace, Airfield and Range Management.* Defines Air Force requirements and responsibilities for managing ranges.

Air Force Instruction 32-7062; 1-Apr-94; Air Force Comprehensive Planning; Implements AFPD 32-70 by establishing Air Force Comprehensive Planning Program for development of Air Force Installations, ensuring that natural, cultural, environmental, and social science factors are considered in planning and decision making.

Air Force Instruction 32-7063; 31-Mar-94; Air Installation Compatible Use Zone Program (AICUZ); Provides a framework to promote compatible development within area of AICUZ area of influence and protect Air Force operational capability from the effects of land use which are incompatible with aircraft operations.

Air Force Instruction 32-7064 22-Jul-94; Integrated Natural Resources Management; Provides for development of an integrated natural resources management plan to manage the installation ecosystem and integrate natural resources management with the rest of the installation's mission. Includes physical and biological resources and uses.

Noise

42 USC 4901 to 4918, Public Law 92-574; 1997-Supp; Noise Control Act of 1972 (NCA); Provides that each federal agency must comply with federal, state, interstate, and local requirements for control and abatement of environmental noise.

49 USC 44715; 1997-Supp; Controlling Aircraft Noise and Sonic Boom; Provides that the FAA will issue regulations in consultation with the USEPA to control and abate aircraft noise and sonic boom.

Executive Order 12088; 1978; Federal Compliance with Pollution Control Standards; Requires the head of each executive agency to take responsibility for ensuring all actions have been taken to prevent, control, and abate environmental (noise) pollution with respect to federal activities.

Air Force Instruction 32-7063; 1-Mar-94; Air Installation Compatible Use Zone Program (AICUZ); The AICUZ study defines and maps noise contours. Update when noise exposure in air force operations results in a change of Day-Night Average Sound Level of two decibels (dBs) or more as compared to the noise contour map in the most recent AICUZ study.

Water Resources

33 USC 426, 577, 577a, 595a; 1997-Supp; River and Harbor Act of 1970 (RHA); Keeps navigable waterways open, authorizing the Army Corps of Engineers to investigate and control beach erosion and to undertake river and harbor improvements.

33 USC 1251 et seq.; 1997-Supp; Clean Water Act (CWA) (Federal Water Pollution Prevention and Control Act, FWPCA); In addition to regulating navigable water quality, the CWA establishes NPDES permit program for discharge into surface waters and storm water control; Army Corps of Engineers permit and state certification for wetlands disturbance; regulates ocean discharge; sewage wastes control; and oil pollution prevention.

33 USC 1344-Section 404; 1997-Supp; Clean Water Act (CWA) (Federal Water Pollution Control Act, FWPCA), Dredged or Fill Permit Program; Regulates development in streams and wetlands by requiring a permit from the

Army Corps of Engineers for discharge of dredged or fill material into navigable waters. A Section 401 (33 USC 1341) Certification is required from the state as well.

42 USC 300f et seq.; 1997-Supp; Safe Drinking Water Act (SDWA); Requires the promulgation of drinking water standards, or MCLs, which are often used as cleanup values in remediation; establishes the underground injection well program; and establishes a wellhead protection program.

42 USC 6901 et seq.; 29-May-05; Resource Conservation and Recovery Act of 1976 (RCRA); Establishes standards for management of hazardous waste so that water resources are not contaminated: RCRA Corrective Action Program requires cleanup of groundwater that has been contaminated with hazardous constituents.

42 USC 9601 et seq., Public Law 96-510; 11-Dec-80; Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA); Establishes the emergency response and remediation program for water and groundwater resources contaminated with hazardous substances.

Executive Order 12114, 44 FR, No. 62; 04-Jan-79; Environmental Effects Abroad of Major Federal Actions. Activities outside the jurisdiction of the United States, which significantly harm the natural or physical environment, shall be evaluated. An EIS shall be prepared for major federal actions having significant environmental effects within the global commons (i.e. Antarctica, oceans).

Department of Defense Directive 6050.7; 31-Mar-79; Environmental Effects Abroad of Major Department of Defense Actions. Implements Executive Order 12114.

Air Force Policy Directive 32-70; 20-Jul-94; Environmental Quality; Develops and implements the Air Force Environmental Quality Program composed of cleanup, compliance, conservation, and pollution prevention. Implements Clean Water Act, Safe Drinking Water Act, and Water Quality Act of 1987.

Air Force Instruction 32-7006 29-Apr-94; Environmental Program in Foreign Countries; Implements DoD Directive 6050.7.

Air Force Instruction 32-7041; 13-May-94; Water Quality Compliance; Instructs the Air Force on maintaining compliance with the Clean Water Act; other federal, state, and local environmental regulations; and related DoD and Air Force water quality directives.

Air Force Instruction 32-7064; 22-Jul-94; Integrated Natural Resources Management; Sets forth requirements for addressing wetlands, floodplains, and coastal and marine resources in an integrated natural resources management plan (INRMP) for each installation.

Florida Statutes Chaps. 253, 258; 1996; Florida Aquatic Preserves Act; Establishes state aquatic preserves.

Florida Statutes Chap. 403, Part I; Florida Air and Water Pollution Control Act; Establishes the regulatory system for water resources in Florida.

Florida Administrative Code Chap. 62-302; 1995; Surface Water Quality Standards; Classifies Florida surface waters by use. Identifies Outstanding Florida Waters.

Florida Administrative Code Chap. 62-312; 1995; Florida Dredge and Fill Activities; Requires a state permit for dredging and filling conducted in, on, or over the surface waters of the state.

Biological Resources

Animal Resources

16 USC 703 - 712; 1997-Supp; Migratory Bird Treaty Act (MBTA); Makes it illegal to take, kill, or possess migratory birds unless done so in accordance with regulations. An exemption may be obtained from the Department of the Interior for taking a listed migratory bird.

16 USC 1361 et seq.; 1997-Supp; Marine Mammal Protection Act of 1972, as amended (MMPA); Makes it illegal for any person to "take" a marine mammal, which includes significantly disturbing a habitat, unless activities are conducted in accordance with regulations or a permit.

Air Force Instruction 32-7064; 22-Jul-94; Integrated Natural Resources Management; Explains how to manage natural resources on Air Force property, and to comply with federal, state, and local standards for resource management.

Threatened and Endangered Species

16 USC 1361 et seq., Public Law 92-574; 1997-Supp; Marine Mammal Protection Act of 1972, (MMPA); Makes it illegal for a person to "take" a marine mammal, which includes significantly disturbing the habitat, unless done in accordance with regulations or a permit.

16 USC 1531 to 1544-16 USC 1536(a); 1997-Supp; Endangered Species Act 1973 (ESA); Federal agencies must ensure their actions do not jeopardize the continued existence of any endangered or threatened species or destroy or adversely modify the habitat of such species and must set up a conservation program.

50 CFR Part 402; 1996; Endangered Species Act - Interagency Cooperation; These rules prescribe how a federal agency is to interact with either the FWS or the NMFS in implementing conservation measures or agency activities.

50 CFR Part 450; 1996; Endangered Species Exemption Process; These rules set forth the application procedure for an exemption from complying with Section 7(a)(2) of the ESA, 16 USC 1536(a)(2), which requires that federal agencies ensure their actions do not affect endangered or threatened species or habitats.

Air Force Policy Directive 32-70; 20-Jul-94; Environmental Quality; Develops and implements the Air Force Environmental Quality Program composed of cleanup, compliance, conservation, and pollution prevention. Implements Endangered Species Act.

Air Force Instruction 32-7064; 22-Jul-94; Integrated Natural Resources Management; This AFI directs an installation to include in its INRMP procedures for managing and protecting endangered species or critical habitat, including state-listed endangered, threatened or rare species; and discusses agency coordination.

Human Safety

29 CFR 1910.120; 1996; Occupational Safety and Health Act, Chemical Hazard Communication Program (OSHA); Requires that chemical hazard identification, information and training be available to employees using hazardous materials and institutes material safety data sheets (MSDS) which provide this information.

Department of Defense Instruction 6055.1; Establishes occupational safety and health guidance for managing and controlling the reduction of radio frequency exposure.

Department Of Defense Directive Number 6055.9; 1996; Addresses DoD Explosives Safety Board and DoD Component Explosives Safety Responsibilities.

Department of Defense Flight Information Publication; Identifies regions of potential hazard resulting from bird aggregations or obstructions, military airspace noise sensitive locations, and defines airspace avoidance measures.

Air Force Instructions 13-212v1 and v2; 1994; Weapons Ranges and Weapons Range Management; Establishes procedures for planning, construction, design, operation, and maintenance of weapons ranges as well as defines weapons safety footprints, buffer zones, and safest procedures for ordnance and aircraft malfunction.

Air Force Instruction 32-2001; 16-May-94; The Fire Protection Operations and Fire Prevention Program; Identifies requirements for Air Force fire protection programs (equipment, response time, and training).

Air Force Instruction 32-7063; 1-Mar-94; Air Installation Compatible Use Zone Program (AICUZ). The AICUZ Study defines and maps accident potential zones and runway clear zones around the installation, and contains specific land use compatibility recommendations based on aircraft operational effects and existing land use, zoning, and planned land use.

Air Force Manual 91-201; 12-Jan-96; Explosives Safety Standards; Regulates and identifies procedures for explosives safety and handling as well as defining requirements for ordnance quantity distances, safety buffer zones, and storage facilities.

Air Force Instruction 91-301; 1-Jun-96; Air Force Occupational and Environmental Safety, Fire Protection and Health (AFOSH) Program); Identifies occupational safety, fire prevention, and health regulations governing Air Force activities and procedures associated with safety in the workplace.

Habitat Resources

Executive Order 11990; 24-May-77; Protection of Wetlands; Requires federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands in their activities. Construction is limited in wetlands and requires public participation.

Executive Order 11988; 24-May-77; Floodplain Management; Directs federal agencies to restore and preserve floodplains by performing the following in floodplains: not supporting development; evaluating effects of potential actions; allowing public review of plans; and considering in land and water resource use.

Executive Order 13089; 11-June-98; Coral Reef Protection; Provides for implementation of measures needed to research, monitor, manage, and restore affected U.S. Coral Reef Ecosystems from federal agency actions. U.S. coral reef ecosystems include those species, habitats, and other natural resources associated with coral reefs within the maritime areas and zones subject to U.S. jurisdiction or control. Coral reef development is typically restricted to the warmer waters of the tropic and sub-tropic regions of the continent.

Air Force Policy Directive 32-70; 20-Jul-94; Environmental Quality; Develops and implements the Air Force Environmental Quality Program composed of cleanup, compliance, conservation, and pollution prevention. Implements Executive Order 11988 and 11990.

Anthropogenic Resources

Hazardous Materials

7 USC 136 et seq., Public Law 92-516; 1997-Supp; Federal Insecticide, Fungicide, and Rodenticide Act Insecticide and Environmental Pesticide Control (FIFRA); Establishes requirements for use of pesticides that may be relevant to activities at Eglin Air Force Base.

33 U.S.C. 1401 et seq.; 1972; Marine Protection, Research, and Sanctuaries Act (MPRSA) 1972 (Ocean Dumping Act), amended in 1988 [Ocean Dumping Ban Act (ODBA)] states that U.S. policy is regulate all materials dumped into U.S. waters, and to prevent or limit the dumping of materials that pose a human health risk or would adversely affect the marine environment. The act was designed to prevent the dumping of sewage sludge, industrial wastes, and potentially infectious medical waste and to regulate the amounts of less hazardous waste dumped in ocean waters.

42 U.S.C. Sect. 2011 - Sect. 2259; 1997-Supp; Atomic Energy Act of 1954 (AEA); Assures the proper management of source, special nuclear, and byproduct radioactive materials.

42 USC 6901 et seq.; 1980; Resource Conservation and Recovery Act of 1976 and Solid Waste Disposal Act of 1980 (RCRA); Subchapter III sets forth hazardous waste management provisions; Subchapter IV sets forth solid waste management provisions; and Subchapter IX sets forth underground storage tank provisions; with which federal agencies must comply.

42 USC 9601 et seq., Public Law 96-510; 1997-Supp; Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA); Establishes the liability and responsibilities of federal agencies for emergency response measures and remediation when hazardous substances are or have been released into the environment.

42 USC 11001 to 11050; 1995; Emergency Planning and Community Right-to-Know Act (EPCRA); Provides for notification procedures when a release of a hazardous substance occurs; sets up community response measures to a hazardous substance release; and establishes inventory and reporting requirements for toxic substances at all facilities.

42 USC 13101 to 13109; 1990; Pollution Prevention Act of 1990 (PPA); Establishes source reduction as the preferred method of pollution prevention, followed by recycling, treatment, then disposal into the environment. Establishes reporting requirements to submit with EPCRA reports. Federal agencies must comply.

Air Force Policy Directive 32-70; 20-Jul-94; Environmental Quality; Provides for developing and implementing an Air Force Environmental Quality Program composed of four pillars: cleanup, compliance, conservation and pollution prevention. Implements Resource Recovery and Conservation Act, Comprehensive Environment Response Compensation and Liability Act of 1980, Emergency Planning and Community Right-to-Know Act, Pollution Prevention Act, Executive Order 12088, Executive Order 12777, and Executive Order 12586. Implements DoD Instruction 4120.14, DoD Directive 4210.15, and DoD Directive 5030.41.

Air Force Instruction 32-7020; 19-May-94; The Environmental Restoration Program; Introduces the basic structure and components of a cleanup program under the Defense Environmental Restoration Program. Sets forth cleanup program elements, key issues, key management topics, objectives, goals and scope of the cleanup program.

Air Force Instruction 32-7042; 12-May-94; Solid and Hazardous Waste Compliance; Provides that each installation must develop a hazardous waste (HW) and a solid waste (SW) management plan; characterize all HW streams; and dispose of them in accordance with the AFI. Plans must address pollution prevention as well.

Air Force Instruction 32-7080; 12-May-94; Pollution Prevention Program; Each installation is to develop a pollution prevention management plan that addresses ozone depleting chemicals; EPA 17 industrial toxics; hazardous and solid wastes; obtaining environmentally friendly products; energy conservation, and air and water.

Air Force Policy Directive 40-2; 8-Apr-93; Radioactive Materials; Establishes policy for control of radioactive materials, including those regulated by the US Nuclear Regulatory Commission (NRC), but excluding those used in nuclear weapons.

Cultural Resources

10 USC 2701 note, Public Law 103-139; 1997-Supp; Legacy Resource Management Program (LRMP); Provides funding to conduct inventories of all scientifically significant biological assets of Eglin AFB.

16 USC 431 et seq.; PL 59-209; 34 Stat. 225; 43 CFR 3; 1906; Antiquities Act of 1906; Provides protection for archeological resources by protecting all historic and prehistoric sites on federal lands. Prohibits excavation or destruction of such antiquities without the permission (Antiquities Permit) of the secretary of the department, which has the jurisdiction over those lands.

16 USC 461 to 467; 1997-Supp; Historic Sites, Buildings and Antiquities Act (HAS); Establishes national policy to preserve for public use historic sites, buildings and objects of national significance: the Secretary of the Interior operates through the National Park Service to implement this national policy.

16 USC 469 to 469c-1; 1997-Supp; Archaeological and Historic Preservation Act of 1974 (AHPA); Directs federal agencies to give notice to the Secretary of the Interior before starting construction of a dam or other project that will alter the terrain and destroy scientific, historical or archeological data, so that the Secretary may undertake preservation.

16 USC 470aa-470mm, Public Law 96-95; 1997-Supp; Archaeological Resources Protection Act of 1979 (ARPA); Establishes permit requirements for archaeological investigations and ensures protection and preservation of archaeological sites on federal property.

16 USC 470 to 470w-6-16 USC 470f, 470h-2; 1997-Supp; National Historic Preservation Act (NHPA); Requires federal agencies to (1) allow the Advisory Council on Historic Preservation to comment before taking action on properties eligible for the National Register and (2) preserve such properties in accordance with statutory and regulatory provisions.

25 USC 3001 - 3013), (Public Law 101-601; 1997-Supp; Native American Graves Protection and Repatriation Act of 1991 (NAGPRA); Federal agencies must obtain a permit under the Archeological Resources Protection Act before excavating Native American artifacts. Federal agencies must inventory and preserve such artifacts found on land within their stewardship.

42 USC 1996; 1994; American Indian Religious Freedom Act (AIRFA); Federal agencies should do what they can to ensure that American Indians have access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites in the practice of their traditional religions.

32 CFR Part 200; 1996; Protection of Archaeological Resources: Uniform Regulations; Provides that no person may excavate or remove any archaeological resource located on public lands or Indian lands unless such activity is conducted pursuant to a permit issued under this Part or is exempted under this Part.

36 CFR Part 60; 1996; Nominations to National Register of Historic Places; Details how the federal agency Preservation Officer is to nominate properties to the Advisory Council for consideration to be included on the National Register.

36 CFR Part 800; 1995; Protection of Historic and Cultural Properties; Sets out the Section 106 process for complying with Sections 106 and 110 of the NHPA: the agency official, in consultation with the State Historic Preservation Officer (SHPO), identifies and evaluates affected historic properties for the Advisory Council.

Abandoned Shipwreck Act; 1987; This act places shipwrecks in state or federal waters under the jurisdiction and title of the federal government, and requires the preservation of shipwrecks and the consideration of actions that could impact them.

Florida Statute Title XVIII, Chapter 267; Florida Historical Resources Act; In parallel with the Abandoned Shipwreck Act, this act governs the administration and protection of cultural resources on state-owned lands. Submerged state lands include the bottoms of navigable streams and rivers, lakes, bays, and adjacent Gulf and Atlantic seafloors. Excavation or disturbance of cultural resources on state lands requires a permit from the Florida Division of Historical Resources, Bureau of Archeological Research.

Executive Order 11593, 16 USC 470; 13-May-71; Protection and Enhancement of the Cultural Environment; Instructs federal agencies to identify and nominate historic properties to the National Register, as well as avoid damage to Historic properties eligible for National Register.

Executive Order 13007; 24-May-96; Directs federal agencies to provide access to and ceremonial use of sacred Indian sites by Indian religious practitioners as well as promote the physical integrity of sacred sites.

DoD Directive 4710.1; Archaeological and Historic Resources Management (AHRM); Establishes policy requirements for archaeological and cultural resource protection and management for all military lands and reservations.

Air Force Policy Directive 32-70; 20-Jul-94; Environmental Quality; Develops and implements the Air Force Environmental Quality Program composed of cleanup, compliance, conservation, and pollution prevention. Implements National Historic Preservation Act, Executive Order 11593, and DoD Directive 470.1.

Air Force Instruction 32-7065; 13-Jun-94; Cultural Resource Management; Directs Air Force bases to prepare cultural resources management plans (CRMP) to comply with historic preservation requirements, Native American considerations; and archeological resource protection requirements, as part of the Base Comprehensive Plan.

Air Force Policy Letter; 4-Jan-82; Establishes Air Force policy to comply with historic preservation and other federal environmental laws and directive.

APPENDIX B

CURRENT AND PROPOSED OPERATIONAL CONSIDERATIONS AND MANAGEMENT PRACTICES

CURRENT AND PROPOSED OPERATIONAL CONSIDERATIONS AND MANAGEMENT PRACTICES

CURRENT MANAGEMENT PRACTICES

Air Operations

AACI 11-201, Air Operations, implements aircraft rules and procedures that apply to all air operations at Eglin AFB, auxiliary fields, and test areas within the Eglin Gulf Test and Training Range (EGTTR) with the exception of Auxiliary Field 10 (Dillon Field known as NOLF Choctaw). Currently observed practices are:

Eglin Water Test Areas (EWTAs). Procedures for their use have been established by letter of agreement between Jacksonville Air Route Traffic Control (ARTC) Center and AAC. They do not encompass any warning or restricted airspace. Their purpose is to simplify the process of issuing a Notice to Airmen (NOTAM) when AAC tests require this airspace. The areas are known as EWTA-1 through 6.

Fuel Tank Jettison. Whenever possible, the Eglin Range Control Facility (ERCF) shall provide navigation assistance at the pilot's request to the area where the tanks are to be jettisoned. Release of external fuel tanks shall be made over water or uninhabited land areas and, if possible, coordinated with the controlling agency.

HC/MC-130 Refueling Hose Jettison Procedures. HC/MC-130 aircraft with a hung refueling hose shall jettison over the following ranges: SONTAY DZ (R-2915A CEW 218/12), PINO DZ (R-2914A CEW120/17), any range not active, or Eglin water range.

Ordnance Testing and Training

AFDTCI 11-201, Air Operations, implements aircraft rules and procedures which apply to all air operations at Eglin AFB, auxiliary fields and test areas within the Eglin Gulf Test and Training Range with the exception of Auxiliary Field 10 (Dillon Field known as NOLF Choctaw).

Explosive Detonations

No detonation can produce a seismic shock of more than 1 inch/sec peak particle velocity when reaching any structure. An approximate calculation is 60 times the square root of the NEW equals distance in feet to the structure.

Fragmentation Hazards - AAC Safety Office routinely imposes restrictions on bomb detonations due to fragmentation of the weapon. Typical restrictions include bomb orientation and a safety footprint as dictated by the bomb size and amount of HE, etc.

Targets

Most targets are environmentally cleaned before placed into use. All static targets (stationary targets on either the land or water) are always environmentally cleaned. This includes removal of all petroleum products, hazardous material (batteries, radium dials, certain metals, PCB's, etc.), loose debris, and anything that could float. The exception to this is moving targets. This includes remote control vehicles, vessels, and aircraft. Because they are moving or "operational," environmental cleaning cannot be accomplished. Within 24 hours of "using" a remotely controlled target, ground restoration should start.

Since there is a potential and/or a desire to sink sea targets, all targets must be placed so that there is at least 11 fathoms (66 feet) of water from the highest point on the sunken wreck to the surface. The U.S. Coast Guard in Mobile must approve the vessel's siting and precise coordinates with good bottom profile must be recorded before and after sinking.

Proposed Management Practices

Underwater Noise

Noise impact reduction procedures may be costly and may significantly limit the test activities. However, implementing such procedures may preclude the need for a permit, and minimize concerns of regulators and the public.

Certain impact management schemes have become almost standard, appearing in numerous NEPA documents that concern underwater noise. There is also an important guideline sometimes voiced by regulators regarding the need to manage potential impacts beyond some practical level.

Because of the very specific types of actions planned for the EGTTR, certain noise management approaches will not be possible. On the other hand, effectiveness of candidate schemes can be gauged at the start.

Potential management practices to reduce impact of the AC-130 A/S Gunnery tests and training are summarized below according to the following outline:

- Seasonal and Geographic Considerations
- Modification of the Action in Response to Monitoring (Visual/Acoustic)
- Deterrence, "Ramp-Up," and Warning Procedures
- Customized Modification of the Action Itself as a Management Practice
- Research Programs to Measure and Limit Impact

Site and Season Selection to Manage Potential Impacts

As part of NEPA compliance, it is general procedure to consider alternate sites/seasons. As part of the tradeoff, it is usual to balance test requirements with risk reduction. This is perhaps the most effective of all management practices, and it may also be the most cost-effective.

Estimation of Occurrence (of Protected Species) in Advance of the Action – Traditional Approach

This subsection is included to emphasize the importance of developing dependable statistical bounds on the occurrence of protected species. The process begins with estimates of stock populations, relative abundance, migration patterns, etc., from NMFS/USFWS, and with published siting and statistical data (as may now be found in such data bases as the Navy's LMRIS). For actions with large zones of influence, the estimates must often be highly refined, and may call for new, dedicated surveys (e.g., SEAWOLF).

In the case of the EGTTR, the zones of influence are relatively small, and previous studies provide realistic bounds on animal densities in the region. These data provide guidance on times of year and specific ocean regions (e.g., regions covering the 100 meter depth contour) to avoid or to exploit.

Estimates of Occurrence Based on Ocean Conditions

A number of studies have sought correlations of meteorological and oceanographic conditions with the presence or absence of specific marine species. Among the more obvious examples are the water temperature limits observed by most marine mammals and sea turtles, and the tendencies of marine life to move with the food sources. Other examples include local correlations with tides and currents (also likely to be connected with food sources). Satellite data on sea-surface temperature and wind-wave activity are being studied as a source of information for predicting the presence or absence of food sources and marine life.

This type of information is not well organized and not to be found in any unified data base. Nonetheless, the approach is in use today and has considerable promise for the future.

In-Situ Modification of the Action

Perhaps the most common form of management practice is to monitor the area for protected species and cease or postpone actions when animals are detected within the risk zone. It is very important to estimate in advance the likelihood of animals being within the zone and the likelihood of possible contacts. There have been cases for which the management practices and permit conditions have essentially not allowed the test to occur (e.g., because the monitoring system detected animals all of the time).

In-Situ Monitoring – Visual

Visual monitoring is by far the most commonly used and most effective form. For small zones of influence, monitoring from the source platform itself may suffice. For larger areas or regions with no vessel nearby, aircraft monitoring is the best alternative. It is used in most tests of explosives in water (SEAWOLF, DDG-81, Standard EIGER, SSQ-110).

In certain large-scale explosive and sonar tests (e.g., SEAWOLF FEIS), the effectiveness of visual monitoring has been estimated through detailed analyses of each species' likelihood for being detected within the "injury" zone. Two properties are estimated for each species of marine mammals (and for sea turtles): the fraction of time that the animal will be at the surface and the average pod (group) size. The latter is useful as well for estimating the chances that the zone will be clear of that species (e.g., via a Poisson model as used in Standard EIGER and DDG-81).

Visual monitoring is expected to be neither effective nor necessary for the EGTTR actions. The risk of harassment to protected species is small to begin with, and the conduct of nighttime training precludes use of the approach.

In-Situ Monitoring – Passive Acoustic

Passive acoustic monitoring has great promise, but has been only modestly successful in the past. Visual monitoring tends to be much more effective. Value added by acoustic monitoring to comprehensive visual monitoring during periods of good visibility has been small in at least two cases (DDG-53 and Standard EIGER with the Marine Mammal Acoustic Tracking System [Clark et al, 1994]). Moreover, most of the success of passive acoustic monitoring has been with the great whales, and then only when they have distinctive vocalizations. There has been very little success with small odontocetes (which are by far the most abundant animals at risk in the EGTTR). Sea turtles do not have detectable acoustic signals.

A problem that may occur with passive acoustics is the inability of the monitoring system to identify and localize contacts well enough to determine if the test should be halted or postponed. This must be kept in mind when permit conditions or management practices are set forth in a compliance document (e.g., the plan should not promise to cease the action whenever there is a passive acoustic contact).

The one possible application of acoustic monitoring for EGTTR might be in connection with a research program (as mentioned below) to learn the impact of the tests on marine life.

In-Situ Monitoring – Active Acoustic

A number of approaches have been proposed and at least one is planned for use. Moreover, a study conducted by the Marine Mammal Commission in 1999 examined the potential value of a ship-mounted sonar system to detect whales for collision avoidance (especially northern right whales). That study concluded that it was not feasible for a variety of reasons, such as the need for the sonar to detect and localize the whale at great enough range to allow the ship to take action.

The system that is planned for use is a towed high-frequency active system for the SURTASS-LFA (Surveillance Towed Array Sensor System - Low Frequency Active) sonar. It is designed to detect marine mammals within about 1,000 meters of the slowly moving platform. That range (1,000 meters) defines the zone for which injury is judged to occur, and the active system would provide an alert to cease LFA transmissions while the animal is in the zone. The system has been tested, but results have not been formally reported.

In-Situ Monitoring – Other

Radar, infrared, and low-light-level TV sensors are available on certain ships and aircraft (e.g., Navy P-3C aircraft) and have been applied to the monitoring problem. Because of the limited signature of most marine animals, these sensors are generally not used for permit condition monitoring.

Deterrence, "Ramp-Up," and Warning Procedures

There is sometimes good reason to alert animals in advance of injurious sound waves by transmitting low-power "warning" signals a short time before the action. It makes sense in a case where there is a significant risk of injury. On the other hand, if the warning signal is designed to induce the animal to leave the area, then it may well be a cause of harassment.

Such "Ramp-Up" procedures for acoustic projectors are incorporated in many formal consultation requirements and seem to be expected by the regulators. The logic seems to be that the warning signal lowers the risk of the animal being subjected to extreme intensities because of being very close to or touching the projector. In that case, the animal is not viewed as harassed, but only expected to move a short distance away from the projector.

In the case of explosives, there is no precedent for warning signals. For the explosives from gun shells, there is no obvious approach short of deterring the animals from the area.

Customized Modification of the Action Itself as a Management Practice

Under this title are such modifications as reduction in source levels, exploitation of source directivity to limit ensonified areas, or modifying the tempo of operations to minimize multiple exposures. Management practices in this form may well be the most important for the EGTTR A/S Gunnery actions. They will be emphasized in the overall risk assessment.

EGTTR actions already anticipate two management practices of this type. The first is in the option to use training rounds in some cases instead of the full-weight rounds. This dramatically reduces the ensonification, and directly reduces risk of harassment. The second practice may be viewed as accidental, but, at least in theory, may dramatically reduce impact, namely in the use of impact fuses for which the explosion occurs within inches of the ocean surface. At least in some similar cases, and perhaps to be demonstrated in data now being processed, the near-surface explosion sends the majority of the energy into downward angles, with only greatly reduced energy propagating to range. The geometry also eliminates bubble pulse energy, which can be quite significant for small explosives at greater depths.

Research Programs to Measure and Limit Impact

For programs in which takes are expected, and permits are sought, it is sometimes important to show good faith for regulators and the public by funding a research program to measure the impact of the actions on vulnerable species, and devise methods to reduce impact. In the case of the EGTTR, it may be worthwhile to monitor (through tagging) the response of particular animals to the A/S Gunnery actions. In the region itself, the most populous mammal at risk is the small odontocetes (i.e. dolphins). Sea turtles can also be present in numbers, and merit attention. The difficult aspects of the research program, as shown in previous cases, are the determination of injury and harassment as defined in the MMPA and ESA. Scientifically sensible protocols must be established at the start and agreed upon by technical experts. While a slight change in diving behavior may be of interest and worth logging, for example, the determination of whether or not it constitutes harassment is the challenge.

OTHER MANAGEMENT PRACTICES

Ordnance

All ranges have a limit on the type or size and if the weapon is Live or Inert. These limits are based on the NEW of the weapon and/or if the range is designated for Live ordnance. These determinations are made by either the Range Division through AFDTC Technical Facilities Vol. II, Land Test Area or through the AAC Safety Office.

All Live ordnance dropped into the Gulf Range must be dropped beyond the 100 fathom line depth. The 100 fathom line is approximately 30 miles from shore.

Flares and Chaff

Flares and Chaff operations are covered under Operational Procedures for the Employment of ECM, Chaff, and Flares, chapter 9 of AFDTCI 11-201, for both land and water. This section outlines when, where, and how ECM, Chaff, and Flares Operations can be conducted.

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APPENDIX B REFERENCES

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APPENDIX C

AIRCRAFT NOISE IN THE EGTTR

AIRCRAFT NOISE IN THE EGTTR

SUBSONIC NOISE

In order to characterize noise levels throughout the EGTTR, 15 individual airspace elements were considered (Table C-1). It is recognized that these elements abut, forming a large block of contiguous airspace, and that noise from aircraft operations does not stop abruptly at the lateral boundaries of each. Nevertheless, since specific airspace supports specific operational activities, individual airspace modeling provides the best representation of noise resulting from those specific operations. Aircraft types, sortie numbers, time in the airspace, and altitudes were developed from data contained in FY95, FY96, FY97, FY98, and FY99 Range Utilization Reports (RURs). Two basic altitude blocks for operations were considered. Since Air Combat Command limits low altitude flight to 500 feet AGL, the first block ranged from 500 feet to 3,000 feet AGL. The sortie's proportionate time in this block was derived from information provided. Although the ceilings of most of the airspace of concern extend to extremely high altitudes, the second altitude block was defined as extending from 3,000 feet to 15,000 feet AGL in order to construct a conservative scenario. It should be noted that sound levels of aircraft flying above 15,000 feet are low enough that they would have little or no effect on sound level calculations.

Using the Air Force's MR_NMAP noise model (Lucas and Calamia 1996), the uniformly distributed sound level resulting from aircraft operations in each specific airspace element was calculated. Based on an average utilization of each airspace element over the last five years, and operational performance data provided, the Onset Rate-Adjusted Monthly Day-Night Average Sound Level (L_{dnmr}) created by the indicated operations in each element is reflected in Table C-1.

Table C-1. Noise Levels in EGTTR Airspace

Airspace	Total Sorties	L_{dnmr}
W-151A	20,567	61.8
W-151B	13,031	60.2
W-151C	9,803	60.1
W-151D	8,431	58.7
W-151S	3,410	54.6
W-155A	1,016	48.3
W-155B	955	47.4
W-168	140	27.0
W-470A	21,722	64.1
W-470B	20,310	63.7
W-470C	20,136	66.4
EWTA-1	15	18.8
EWTA-2	52	22.7
EWTA-3	27	20.6
EWTA-5	8	18.7

Source: Lucas and Calamia, 1996

Ambient background noise is normally estimated to have an average sound level of 35 to 40 dB. Therefore, in aircraft noise analyses, calculated values below 35 are normally reported only as "less than 35," since levels this low would be essentially undetectable over time. However, in this study, actual calculated values are shown for comparative purposes.

SUPERSONIC NOISE

Operations in each element of airspace were also used to estimate noise levels resulting from supersonic flight (sonic booms). Data supporting this assessment included aircraft types, minimum and maximum altitudes flown, Mach numbers associated with those altitudes, and the durations of those specific events. As with the evaluation of subsonic noise, emphasis was placed on the lower altitude regime to develop conservative estimates.

The airspace elements considered in this study are used for two broad purposes. The first is air combat training. This training involves use of the airspace by individual or groups of opposing aircraft. They are usually widely separated and use a wide range of altitudes and power settings. However, these aircraft usually fly in the higher altitude ranges (20,000 feet AGL and above). These high altitudes significantly reduce the effects of sonic booms at the surface. The second major use of the airspace involves support for test and training activity that often requires supersonic flight, but at much lower altitudes and often of longer duration than that exhibited during air combat maneuvering. In order to consider all of these uses and develop a conservative estimate of noise resulting from sonic booms, the estimation technique used data developed by running the Air Force's PCBoom3 model (Plotkin, 1995). This single-event model was used to calculate boom footprints on the ground resulting from specific operations conducted by specific aircraft flying a range of trajectories, at various speeds and altitudes. These data were then applied using a methodology similar to that used by MR_NMAP to calculate estimated uniformly distributed C-weighted Day-Night Average Sound Levels (shown in L_{cdn} or CDNL). These processes and their results are explained below.

Output from the PCBoom3 program includes information on ground locations of overpressures (in pounds per square foot), sound pressure levels (in dBP), and C-weighted sound exposure levels (CSEL). Collectively, these data enable calculation of CSEL values at incremental ground positions, or distances along and on either side of the aircraft's flight track. With this information, the general methodology used by the MR_NMAP program can be employed to calculate uniformly distributed sound levels throughout the airspace. This is described in more detail below.

By plotting incremental overpressures and converting them to CSELs on each side of the flight track, the distance between each can be calculated. If two consecutive SELs are considered (SEL_1 and SEL_2), and they are separated by a given distance (D), and an aircraft is flying in level flight at a given speed (V) for a given time (T), then the total area (A) expected to be exposed to a sound level between SEL_1 and SEL_2 is calculated by Equation C.1.

$$A = (D \times V \times T) \times 2$$

Equation C.1

The multiplier 2 is used because in straight and level flight the separation distances are symmetrical, occurring on both sides of the flight track. During certain maneuvers, the trajectories often produce asymmetrical footprints. When this occurs, distances and associated overpressures on each side of the flight track are considered individually.

If the total area of the airspace in use is considered as R, then the probability (P) of the sound level being between SEL_1 and SEL_2 in that random area is calculated by Equation C.2:

$$P = \frac{A}{R}$$

Equation C.2

Next, the average sound expected in the area exposed is calculated using Equations C.4 and C.5 as follows. First, Equation C.4 is used to convert each CSEL ($L_{1,2}$) value to acoustic energy ($E_{1,2}$):

$$E = 10^{\frac{L}{10}}$$

Equation C.4

Then, the respective acoustic energies are used to calculate the expected energy level (E_{EXP}) in a specific exposed area.

$$E_{EXP} = \frac{E_1 + E_2}{2} \times P$$

Equation C.5

Finally, the total energy (E_{TOTAL}) for the entire area created by the specific event is calculated by summing all of the expected levels. Equation C.6 then yields the CDNL value.

$$CDNL = 10 \times Log_{10} E_{TOTAL}$$

Equation C.6

These calculations must be performed for each specific event in the airspace, and then levels can be summed to determine overall uniformly distributed sound levels. Table C-2 summarizes data for the assessment performed for supersonic operations in the applicable airspace.

In this assessment of supersonic operations, noise values directly along the centerline of the aircraft's flight track ranged from a low of 2.2 pounds per square foot (psf) (108.8 CSEL) to a high of 26.9 psf (130.6 CSEL) (Plotkin, 1995).

Table C-2. Supersonic Noise Levels

Airspace	CDNL Value
W-151A	66.3
W-151B	64.6
W-151C	64.7
W-151D	63.1
W-155A	52.6
W-155B	51.6
W-168	28.8
W-470A	68.7
W-470B	68.1
W-470C	70.9
EWTA-1	23.4
EWTA-2	26.8
EWTA-3	24.6
EWTA-5	25.8

Source: Plotkin 1995

Biological Resources

Ongoing Air Force studies are examining the potential sonic boom impacts to the subsurface marine environment resulting from low-level supersonic flight. Only preliminary and cursory results are currently available. Detailed analyses of these potential impacts to marine resources are, however, beyond the scope of this document.

Preliminary data indicate that aircraft flights in excess of Mach 4.0 may produce sound waves (less than 14° off the vertical) that can penetrate the water's surface. Some portion of the acoustic energy from this penetrating sound wave will be transmitted to the subsurface environment. Aircraft flights below Mach 4.0 generally produce sound waves that are reflected off the water's surface. Although the sound wave is reflected, some of the acoustic energy may still be capable of penetrating to depths as great as 125 meters below the surface.

Socioeconomic Resources

Evaluations of noise impacts to humans are typically discussed in terms of the percentage of the population that would be highly annoyed (disturbed) by the particular noise source. Little information is available to describe the potential population (transient) within the EGTTR at any given time who may experience annoyance due to aircraft activities. Comparable analyses would utilize Equation C.7 to make such evaluations.

Percent of Population Highly Annoyed by A-Weighted Noise:

$$\%HA = \frac{100}{[1 + e^{(11.13-0.14Ldn)}]}$$

Equation C.7

Where: Ldn is the Day-Night Average Sound Level in A-weighted dB.

Supersonic noise levels are of relative concern at the altitude blocks below 5,000 feet. Although no threshold criteria exist for areas over the EGTTR, if compared to similar altitude blocks of populated residential areas, approximately 18 percent of the given population would be annoyed. No conclusions can be made from these analyses due to the lack of EGTTR transient population data (population of shipboard individuals) for appropriate comparisons; however, Equation C.8 does provide an indicator for future comparisons.

Percent of Population Highly Annoyed by C-Weighted Noise:

$$\%HA = \frac{100}{[1 + e^{(11.17 - 0.153 Lcdn)}]}$$

Equation C.8

Where: Lcdn is the Day-Night Average Sound Level in C-weighted dB.

All of the airspace supporting Eglin's activities in the EGTTR overlies the waters of the Gulf of Mexico. As such, there are no land use planning standards for assessing exposure to elevated noise levels. Furthermore, it is difficult to assess human annoyance from noise exposure since there is no established population present on the surface.

For planning purposes it may be useful to estimate changes in noise impacts resulting from changed use of the airspace. Existing conditions were described in Section 3. If it is assumed that specific elements of airspace would continue to support similar operations, (i.e., the same relative mix of aircraft types flying similar altitude patterns), it is possible to scale calculated noise levels from one level of operations to another, or to determine the maximum number of operations that could be conducted in the airspace without exceeding a specified noise level. While estimates of proportionality may be somewhat subjective, and it is recognized that scaling will not always yield the same precision as specific calculations, this method is a useful tool to estimate changes.

Changes in noise levels associated with increases or decreases in operations involving the same relative mix of aircraft may be estimated using Equation C.9.

$$NewdB = 10 \times Log_{10}\left(\frac{NewOps}{OldOps}\right) + OlddB$$

Equation C.9

Where:

NewdB = New Noise Level
NewOps and OldOps are the applicable number of sorties
OlddB = Current Noise Level

For example, if it were proposed to increase operations in W-155A by 10 percent (from 1,016 to 1,118), use of Equation 1 would indicate an increase in noise from L_{dnmr} 48.3 to L_{dnmr} 48.7.

Scaling can also indicate the capacity of an airspace element if it is desirable to maintain noise at or below a selected level. Values are calculated using Equation C.10

$$NewOps = 10^{\frac{NewdB - OlddB}{10}} \times OldOps$$

Equation C.10

Where:

NewOps = New Level of Operations
NewdB = Desired Noise Level
OlddB = Current Noise Level
OldOps = Current Level of Operations

As can be seen, simply calculating the first half of the right side of the equation provides a multiplier that can then be applied against the current level of operations. This multiplier may be used to scale operations up or down, as required. Application of Equation C.10 is illustrated in Table C-3, which reflects the multipliers for current airspace use that would expand or contract operations in each element to maintain an L_{dnmr} of 60 or 65. The L_{dnmr} values shown are only illustrative. Planners could use any value desired.

Table C-3. Scaling Factors for Airspace Capacity

Airspace	Current L_{dnmr}	Multipliers To Maintain L_{dnmr} Levels	
		< 60	< 65
W-151A	61.8	0.66	2.09
W-151B	60.2	0.95	3.02
W-151C	60.1	0.98	3.09
W-151D	58.7	1.35	4.27
W-151S	54.6	3.47	10.96
W-155A	48.3	14.79	46.77
W-155B	47.4	18.20	57.54
W-168	27.0	1,995.26	6,309.57
W-470A	64.1	0.39	1.23
W-470B	63.7	0.43	1.35
W-470C	66.4	0.23	0.72
EWTA-1	18.8	13,182.57	41,686.94
EWTA-2	22.7	5,370.32	16,982.44
EWTA-3	20.6	8,709.64	27,542.29
EWTA-5	18.7	13,489.63	42,657.95

The techniques and equations presented above are applicable for dealing with both subsonic (A-weighted) noise and supersonic (C-weighted) noise.

APPENDIX D

UNDERWATER AMBIENT NOISE IN THE EGTTR

UNDERWATER AMBIENT NOISE IN THE EGTTR

Ambient noise in the ocean arises from a number of types of sources. These sources may be categorized in a number of ways. For example, some noise arises from natural sources: wind action on the sea surface, rain or hail striking the sea surface, seismic activity, and various types of biologics. Others are related to human activity: industrial operations on-shore, commercial (and military) ship traffic, seismic profiling for oil exploration, and oil drilling.

Another way of categorizing these noise sources is into sources that persist over time versus sources that are intermittent. The following discussion is organized along those lines. The first subsection addresses the two noise sources, wind and commercial shipping, that are prevalent at virtually all open ocean locations at all times. It begins with predictions of the average ambient noise level across the entire Eglin Gulf Test and Training Range. Particular attention is paid to four sites that are representative of the variability that is seen across the Range. Next, temporal fluctuations of wind and shipping noise are provided.

The second subsection deals with the most significant of the intermittent noise sources. The potential locations of these sources, the frequency band in which they dominate, and the range of noise levels they might produce are discussed. In the final subsection, all data (measured and modeled) due to persistent and intermittent noise source are summarized by a spectral plot that characterizes the bounds of the noise field within the Range.

PERSISTENT SOURCES OF AMBIENT NOISE

Noise sources that tend to dominate the ambient field for extended periods of time, and are likely to be found in most locations (of operational interest), have been the primary focus of measurement and modeling efforts sponsored by the Navy. In open oceans, the primary persistent noise sources tend to be commercial shipping and wind action on the sea surface.

Surface ships generate noise via a number of mechanisms, the most important being propeller blade cavitation. This broadband noise reaches a maximum source spectrum level in the band 40-100 Hz of 180 dB (re 1 microPascal) or more.

At any given time, there are approximately 20,000 large commercial vessels at sea. Since these sources' most significant component is below a few hundred Hertz and since propagation is most favorable at those frequencies (particularly in deep water), surface ships can often be heard at distances greater than 100 kilometers. Thus, at many deep-water locations, it is not unusual for the low-frequency noise field to be influenced by contributions from tens or even hundreds of surface ships.

What is commonly known as wind noise is generated by a number of mechanisms related to wind. The interaction between capillary waves driven by local wind action on the sea surface is one mechanism that has been postulated. However, the clear correlation between the onset of white caps and a rapid increase in noise level suggests that the primary mechanism is related to the breaking of waves. This breaking process causes the formation of vast numbers of bubbles that oscillate at their formation and thereby produce sound.

Although wind noise is present at all frequencies, it tends to dominate above 250 Hz. At the higher frequencies, attenuation works against wind noise propagating to great distances. Thus, unlike shipping noise, wind noise tends to be locally generated and not particularly sensitive to environmental factors that affect propagation. The one notable exception to this rule is that shallow-water wind noise tends to be several dB higher than deep-water wind noise for comparable wind speeds.

The following subsections address the contributions of commercial shipping and wind to the noise field in the region of interest. The discussion begins with a review of noise measurements that have been made in this region. To complete this picture, and to investigate temporal variations, the measurement data are followed by results obtained from a widely-used ambient noise model.

Average Ambient Noise Estimates

Beginning in the 1980s, the Office of Naval Research sponsored the development of the Ambient Noise Directionality Estimation System (ANDES) (Renner, 1995). ANDES was initially designed to predict the average spatial properties of the noise field. These results are best viewed as averages over enough time for the nearby surface ships to transit through the transmission loss (TL) field and adequately sample its variations. Normally this is considered to be on the order of several hours.

Although not a designated Navy Standard, ANDES itself is a collection of Navy-Standard sub-models for propagation and boundary losses, and environmental databases, including shipping. This, coupled with the fact that ANDES is widely used throughout the ASW community, effectively makes ANDES a *de facto* standard.

As mentioned earlier, ambient noise in the 10-250 Hz is typically dominated by contributions from commercial ship traffic. To understand the geographic dependence of average ambient noise at these frequencies, one needs to understand the distribution of surface ship traffic. Tank ships and cargo carriers are the most prevalent types of commercial ships in the Gulf of Mexico. Most of this traffic is to or from one of the following major ports: Tampa, Pascagoula, New Orleans, Galveston and Corpus Christi. Very little of this traffic transits between these ports. Rather, the majority of the traffic is to or from these ports to other ports outside the Gulf of Mexico via the two primary entry points to the Gulf, the Florida Straits and the Yucatan Channel.

The most complete description of historical shipping distributions is given by HITS (Historical Temporal Shipping) database (U.S. Navy, 1993). Figure D-1 provides the HITS shipping densities for its most prevalent class of ship (denoted as merchants) in the area of interest. The major shipping lane connecting New Orleans (and nearby ports) and the Florida Straits clearly is the dominant feature in this figure.

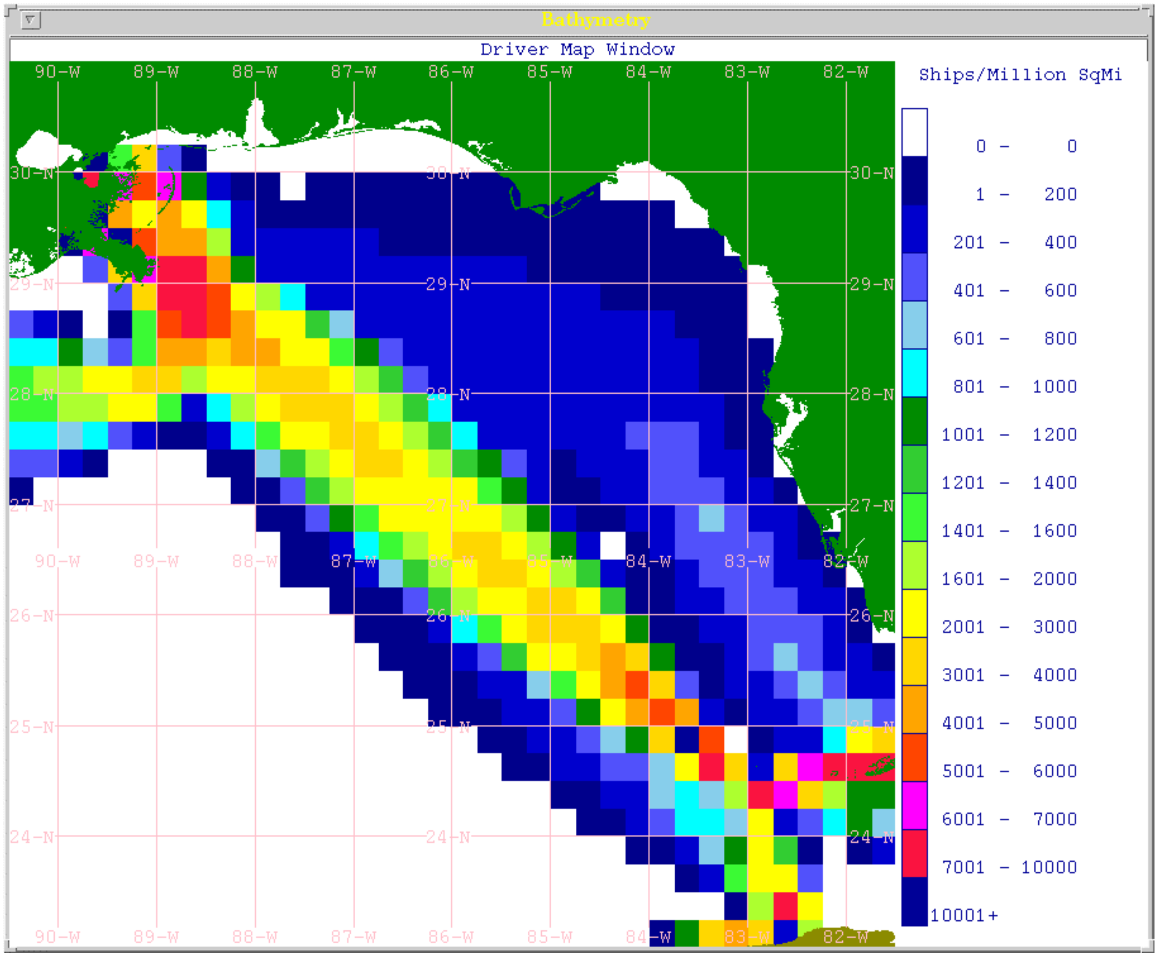

Figure D-1. HITS Merchant Shipping Densities

To understand the spatial variability of low-frequency noise in this region, four representative sites have been selected. These sites are intended to represent the various combinations of the two most significant factors in determining the low-frequency noise level:

Environment (or more specifically, water depth

Source distribution (that is, shipping density)

The four sites are identified and described in Table D-1 below and illustrated in Chapter 4 (Figure 4-1).

Table D-1. Selected Sites for ANDES Modeling

Site	Location	Environment	Source Distribution
A	27 N 86 W	Deep Water	High Shipping
B	24-30 N 87 W	Deep Water	Low Shipping
C	29 N 88 W	Shallow Water	High Shipping
D	28 N 84 W	Shallow Water	Low Shipping

For each of these sites, ANDES was used to generate average noise spectra for winter and summer conditions. In all cases, the predicted noise level is for a receiver located at a depth of 20 meters (average noise levels in this region vary only slightly over the depths of interest) in the presence of 15 knots of wind. These winter spectra are presented in Figure D-2; summer spectra are virtually identical to the winter spectra at all sites. As expected, high-frequency noise (above 300-400 Hz) is relatively insensitive to site location. Equally anticipated is the high spatial variability in the low-frequency noise. Noise levels increase as either the water depth increases (improving propagation) or the shipping density increases. Note that the peak noise level at 40 Hz varies from a low of 69 dB at Site D to a high of 96 dB at Site A.

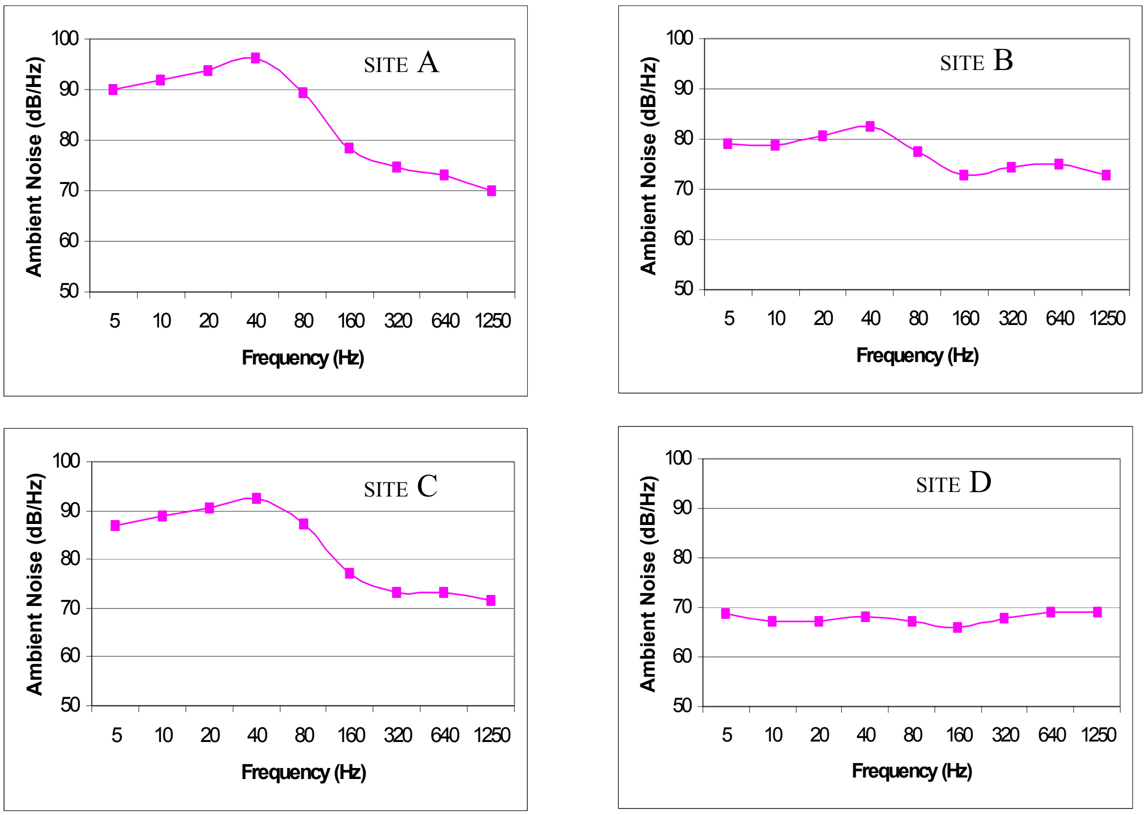

Figure D-2. Noise Spectra for Four Representative Sites

In order to provide a comprehensive picture of the ambient noise field throughout the Eglin Gulf Test and Training Range, average winter noise levels were generated throughout the area using ANDES. These results, again for a receiver at a depth of 20 meters, are presented at two frequencies – 60 Hz (shipping dominated) and 240 Hz (wind dominated) – in Figures D-3 and D-4. The location of the dominant shipping lane to the port of New Orleans is clearly visible in the 60-Hz data. Noise levels diminish slowly at this frequency as the receiver is moved away from the shipping lane in the direction of deep water. However, as the receiver moves out of the shipping lane and into shallow water, noise levels diminish more rapidly. Both of these effects are due to the relative efficiency of low-frequency propagation in deep water versus shallow water. At 240 Hz, noise levels tend to vary less as wind noise begins to dominate.

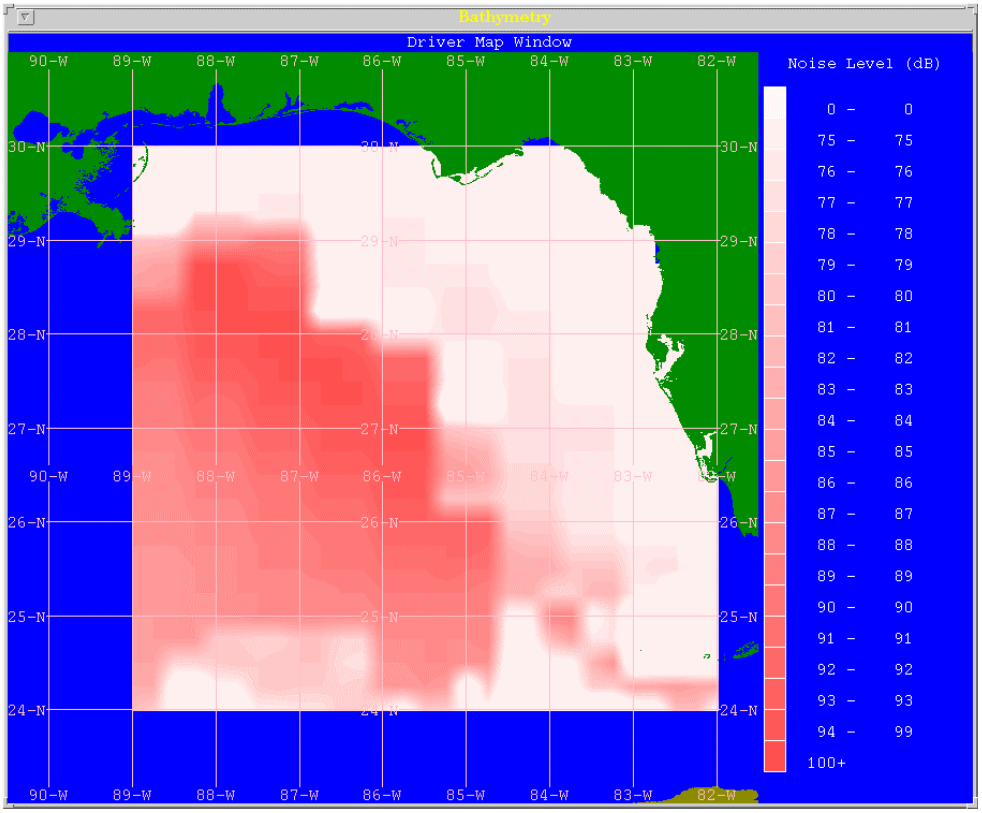

Figure D-3. 60-Hz Ambient Noise Levels

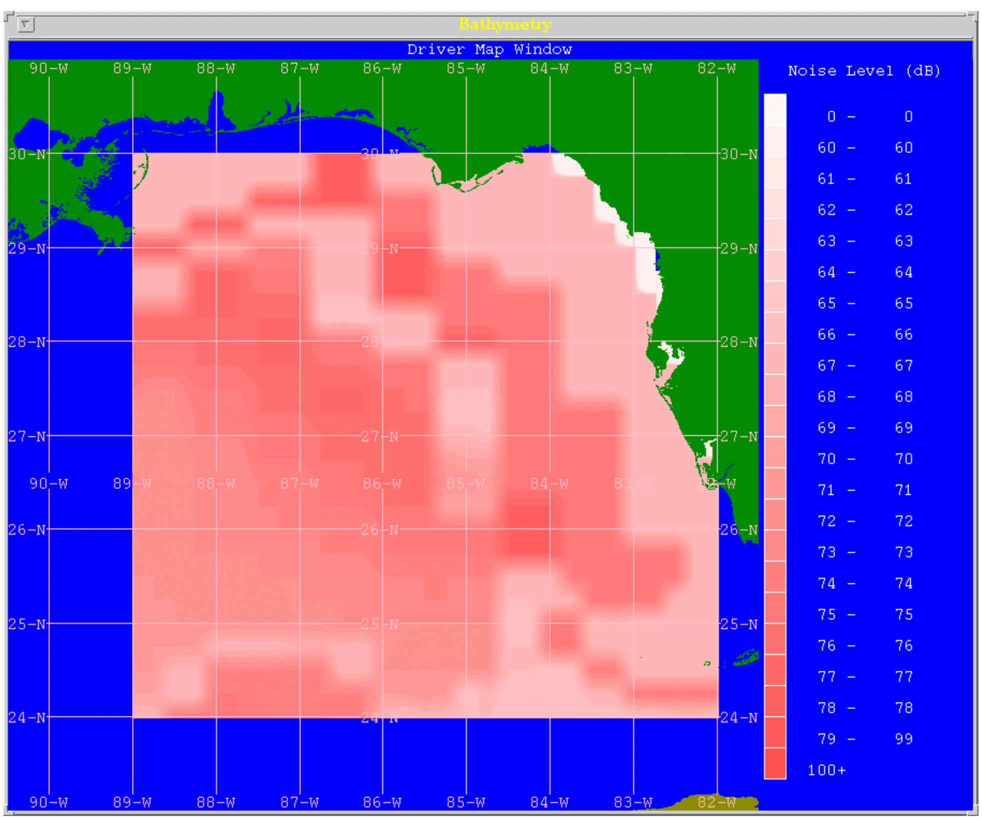

Figure D-4. 240-Hz Ambient Noise Levels

Temporal Fluctuation Estimates

Although shipping and wind noise have been categorized as persistent sources, this is not to suggest that either is constant over time. Both fluctuate over time due to changes in source distribution and propagation loss. These fluctuations occur over several different time scales; of particular interest here are seasonal variations and variations over time scales of a few minutes to a few hours. Seasonal variations for this region are negligible as mentioned in the previous subsection; this section focuses upon fluctuations over a period of minutes to hours.

At low frequencies, the movement of ships (particularly those close to the receiver) causes the largest fluctuations in the ambient noise level. In addition to predicting average noise level, ANDES can also be used to quantify the magnitude of these fluctuations.

Fluctuations in low-frequency shipping noise are clearly a function of the proximity of the receiver site to a major shipping lane. Referring back to the four sites identified in the previous subsection, we would expect to see more frequent and larger fluctuations at Site A (located within the major shipping lane to New Orleans) than at Site B (which is located outside that lane). The magnitude and frequency of fluctuations also depends upon the number of ships that are making significant contributions to the noise field. In shallow water, where propagation is often less favorable, only ships near the receiver are important. Typically then, shallow water sites "see" fewer ships and hence the movement of one ship in close proximity to the receiver can have a dramatic impact upon the noise. Again referring back to the four representative sites, we would expect to see larger fluctuations at shallow-water Sites C and D than at deep-water sites A and B.

These conjectures are supported by predicted noise time series shown in Figure D-5 for the four representative sites. Each is a ten-hour time series, sampled every five minutes, of the noise spectrum level at 60 Hz during the winter. As expected, the two sites in the major shipping lane, A and C, have the most frequent swings in noise level, while sites C and D have the largest fluctuations.

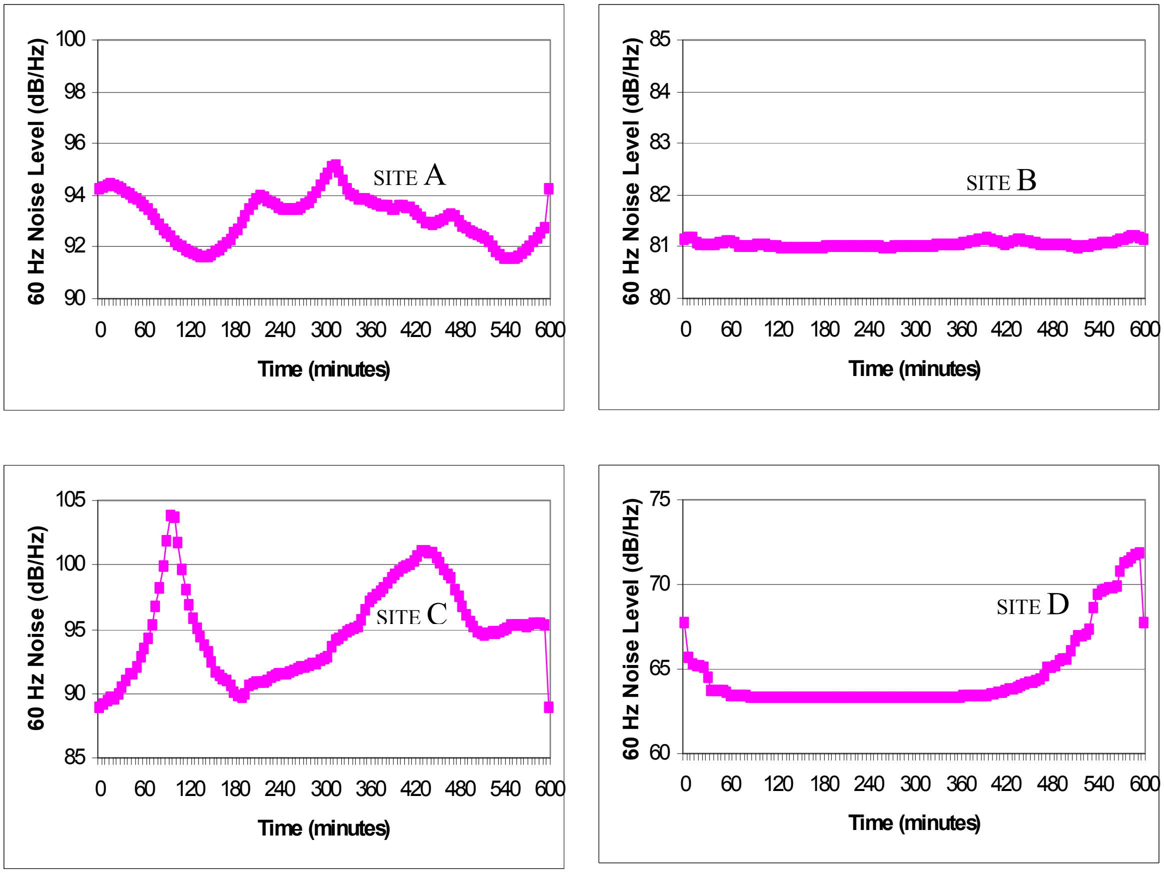

Figure D-5. 60-Hz Ambient Noise Time Series

In addition to fluctuations due to the movement of nearby ships, noise may vary due to changes in wind speed. These variations are most noticeable at frequencies where wind noise is the dominant component (typically above 250 Hz). In that upper frequency band, noise varies with wind speed as defined in Figure D-6 below.

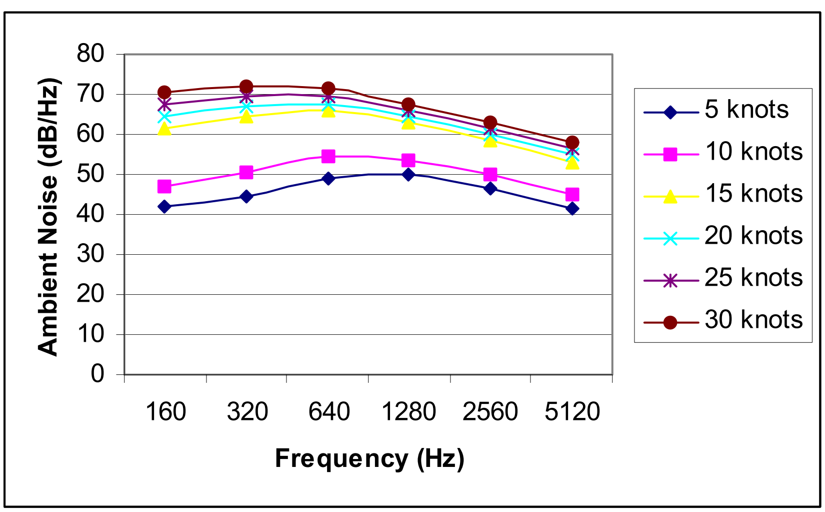

Figure D-6. Ambient Noise Variation with Wind Speed (Renner, 1995)

Intermittent Sources of Ambient Noise

To this point, the discussion of ambient noise levels (both modeled and measured) has focused on noise from the two types of sources that tend to always be present. While these may fluctuate in time and space, they almost always are major contributors to the total field. In the absence of all transient sources, the minimum noise levels attributable to wind and shipping tend to form the lower bound on the ambient noise level.

At varying times and/or in certain locations, there are additional sources of noise that may dominate certain portions of the spectrum. Primary among these are: (1) industrial noise generated by oil production (exploration and drilling), (2) noise generated by various species of marine animals, and (3) noise due to rain or hail striking the sea surface. By and large, it is impossible to forecast the exact time and location of these noise sources, much less the actual noise levels they produce.

Despite this limitation, there is sufficient information on transient noise sources to identify areas in which these sources may be prevalent. It is also possible to estimate likely upper limits for these sources when they are present. This approach is taken in the following subsections.

Oil Production

The oil industry has been active in the Gulf of Mexico prospecting and drilling. Both activities are the source of considerable underwater sound. Yet, despite this, little quantitative information is available concerning the noise levels generated by these activities. It is known that seismic exploration primarily employs very low frequency sources and that these exercises can easily dominate the low-frequency noise field at some range. On the other hand, oil rigs produce noise throughout the frequency domain.

Recently, economic and political factors have not been favorable to offshore oil exploration and production. Nonetheless, oil production continues in the Gulf, particularly along the shelf off the coast of Louisiana and eastern Texas. This activity most likely can be detected acoustically in those areas.

Biologics

Many species of marine life are known to contribute to the underwater noise field over a very wide frequency envelope. These vocalizations range from low frequency grunts and moans to very high frequency chirps, whines, and clicks.

The soniferous marine species tend to belong to one of three major classes: the crustacea (shellfish), marine mammals, and certain species of true fish. Each class includes several species that have been acoustically detected and investigated. The following subsections address the most prevalent among these.

Crustacea

Among the crustacea, the most prevalent noise makers are various types of snapping shrimp. Snapping shrimp are generally found in the more temperate latitudes, including the Gulf of

Mexico. In these warmer waters, the occurrence of snapping shrimp is typically limited to water depths of less than 60 meters, and will be most abundant in regions where the bottom sediments consist of rough boulders, cobbles, or coral rubble, or in regions where the bottom consists of shale or other loose rock structures. Conversely, sand and mud bottoms are not favorable habitats for snapping shrimp. In particular, the shelf off the western coast of Florida has numerous regions of coral that are favorable habitats for snapping shrimp.

Noise generated by snapping shrimp peaks in the frequency band of 3-10 kHz. Examples of measured noise levels (Widener, 1967) indicate that the received noise level can be significant in this frequency band, easily exceeding wind noise by as much as 20 dB. However, due to propagation attenuation at high frequencies, the contribution of a bed of snapping shrimp to the total noise field strongly depends upon their proximity to the receiver.

Other crustacea, such as other species of shrimp, crabs, sea urchins and barnacles, are also known to contribute to the noise field, particularly in warm waters. Most, if not all, produce noise in the same high-frequency band as the snapping shrimp; some produce sounds similar to that of snapping shrimp. However, there is very little known about the actual levels they produce.

Mammals

Many species of marine mammals are known to be significant sources of various types of underwater sounds. These include (Cummings and Holliday, 1987; Cummings and Thompson, 1971; Whitehead and Weilgart, 1990; Thompson et al., 1992):

“Moans” (from blue, finback, bowhead, and Pacific gray whales) in the 300-1000 Hz range

Gargle-like sounds (from bowhead whales) in the 300-1000 Hz range

Clicks (from sperm whales and various dolphins) in the 5-150 kHz range

The sounds generated by these mammals tend to be quite loud (at low frequencies the source levels are equivalent to those of the biggest commercial ships). When present, these mammals also tend to be acoustically active, repeating their vocalization patterns at a rapid rate.

An effort to catalogue the location of various endangered marine species (including many of those listed above) is currently underway. The database being created, the Living Marine Resources Information System (LMRIS, 2000), indicates that the Gulf of Mexico is populated by several of these species. As an example, Figure D-7 illustrates the home waters of the sperm whale; other species of whales likely to produce similar sounds are seen in fewer numbers in this same region.

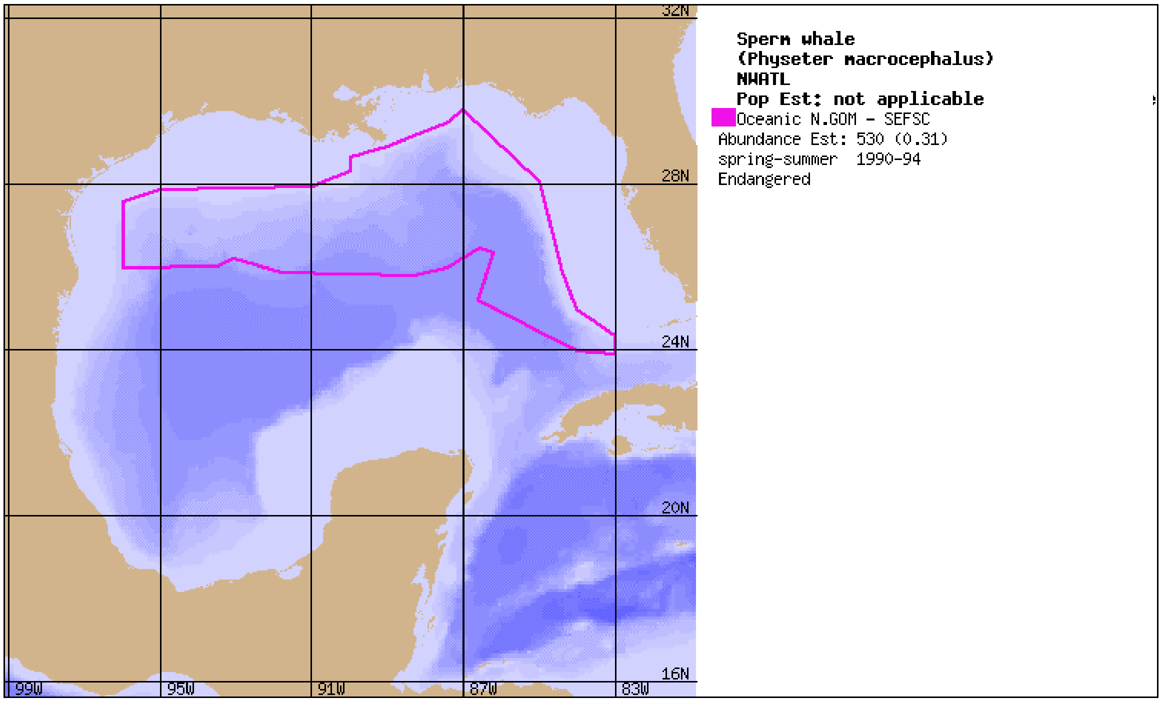

Figure D-7. Sperm Whale Distribution of the Oceanic Northern Gulf (colored polygon)

Fish

Many types of fish have been observed to make noise; among these one of the most common is the croaker or drumfish. Croaker-like noise has been observed in numerous shallow water locations and is often referred to as a chorus because of the number of individual fish that are simultaneously vocalizing. Peak levels (around 1 kHz) that are more than 30 dB above the background level are not unusual.

Noise from another type of "chorus" was observed in the evening, often lasting for several hours following sunset (Cato, 1978). The most significant contribution from this chorus was measured in the band from 400-4000 Hz with a peak usually around 2 kHz. Again, peak levels were often 30 dB above the background levels at the peak frequency.

It is not clear whether either of these examples is pertinent to the Gulf of Mexico. At best, it suggests that fish can produce noise at significant levels in the mid to high frequencies, particularly in shallow water.

Rain

Rain produces noise in much the same manner as does wind. Countless water droplets striking the sea surface produce impulsive sound; however, it is the fluctuation of the bubble formed by the droplets rupturing the sea surface and encapsulating a volume of air that apparently is the dominant source of sound. Rain noise differs from wind noise in that its peak contribution to the field occurs at a slightly higher frequency, typically between 1-3 kHz. Even at moderate rain rates, the noise generated at these frequencies can easily exceed contributions from wind.

While the rain noise mechanism has been well studied, actual measurements of rain noise differ by 10 dB or more for similar rain rates. A conservative estimate of noise levels due to various rates provided by ANDES is presented in Figure D-8.

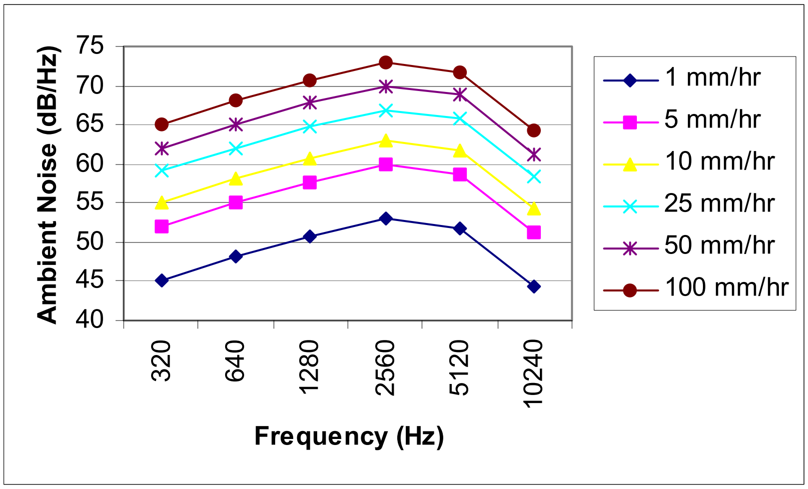

Figure D-8. Ambient Noise Variation with Rain Rate (Renner, 1995)

Bounds on Ambient Noise

Summarizing ambient noise levels over a region as large and diverse as the Eglin Gulf Test and Training Range is a daunting task. The best that can be done is to provide upper and lower bounds on the ambient noise spectrum with the understanding that spatial and temporal factors play a role in determining exactly where the actual noise spectrum falls between those bounds. The lower bound on average noise level is defined at the low frequencies by shipping noise in regions outside the shipping lanes. At high frequencies, the lower bound is defined by wind noise at low wind speeds. From this lower bound, average noise levels increase as either the shipping density or the wind speed increases with the upper bound defined by areas of high shipping and under high wind conditions.

Intermittently, noise levels can significantly exceed the upper bound of average noise levels due to various factors. The passage of a surface ship very close to the receiver can raise low-frequency noise levels by 10 dB or more. The onset of rain raises high-frequency noise levels by 10 dB or more. Finally, biologics of various types can raise noise levels near 20 Hz (due to marine mammals), in the range of a few kiloHertz (due to crustaceans and fish), and in the tens to hundreds of kiloHertz (again due to marine mammals). While the occurrence of biologic noise is limited in time and location, when it is present it can produce noise levels that are as much as 30 dB greater than background levels. The spectra presented in Figure D-9 illustrate the variability due to all of these potential noise sources.

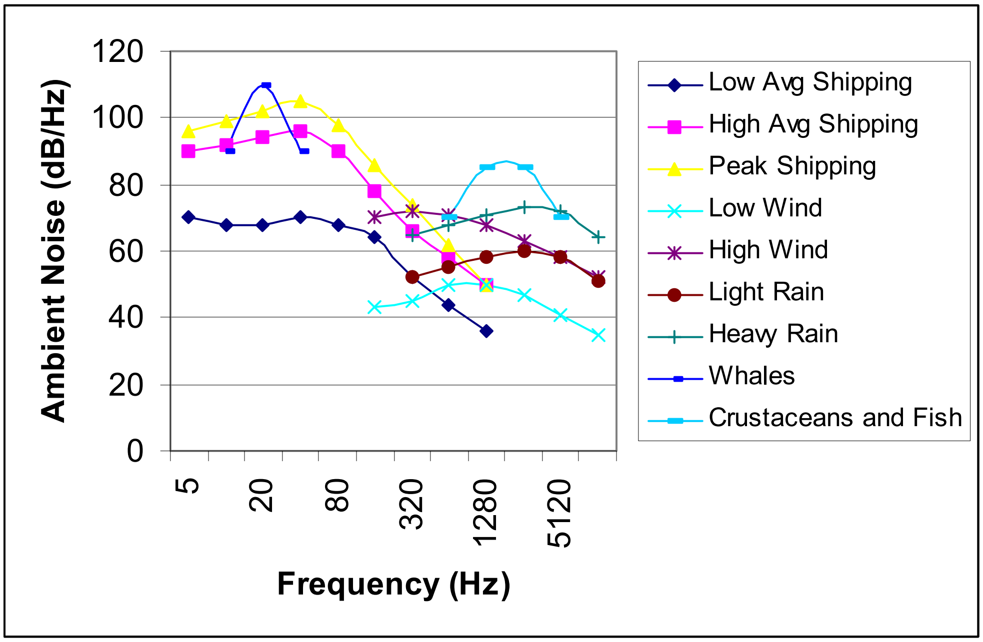

Figure D-9. Ambient Noise Level Bounds in the Eglin Gulf Test and Training Range

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APPENDIX D REFERENCES

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APPENDIX E

IN-WATER CHARACTERIZATION OF A/S GUNNERY NOISE

IN-WATER CHARACTERIZATION OF A/S GUNNERY NOISE

NOISE IN WATER FROM EXPLOSIVE GUNFIRE

The sound level experienced by a marine animal from an explosive round depends on many factors including charge weight, charge depth, animal depth, and propagation loss. These factors depend on one another and each may dominate the physics of the received level for a specific case. Below is a description of the important source and propagation characteristics.

Explosive Round Source Characterization

In general, a fully contained underwater explosion creates a gas globe or bubble that expands to some radius, R, before collapsing due to hydrostatic pressure (Chapman, 1985). The collapsed bubble will contract to near the original charge radius at which point it will re-expand. This process repeats and creates a series of positive pressure pulses known as bubble pulses (Figure E-1).

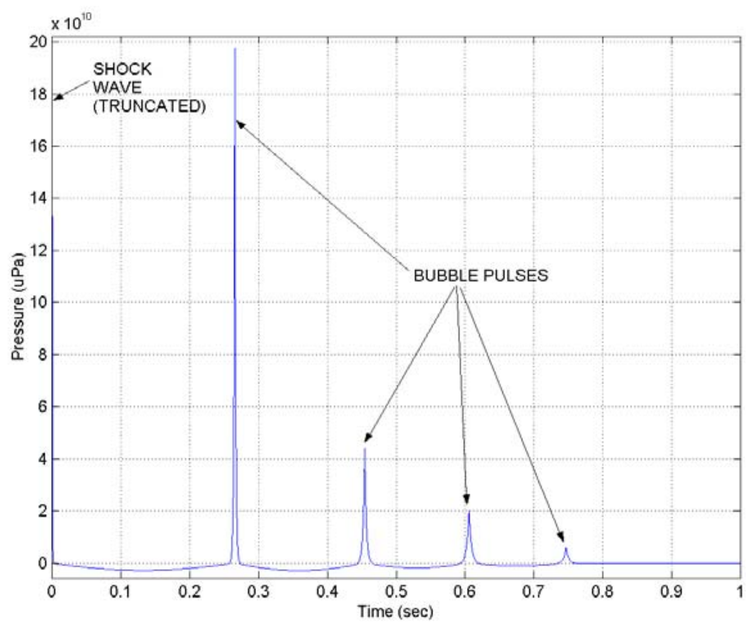

Figure E-1. Theoretical Pressure Time Series from 4.7 lb Explosion at 20 ft (Wakeley, 1978)

Each time the gas globe expands and contracts, energy is lost, reducing the peak level and energy of each successive pulse. The fourth bubble pulse peak is down 30 dB from the initial bubble pulse peak and the fifth bubble pulse is rarely observed. Bubble pulse peak arrival times are nearly periodic with later pulses arriving somewhat closer together. The time between bubble pulses depends on charge weight and depth. The delay time between the shock wave and first bubble pulse is often used to determine the charge depth for calibrated explosions. The bubble pulse period is computed as Equation E.1 (Wakeley, 1978):

$$t_{B1} = 2.1 \frac{w^{1/3}}{(z+10.1)^{5/6}} \text{ where}$$
$$z = \text{water depth (m)}$$
$$w = \text{charge weight (kg)}$$

Equation E.1

For explosions near the ocean surface, the shock wave gas bubble may breach the surface and vent. If this occurs, no bubble pulse is formed (Urick, 1983). All in-water energy for venting explosions is contributed by the initial shock wave. Venting needs to be accounted for when comparing deep underwater source levels to energy levels for similar weight charges that vent.

The maximum gas sphere radius and source depth determine whether an explosion will vent. A useful equation (Equation E.2) for estimating the maximum radius of the gas bubble created by an underwater explosion is given by Cole (1948).

$$R_{\max} = \sqrt[3]{\frac{1.841 \cdot 10^6 w}{4\pi P_a}} \text{ where}$$
$$R_{\max} = \text{maximum bubble radius (m)}$$
$$w = \text{charge weight (kg)}$$
$$P_a = \text{static pressure (Pa)} = 1.013 \cdot 10^5 \left(1 + \tfrac{z}{10}\right)$$
$$z = \text{charge depth (m)}$$

Equation E.2

If the maximum bubble radius, R_{max}, exceeds the charge depth, z, the explosion will vent. The largest depth at which a charge will vent is computed by setting R_{max}=z and solving for z in the above equation. This equation does not account for upward migration of the bubble due to buoyancy and charges somewhat deeper than predicted by the Cole formula may vent. Table E-1 below shows estimated maximum venting depths for the expendables under consideration. Rounds with on contact fuse settings explode at approximately 0.2 feet and will breach the surface. Delayed fuse rounds detonate at 50-60 feet and will be fully contained.

Table E-1. Maximum Venting Depth

Expendable	Charge Weight (kg/lb)	Maximum venting depth (m)
105 mm FU	2.14/4.7	1.98
105 mm TR	0.16/0.35	0.86
40 mm	0.41/0.869	1.17
25 mm	0.03/0.0662	0.50
20 mm	0.013/0.0285	0.38

Explosion Noise Description and Metrics

For rounds that explode on contact, all of the energy in the water comes from the initial shock wave. Non-breaching rounds have additional in-water energy contributed by bubble pulses; however, the energy in the bubble pulses is small compared to the initial shock wave and can be ignored with little error (< 3 dB). The instantaneous shock wave pressure as a function of time is almost always expressed as a simple exponential decay as represented by Equation E.3 (Weston, 1960, Gaspin & Shuler, 1971).

$$P(t) = P_0 e^{-t/t_0}$$
$$t = \text{time from onset of shock front (detonation) (s)}$$
$$P = \text{shock wave pressure } (\mu\text{Pa})$$
$$P_0 = \text{maximum shock wave presure } (\mu\text{Pa})$$
$$t_0 = \text{decay time constant (s)}$$

Equation E.3

The energy flux density in the shock wave is defined (for plane waves) as Equation E.4 (Urick, 1983):

$$E = \frac{1}{\rho c}\int_0^\infty P^2(t)dt = \frac{P_0^2 t_0}{2\rho c} \text{ where}$$
$$E = \text{energy flux density}$$
$$\rho c = \text{acoutic impedance of water}$$

Equation E.4

The energy flux density spectrum $E_0(f)$ is computed as the squared modulus of the Fourier transform of the pressure in Equation E.5:

$$E_0(f) = \frac{2\left|\int_{-\infty}^{\infty} P(t)e^{-i2\pi ft}dt\right|^2}{\rho c}$$

Equation E.5

For an exponentially decaying P(t), the energy spectrum can be computed analytically as Equation E.6 (Weston, 1960):

$$E_0(f) = \frac{2P_0^2}{\rho c\left(1/t_0^2 + 4\pi^2 f^2\right)} \text{ where}$$
$$E_o(f) = \text{energy flux spectral density } (\mu\text{Pa} \cdot \text{m/Hz})$$
$$f = \text{frequency (Hz)}$$

Equation E.6

Energy flux density in 1/3-octave bands is a commonly used metric for risk assessments. It is obtained by integrating $E_0(f)$ over 1/3-octave band limits. This integral may be computed analytically but is well approximated using the simpler formula Equation E.7:

$$E_{1/3}(f_c) = 0.2316 \cdot f_c \frac{2P_0^2}{\rho c\left(1/t_0^2 + 4\pi f_c^2\right)} \text{ where}$$
$$E_{1/3} = \text{energy flux density in 1/3 octave band } (\mu\text{Pa} \cdot m)$$
$$f_c = \text{geometric center of 1/3 octave band}$$

Equation E.7

Peak Pressure and Shock Wave Decay

Time Similitude Equations

Peak pressure in the explosive similitude equations is based on the theory for weak shocks (e.g., Arons et al, 1948) as well as data. It applies to the ideal case of an explosion in a free field without significant absorption or refraction. The peak pressure, P_0, is calculated in Equation E.8 as (Weston, 1960):

$$P_0 = A\left(w^{1/3}/R\right)^B \text{ where}$$
$$P_0 = \text{peak pressure (Pa)}$$
$$w = \text{weight of explosive charge (kg)}$$
$$R = \text{range separation between explosive and receiver (m)}$$
$$\text{A} = 5.2348 \cdot 10^7$$
$$\text{B} = 1.13$$

Equation E.8

The peak pressure formula is used for ranges, R, less than the similitude range limit (see below). For longer ranges, peak pressure is computed using regular linear transmission loss estimates. The peak pressure at 1 meter for each explosive round is shown in Table E-2. These peak pressure values cannot be used with linear propagation estimates to determine levels at other ranges since peak pressure levels decay according to the similitude equations (22.6·log(R) fall-off) until the shock wave becomes linear.

Table E-2. Peak Pressure Levels at 1 Meter

Expendable	Charge Weight (kg/lb)	Peak Pressure (dB re 1 μPa @ 1m)
105 mm FU	2.14 / 4.7	276.5
105 mm TR	0.16 / 0.35	268.1
40 mm	0.41 / 0.869	272.1
25 mm	0.03 / 0.0662	262.6
20 mm	0.013 / 0.0285	259.8

The decay time constant, t_0, from the pressure-time similitude equation is the time required for the pressure to decay to 1/e (0.368) of its initial value P_o. As a function of range, the decay constant becomes larger until the range R reaches the similitude range limit. The shock wave decay time constant, t_0, is computed in Equation E.9 as follows (Wakley, 1960):

$$t_0 = Aw^{1/3}\left(w^{1/3}/R\right)^B \text{ where}$$
$$A = 9.62 \cdot 10^{-5}$$
$$B = -0.26$$

Equation E.9

The decay time constant at 1 meter is shown in Table E-3 for each round.

Table E-3. Shock Wave Decay Rate at 1 Meter

Expendable	Charge Weight (kg/lb)	Similitude Decay Constant (ms) @ 1 m
105 mm FU	2.14 / 4.7	0.116
105 mm TR	0.16 / 0.35	0.061
40 mm	0.41 / 0.869	0.077
25 mm	0.03 / 0.0662	0.041
20 mm	0.013 / 0.0285	0.033

Similitude Range Limits

The similitude equations for peak pressure, $P_{0,}$ and decay constant, t_0, depend on range, R. At some range, R, the similitude equations no longer hold and regular transmission loss applies. Since the similitude equations describe a shock wave, it follows that the similitude equations should hold only to the range where the shock wave becomes a regular linear acoustic wave. A shock wave is defined as a "fully developed compression wave of large amplitude, across which density, pressure, and particle velocity change drastically" (Lapeds, 1978). The distinguishing feature of a shock wave compared to a linear acoustic wave is that, for the linear wave, particle velocity is small compared to the speed of sound in the ocean. Ross (1987) concludes that non-linear effects are negligible if the product of the sound pressure level and frequency is less than 30 kHz-atm (440880 Hz-psi). Cole (1948) provides a simpler, frequency-independent limit for non-linear effects of 100 psi that is based on comparing data to standard similitude equations. The maximum non-linear shock ranges based on the 100 psi limit are given in Table E-4 for the expendables of interest.

Table E-4. Similitude Range Limits

Expendable	Charge Weight (kg)	Similitude Range Limit (m)
105 mm FU	2.14	57.5
105 mm TR	0.16	24.2
40 mm	0.41	32.8
25 mm	0.03	13.9
20 mm	0.013	10.5

Other Issues Affecting Source Level

The exponential decay model used for the shock wave assumes a fully contained shock wave gas globe. If the shock wave gas globe vents prior to reaching its full radius, peak pressure and/or total energy may be reduced because the gas sphere may not reach the predicted radius, affecting the pulse rise and truncating the decay. The reduction in source strength is not well known and needs to be determined through a combination of source level measurements and development of theory beyond the scope of this document. Previous estimates suggested total energy reductions from 0 to 12 dB with 6 dB selected as a nominal value corresponding to 75 percent of the energy going into the atmosphere (EGTR BA, 1997). Lacking data to quantify possible source level reductions, non-breaching shock waves with no bubble pulse will be assumed for this paper.

Much of the data used to generate the underwater explosion similitude equations is based on TNT (Gaspin & Shuler, 1971). Other explosives result in slightly different peak pressures and decay constants. Weights entered into the similitude equations for alternative explosives should be converted into equivalent TNT weights. Table E-5 shows approximated metric conversion factors for Pentolite and Tetryl (Cole, 1948). Although Pentolite 50/50 shows a 27 percent higher energy density level than TNT, this only translates into a 1 dB shift in level. Generally, differences in explosive type when converted into equivalent TNT weight have a negligible effect on the metrics for concern for marine mammals.

Table E-5. Ratios of Shock Wave Parameters Compared to TNT (Cole, 1948)

Explosive	Pentolite 50/50	Loose Tetryl
Peak Pressure	1.04	0.97
Impulse	1.29	1.09
Energy Density	1.27	1.19

Underwater Noise Resulting from Sounds in Air

In addition to the exploding rounds, the proposed AC-130 gunship operations will result in several other noise sources that may exceed ambient levels in the ocean. These additional noise sources include projectile sonic boom, muzzle blast, and aircraft noise. Assuming a worst-case scenario of a 50 kilogram, 0.54 meter long projectile traveling at Mach 3.0 one meter over the ocean, the estimated sonic boom peak pressure level in the water at the surface would be 205 dB re 1 μPa (2.4 psi). The duration of the sonic boom is less than 1.0 ms and the energy flux density is less than 172 dB re 1 $\mu Pa^2 \cdot s$.

Muzzle blast refers to the impulsive pressure wave created when the projectile and propulsive gasses are expelled from the gun muzzle (see Figure E-2). Based on equations from Pater (1981), the gun muzzle blast will have peak pressure levels less than 179 dB re 1 μPa and energy levels less than 160 dB re 1$\mu Pa^2 \cdot s$ in the water at the surface. These levels are less than normally reported levels of concern for marine mammals and are significantly lower than levels generated by the explosive rounds themselves.

Figure E-2. MK 45 5"/54 Muzzle Blast

Aircraft noise is a continuous source rather than impulsive and is subject to different metrics and thresholds than explosions, sonic booms and muzzle blast. AC-130 Gunships have total source levels of approximately 180 dB re 1 μPa. This level falls-off like spherical spreading in the atmosphere to ranges of 1,000 meters at which point the level is below 120 dB re 1 μPa (Eller & Cavanagh, 2000). Levels of this magnitude affect marine mammals only if an aircraft stays in one position for many hours. Since the proposed actions involve total flight times on the order of about 6 hours and firing runs less than 30 minutes, the aircraft will not be in one location long enough to accumulate levels of concern to marine mammals.

Propagation Conditions and Propagation of Key Parameters

The primary areas used for AC/C-130 gun testing include regions W-151[A B C D S] of the EGTTR encompassing parts of the Florida Middle Ground, Mississippi–Alabama Shelf and Upper Continental Slope. Propagation in these areas will be dominated by bottom loss since the profiles are downward refracting and the water is generally shallow. Little propagation data exists for the region; however, data from a site in the Florida Middle Ground is available which can be used to motivate model parameters for the entire region. A general overview of EGTTR bathymetry, sound velocity profiles, and bottom sediments will be followed by a discussion of available propagation data and surface image effects relevant to on-contact explosive shells.

Bathymetry

Water depth, bottom slope, and other features such as seamounts and shelf breaks play an important role in determining transmission loss. The EGTTR contains water depths from 20 meters to over 3,000 meters. The eastern portion of the range is dominated by the gently sloping (1°-2°) West Florida Shelf that gives way to the Upper Continental Slope near the 100-meter contour. The Upper Continental Slope breaks at 1,000 meters and drops quickly to 3,000 meters forming the Florida Escarpment. Portions of the Florida Escarpment are among the steepest on Earth with some places steeper than 30° (Pyle et al.). To the North lies the Mississippi Alabama shelf that is narrower than the Florida shelf and drops quickly from 40 to 200 meters. Other prominent bathymetric features such as the DeSoto Canyon, Lower Mississippi fan, and Florida Middle Ground also occur within the boundaries of the EGTTR. Below is an annotated bathymetry map (Figure E-3) (NOAA, 1985), as well as a contour plot (Figure E-4) of the NOAA produced Earth Topography – 5 min (ETOPO5).

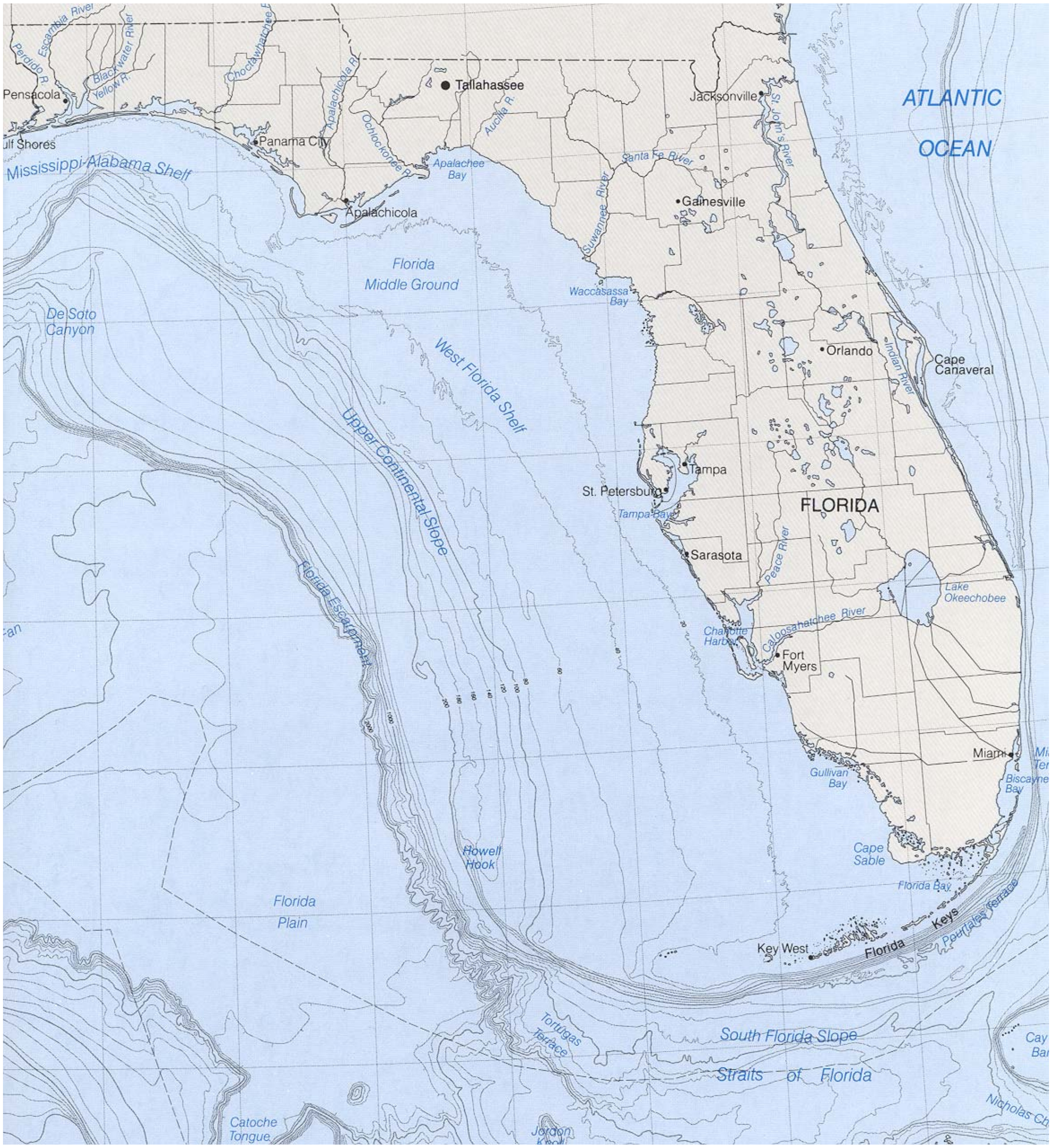

Figure E-3. NOAA Annotated Bathymetry

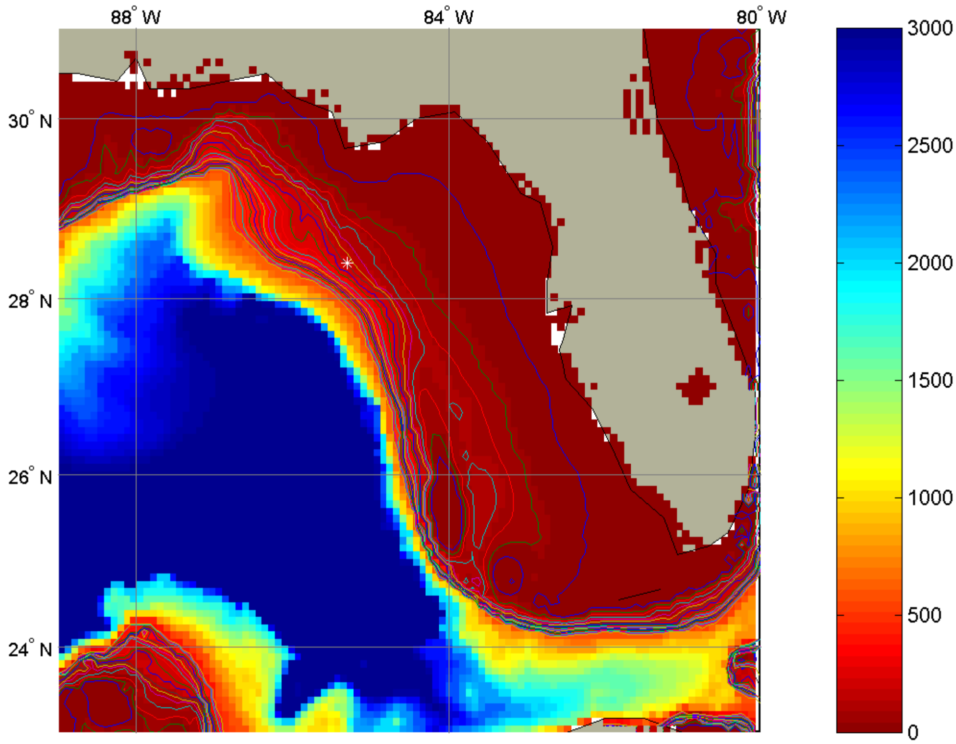

Figure E-4. ETOPO5 Bathymetry / 25m Contours

Sound Velocity Profiles

Ocean sound speed depends on water temperature, salinity and pressure. Ocean temperature and salinity in turn vary with geographic location and time (season). Sound speed profiles, which describe ocean speed of sound as a function of depth, can be divided into several layers (Urick, 1983). The occurrence and thickness of each layer is determined by location, season, and water depth (Figure E-5). The top or surface layer is typically the thinnest layer and changes based on local temperature and wind action. Depending on wind conditions, an isothermal surface layer may be formed that can channel sound and produce low levels of transmission loss. Below the surface layer lies the seasonal thermocline that may change with season or current shifts. Below the surface layer is the main thermocline that varies little over season. Below the main thermocline is the deep isothermal layer. This layer tends to stay a constant 39 °F year round (Urick, 1983) and the sound speed here increases due to the effects of increased pressure. In shallow water, velocity profiles are limited to the first several layers and are difficult to predict. Shallow regions near the coast may be influenced by the inflow of fresh water whose volume may vary significantly with time.

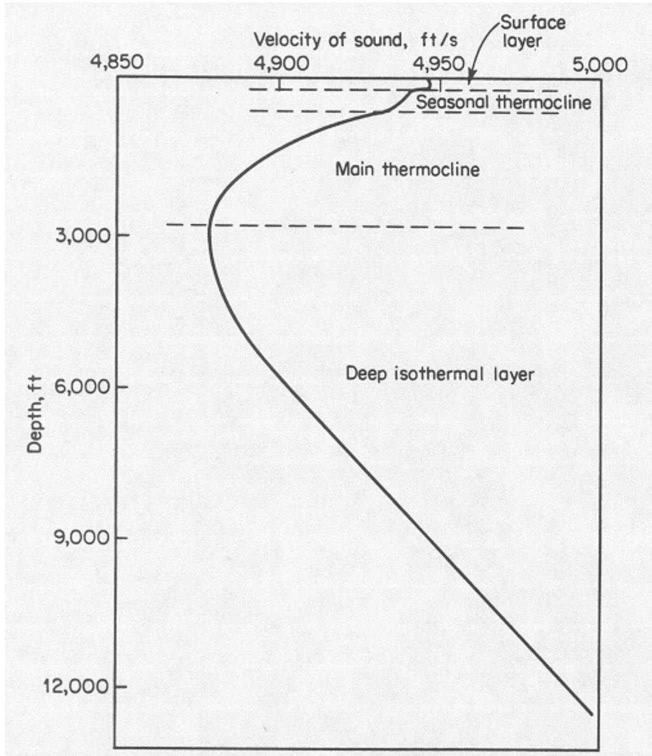

Figure E-5. Typical Deep Water Sound Speed Profile (Urick, 1983)

An important factor affecting water temperatures and therefore sound velocity in the EGTTR is the Gulf Loop Current (Figure E-6). The Loop Current is the upstream extension of the Gulf Stream and is formed by influx through the Yucatan Strait into the Gulf and outflow through the Florida Strait (Milliman and Imamura, 1992). The intensity of this clockwise flow varies considerably over time and determines the extent of the Loop. During periods of low intensity, the loop enters through the Yucatan and heads for Key West almost immediately. During times of high intensity, the loop may extend northward toward the Mississippi, Alabama and Florida Coasts. The Gulf Loop is cyclical, but not necessarily annual. Loop Current frontal eddies and freshwater inflow from the Mississippi river add to the complexity of temperature and salinity contours in the EGTTR.

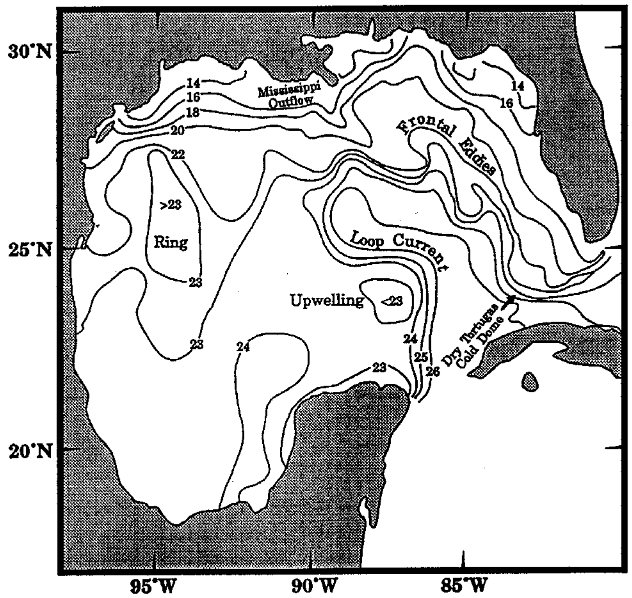

Figure E-6. Typical Gulf Currents (Milliman and Imamura, 1992)

Surface waves affect the formation and depth of surface channels or ducts. Typical wave heights for several sites in the Gulf are shown in Figure E-7. The higher waves occur in the fall and winter months. Waves about 2 m from the mean are within one standard deviation of the mean and are therefore likely to occur regularly (Std. Eiger EA). Areas where surface channels are typically formed will show channels in the historic profiles. In other regions where surface channels are more irregular, their presence and properties are best determined through direct measurement. Since surface waves are directly correlated with wind, mixing of the surface layer can be inferred from wind speed if direct sound speed measurements are unavailable.

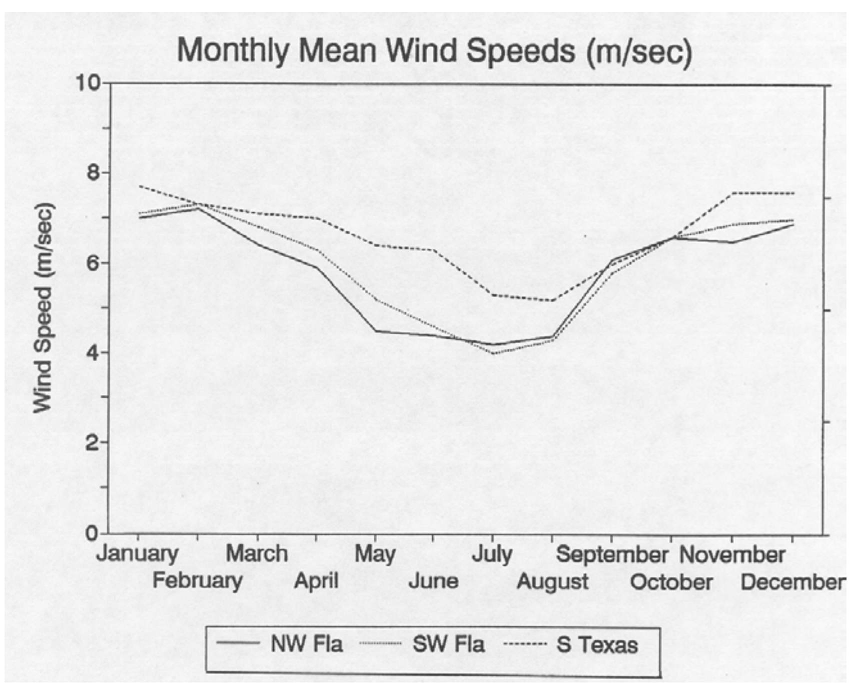

Figure E-7. Mean Wind Speed (Std. Eiger EA)

The U.S. Navy, through the Naval Oceanographic Office (NAVOCEANO), has compiled an unclassified database of worldwide ocean temperature and salinity. Both researchers and operational Navy personnel use the database to estimate sound speeds in the ocean. The database known as the Generalized Digital Environmental Model (GDEM) is a coherent (in both space and time) set of temperature and salinity depth profiles on a 30' by 30' grid for the world's oceans (GDEM, 1993). Regions with similar sound speed profiles have been combined to create a limited set of provinces where sound historical speed measurements show little spatial variability. The database contains monthly profiles of temperature in the upper 400 m to account for seasonal variations. Figure E-8 shows GDEM provinces for the EGTTR and Figure E-9 shows representative profiles for each province. The profiles show sound speed in m/s versus depth in meters. The profiles throughout the region are similar with a prominent mixed layer to about 100 meters in the winter. The main thermocline is predictable with a slope of about 0.1 m/s. The profiles are bottom limited for all near surface sources whenever the water depth is less than about 3,500 meters.

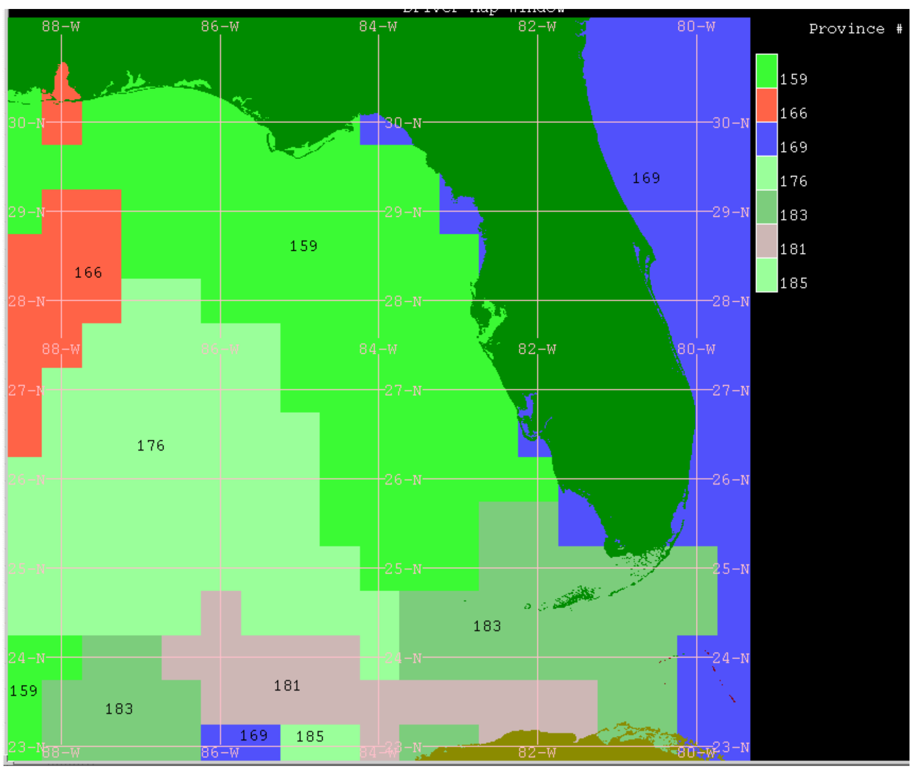

Figure E-8. GDEM Province Map

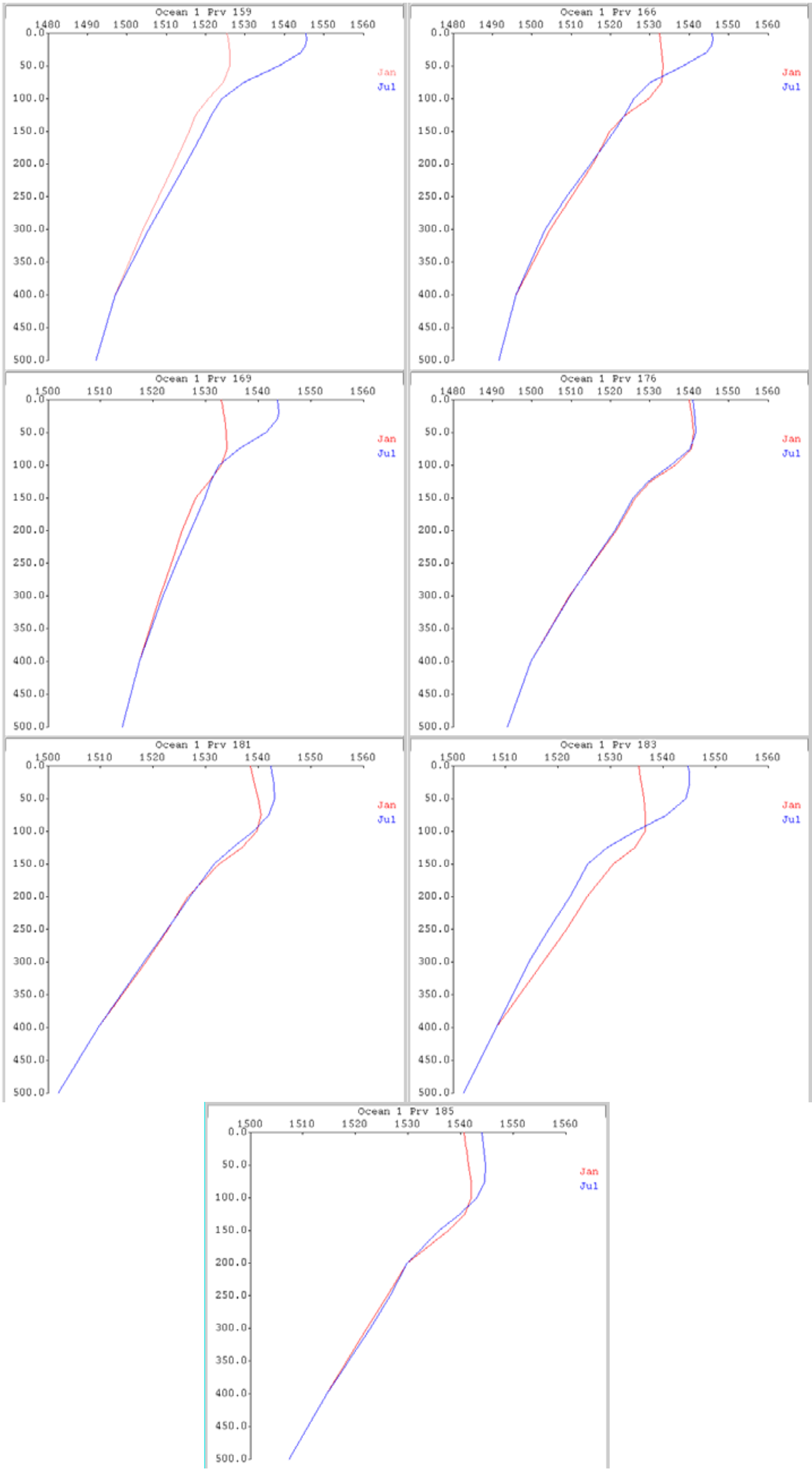

Figure E-9. GDEM Sound Speed Profiles

Bottom Sedimentation

A cross section of the carbonate ramp slope from the west Florida escarpment to the outer shelf hard-grounds is shown in Figure E-10. Piston-core samples show three major belts: 1) a hard-ground facies with algal ridges along outer shelf at water depths of 200-400 meters, 2) a winnowed-sand facies with deep-water coral mounds along the shelf margin at water depths of 400-600 meters, and 3) a bioturbated pelagic-ooze facies from depths of 600-2,000 meters (Mullins et al., 1988).

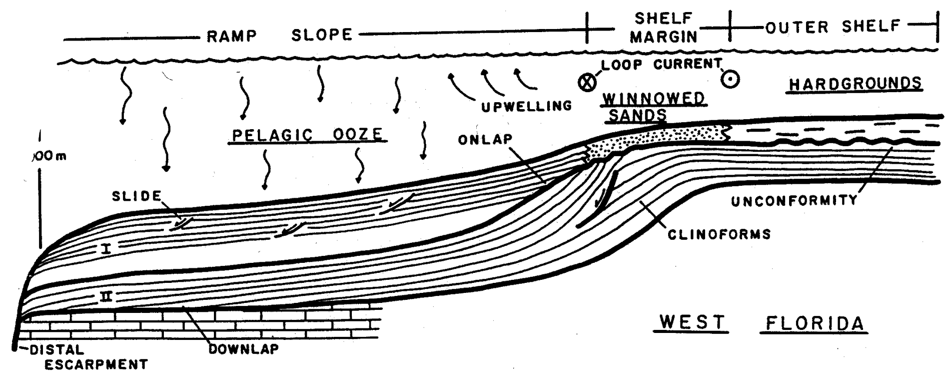

Figure E-10. Central West Florida Slope Carbonate Ramp (Mullins et al, 1988)

Figure E-11 shows the surficial bottom sediments in the Eastern Gulf (Brooks, 1974). On the West Florida Shelf is a recent and discontinuous veneer of carbonate sediments. A thick belt of algal and peletoid sediments lies in water less than 100-fathoms. The Florida middle ground is a relic reef from the Pleistocene era over which lies several meters of worm, algal and coral growth (Brooks, 1974). In addition to these studies, geoacoustic descriptions for the EGTTR area are available in the classified Low Frequency Bottom Loss (LFBL) and High Frequency Bottom Loss (HFBL) databases. The ACT-I bottom description of a thin sand layer over a consolidated half-space is probably representative of the entire Florida Middle Ground. Overall, surface sediments in the EGTTR are expected be acoustically reflective with little loss to critical angles of about 10° to depths of 600 m. Deeper sediments may have higher losses, but are less important for long range ducted sound transmission.

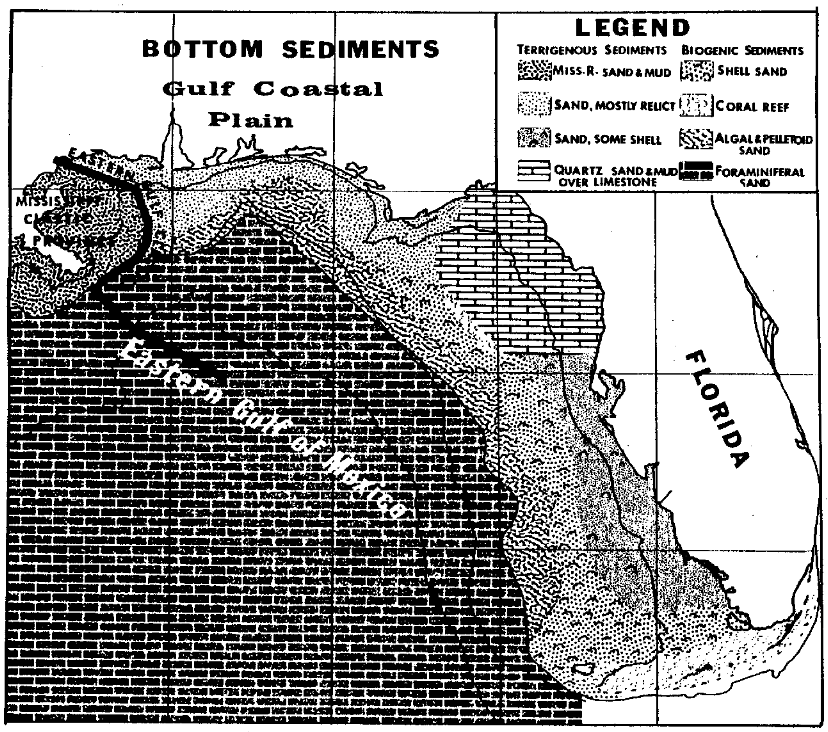

Figure E-11. Gulf Coastal Plain Bottom Sediments (Brooks, 1974)

ACT-I and Eiger-I Data

In September of 1992 as part of the Multi-static Active Sonar for Adverse Environments program Area Characterization Test I (ACT-I), transmission loss data was collected at a site in the Florida Middle Ground (28.4° N, 85.3° W) (see Figure E-3). The ACT-I test included both horizontal and vertical line arrays with the horizontal array oriented upslope in about 100 fathoms (183 m) of water (Gomes & Matthews, 1992). Transmission loss (TL) data was collected both up and down the slope from the horizontal array and processed into the four bands shown in Figure E-12. In addition to the transmission loss runs, expendable bathythermograph (XBT) and conductivity-temperature-depth (CTD) were collected. Figure E-13 is a representative sound speed profile taken during the TL portion of the test (Gomes and Matthews, 1992).

In November of 1995 the ACT-I site was revisited during the Standard Eiger (SAIC, 1995) exercise. This test also collected TL data that is shown in Figure E-14.

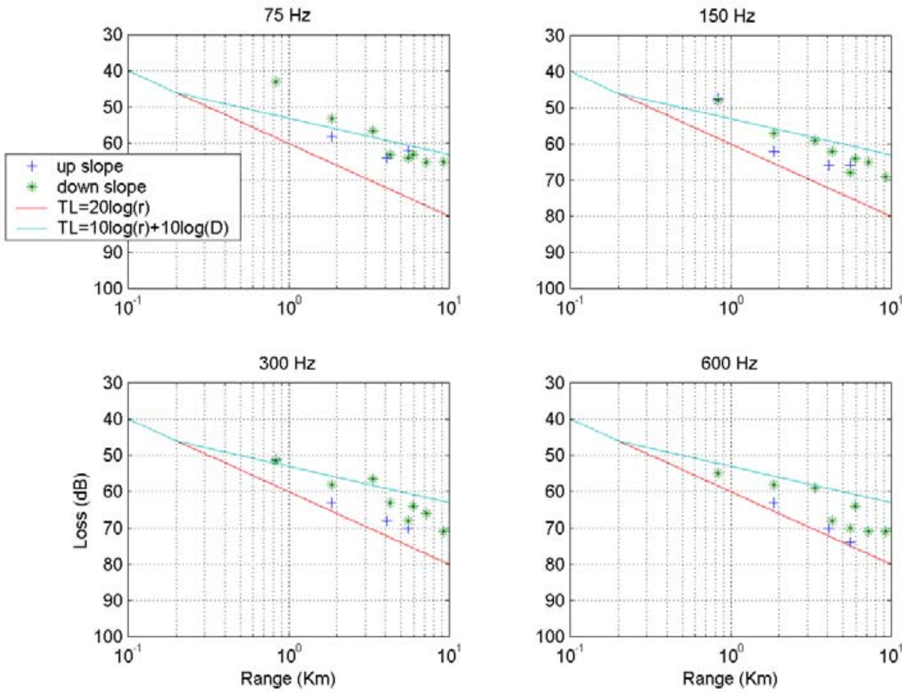

Figure E-12. ACT-I Transmission Loss Data

The TL data collected from the ACT-I site is remarkable for the low transmission loss levels observed. In most environments, TL can be expected to fall-off as 20*log(R) (spherical spreading), where R is range in meters, for 2-3 water depths at least before waveguide effects slow the rate of loss. At the ACT-I site where the bottom is composed of a thin layer of sand over an acoustically fast half-space, the data shows that TL drops-off like spherical spreading to a range of only one water depth (200 m). Figure E-15 provides a detailed acoustic description of the ACT-I sediments (Laney, 1994).

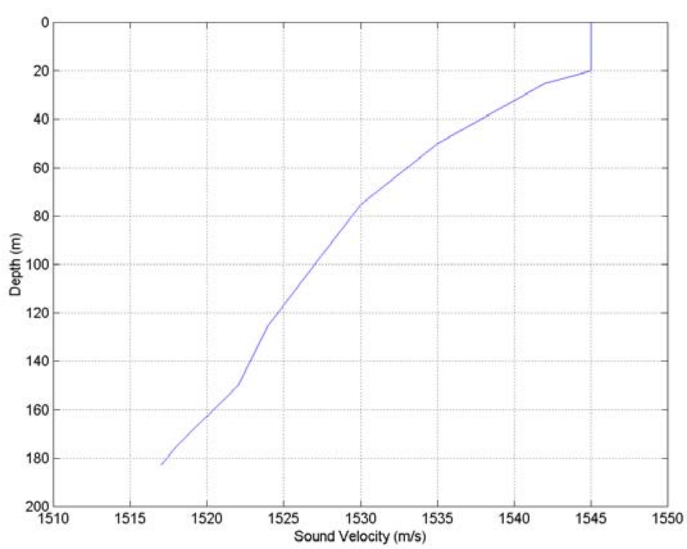

Figure E-13. ACT-I Sound Velocity Profile

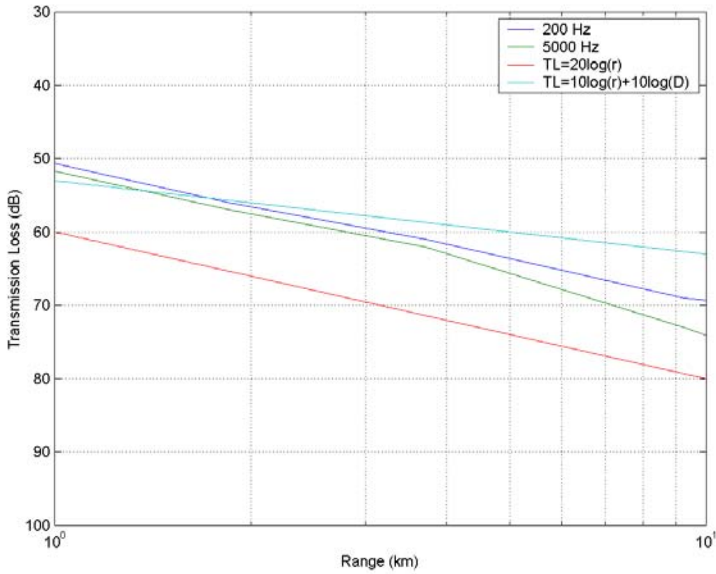

Figure E-14. Standard Eiger Transmission Loss Data

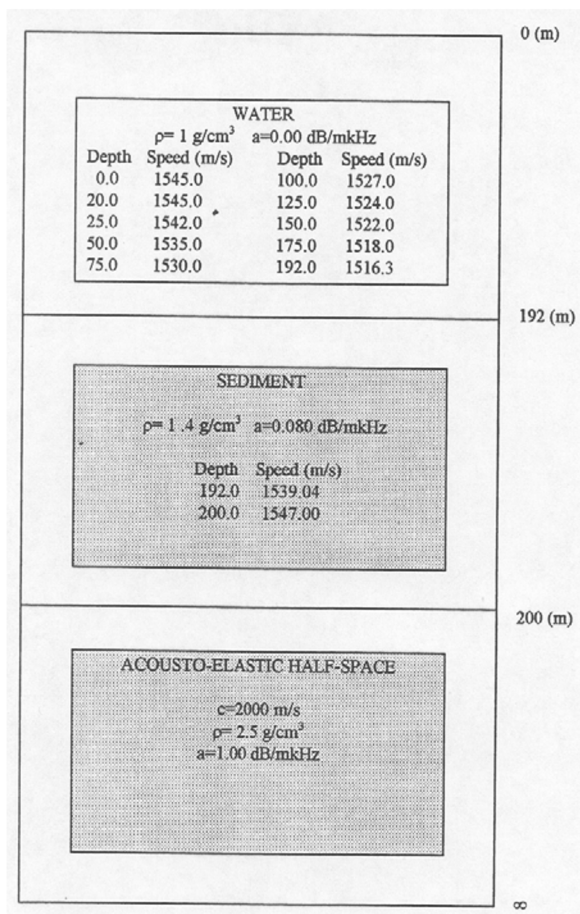

Figure E-15. ACT-I Sediment Properties (Laney, 1994)

Cut-Off and Surface Image Interference

On-contact explosive shells are subject to surface image interference. For the vast majority of exploding rounds used in the EGTTR, this transmission loss phenomenon will dominate energy levels. The surface of the ocean is well approximated as a pressure release boundary (large impedance mismatch and 180° phase shift for reflected waves). In calm seas, the pressure release sea surface creates an interference pattern in the underwater sound field caused by the direct and surface reflected sound (see Figure E-16). This effect, known as Lloyd's mirror or image-interference, causes a source that is omni-directional in the free field appear as a dipole with the beam pointing down (Urick, 1983). The dipole beam becomes narrower as the source moves toward the sea surface where the direct and surface bounce pressure time series start to cancel each other out entirely. A similar effect occurs for receivers near the surface where the receiver has a corresponding image receiver that creates a second dipole.

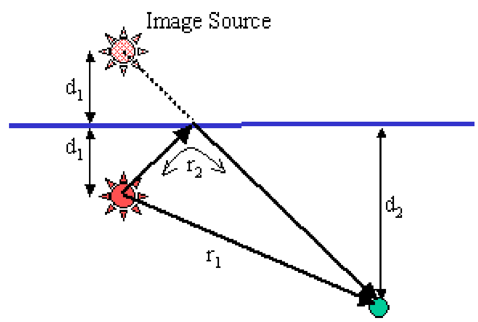

Figure E-16. Surface Image Interference Geometry

For explosive sources, there is period of time, T, between the direct path arrival and the surface reflected arrival because the surface reflected path, r_2, is longer than the direct path, r_1 (Officer, 1958). Unless either the source or receiver is near the surface, these arrivals are separated in time and do not interfere (top Figure E-17). As the source or receiver approaches the surface, the delay time T can become small relative to the waveform and creates overlap between the direct and reflected paths (bottom, Figure E-17).

In the period of time between the arrival of the direct and surface path, the peak pressure is able to reach the receiver with no image interference regardless of how small T may become. The peak pressure will, however, be modified by diffraction and other effects for very near surface sources and receivers. Peak pressure for an ideal point source directly at the surface will be zero. These extremely near surface effects are not modeled here. Wave and mode propagation models (including PE) assume a continuous wave source and will not properly predict peak pressure for near surface explosive sources. Ray models can be configured to properly treat this case. Unlike peak pressure, surface-image interference effects do affect energy levels.

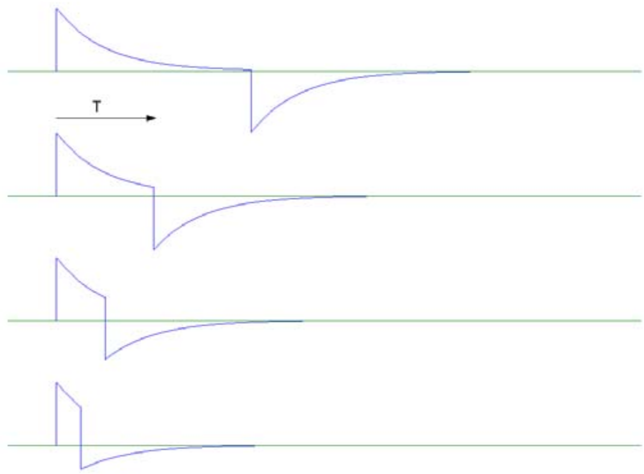

Figure E-17. Interfering Direct and Surface Reflected Shock Wave

The broad-band energy for a given delay time in the combined interfering direct and surface reflected path (neglecting propagation losses) is computed as (Officer, 1958):

$$\frac{1}{\rho c}\int_0^\infty [P(t) - P(t-T)]^2 dt = \frac{P_0^2 t_0}{\rho c}\left[1 - e^{-T/t_0}\right] \text{where}$$

$$T = (r_2 - r_1)/c$$

r_1 = direct path length

r_2 = surface reflected path length

(other variables as in Equation E.4)

Equation E.10

Figure E-18 shows the relative broadband energy level in dB of a 4.7 pound source 0.2 foot from the ocean surface compared to the same source in the free field assuming an iso-velocity sound speed profile. Propagation losses have not been included. Note that directly below the source, levels are twice those of the free field source and that at shallow angles, the broadband energy is significantly reduced. As the source moves closer to the surface, levels everywhere except directly below the source are reduced.

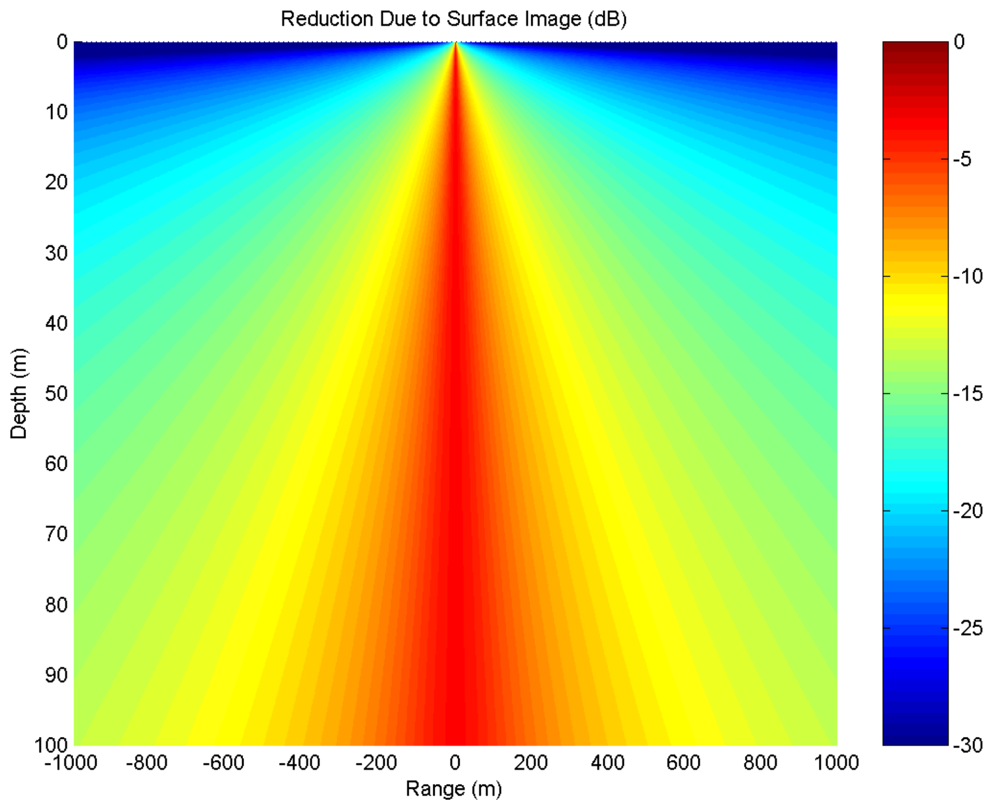

Figure E-18. Broadband Pressure Release Surface Energy Reduction

Spectrum levels for several fixed delay times are shown in Figure E-19 for a 4.7 pound shot at 0.2 foot depth. Short delay times result in significant energy reductions at low frequencies compared to the free field. Most geometries of interest result in very small delay times and have spectra similar to the $0.25 \cdot t_o$ case shown.

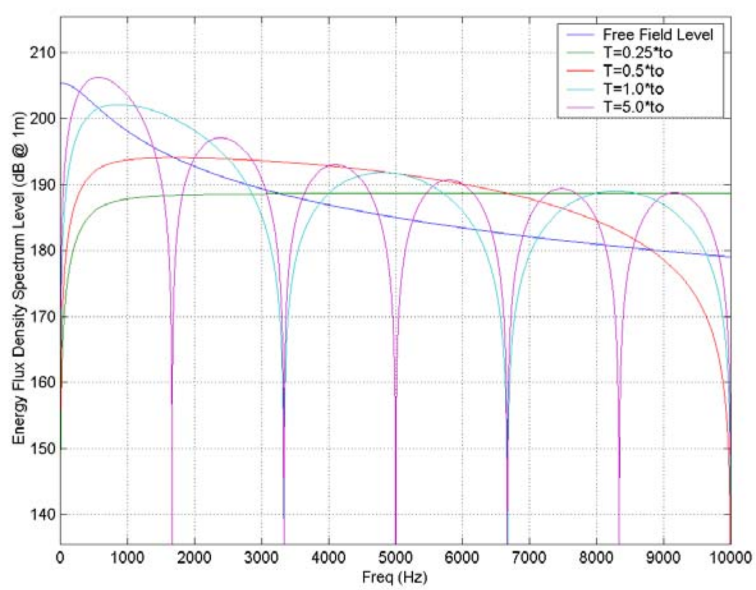

Figure E-19. Pressure Release - Energy Flux Density Spectrum Levels

Image-interference effects are well understood for underwater explosions that do not breach the surface. Data (Bluy & Payne, 1974) show that breaching 1-pound shots at 1.5 feet and 3 feet exhibit normal image-interference directional source effects. It is expected that image-interference will occur in the normal way for the explosive shells under consideration, but data is needed to verify that near surface explosions do not alter the surface image.

Transmission Loss Estimation

The EGTTR area contains a wide range of water depth, sound speed profiles and bottom sediment types. For the purposes of this report a simple conservative estimate of transmission loss is needed. In support of the metrics and thresholds in common use, transmission loss (TL) is only required to 1-2 kilometers for the explosives of interest. These short ranges minimize the importance of sound speed and bottom type except in very shallow water or conditions where a strong surface duct appears. In a loss-less ocean with perfectly reflecting boundaries, TL will transition from spherical spreading to cylindrical spreading as a function of range from the source (Marsh and Schulkin, 1962). The transition point suggested by the ACT-I data is one water depth. For this report, TL will be modeled as either spherical spreading (20log(R)) (Equation E.11) or as (Figure E-20):

$$
\begin{aligned}
TL(R) &= 20\log(R) \quad R \le D \\
&\quad 10\log(\mathrm{R}) + 10\log(\mathrm{D}) + \alpha R \quad \mathrm{R} > N\mathrm{D} \quad \text{where} \\
\mathrm{R} &= \text{range (m)} \\
\mathrm{D} &= \text{water depth in m} \\
\alpha &= \text{attenuation factor (dB/m)} \\
\mathrm{N} &= \text{integer, typically 1 - 10 (1 suggested by ACT - I)}
\end{aligned}
$$

Equation E.11

The attenuation factor, α, in equation E.11 depends on bottom type and the number of bottom interactions per meter traveled. For specific cases, a transmission loss model where sound speed, bathymetry, and sediment effects can be properly accounted for should be used to estimate TL. The bottom description shown in Figure E-11 provides a good estimate of environmental conditions for the Florida Middle Ground region. By setting α=0 in Equation E.11, a worst case (lowest loss) bound is obtained. In contrast, spherical spreading results in a best case (highest loss) TL estimate. These bounds are useful for determining cases where further analysis and more careful modeling may be required.

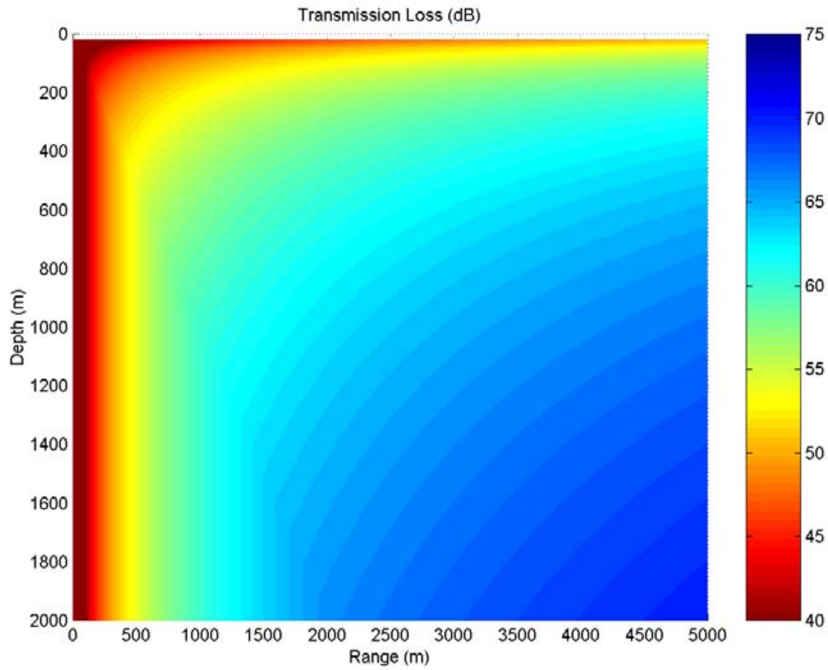

Figure E-20. 10log(R) + 10log(D) Transmission Loss

Explosive Projectile Metric Levels

Peak Pressure Estimate

Extrapolated peak pressure at 1 m for each projectile is shown in Table E-6. These values were determined from the peak pressure at the maximum similitude range and extrapolated back to 1 m using spherical spreading (20log(R)). Figure E-21 shows how peak pressure falls-off as a function of range assuming spherical spreading loss. The dashed reference line in Figure E-21 is at a common peak pressure threshold of 12 psi (218 dB). Figure E-22 shows peak pressure as a function of range and depth using TL =10log(R) + 10log(D) where R is range in meters and D is water depth in meters.

Table E-6. Extrapolated Peak Pressure Levels at 1 m

Expendable	Charge Weight (kg)	Peak Pressure (dB @ 1m)
105 mm FU	2.14	272.0
105 mm TR	0.16	264.4
40 mm	0.41	267.1
25 mm	0.03	259.6
20 mm	0.013	257.2

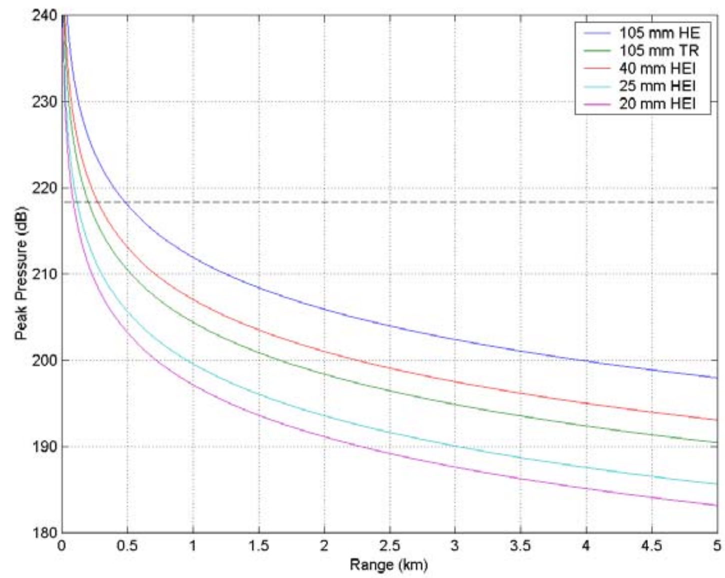

Figure E-21. Peak Pressure, Spherical Spreading

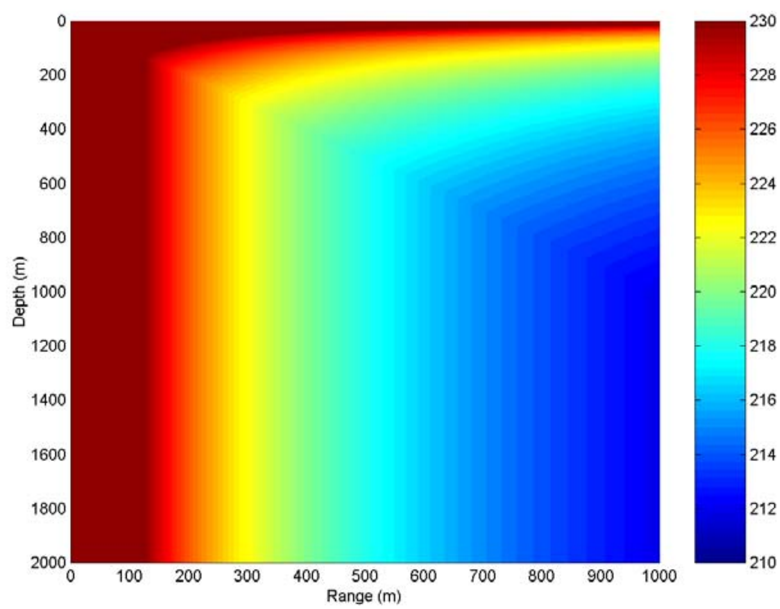

Figure E-22. Peak Pressure (dB) 105 mm HE / TL=10log(R)+10log(D)

Energy Level Estimate- Free Field

Explosive rounds set with a delayed fuse detonate at 50-60 ft., which is deep enough that a free field assumption holds. Total extrapolated free-field energy levels at 1 m over several bands are given in Table E-7. Figures E-23 and E-24 show total spectrum levels and maximum 1/3-octave bands levels versus range assuming 20log(R) transmission loss. Figure E-25 shows maximum 1/3-octave band levels for the 105 mm HE shell as a function of range and depth assuming 10log(R) + 10log(D) spreading.

Table E-7. Extrapolated Energy Metrics at 1 m

Expendable	Charge Weight (kg)	Total Energy Flux Density	EFD in greatest 1/3 octave band > 10 Hz	EFD in greatest 1/3 octave band > 100 Hz
105 mm FU	2.14	234.2	222.9	222.9
105 mm TR	0.16	222.9	211.6	211.6
40 mm	0.41	226.8	215.5	215.5
25 mm	0.03	215.7	204.3	204.3
20 mm	0.013	212.0	200.7	200.7

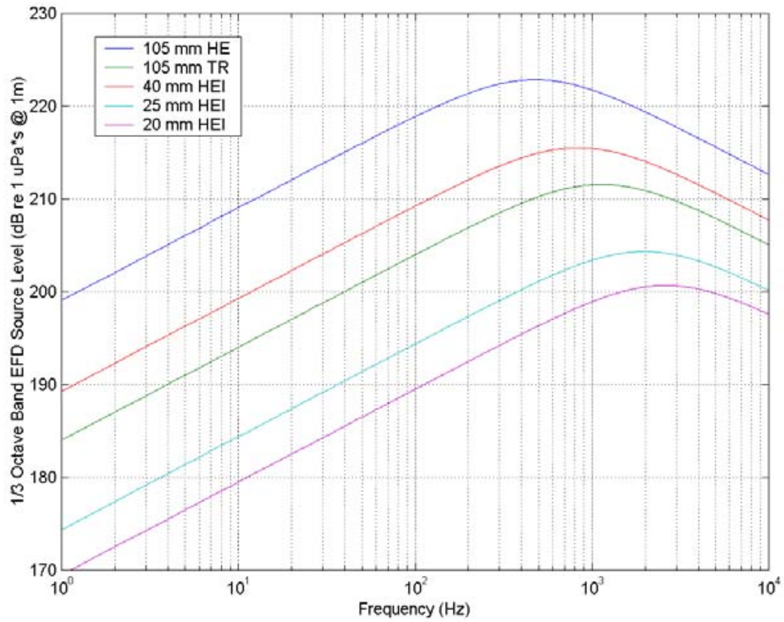

Figure E-23. Free Field 1/3-Octave Band EFD Source Levels

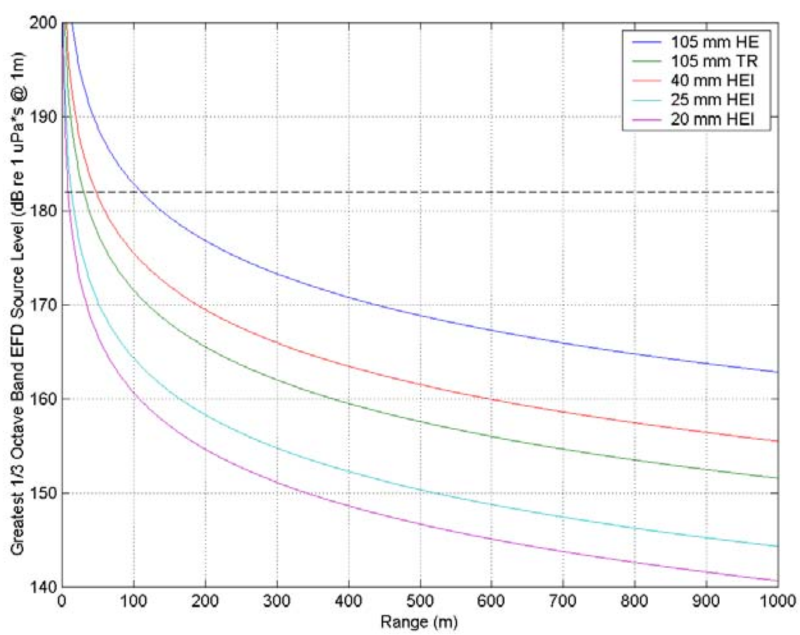

Figure E-24. 1/3-Octave Bands EFD Level, Spherical Spreading

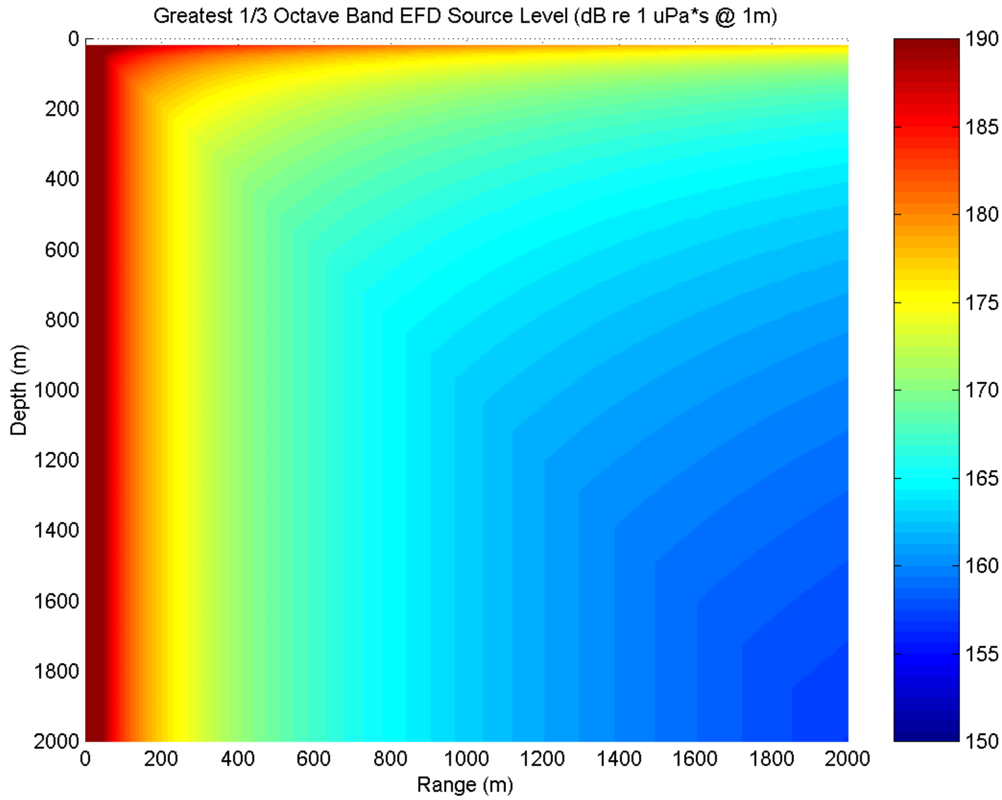

Figure E-25. 105 mm HE 1/3-Octave Band EFD Level (dB) / TL = 10log(R)+10log(D)

Energy Level- Pressure Release Surface

Explosive projectiles set for surface detonation explode approximately 0.2 ft below the surface. At this depth, surface image effects will significantly affect received energy levels compared to the free field case. Energy spectrum levels in the greatest 1/3-octave wide band are shown below for a 4.7 lb charge 0.2 ft below the surface in an iso-velocity ocean both without (Figure E-26) and with (Figure E-27) propagation loss included. Near surface depths with no level shown in Figure E-27 correspond to levels below 125 dB. For all points in the field, the center of the maximum 1/3-octave band is above 100 Hz so levels are the same for the >10 Hz and >100 Hz band pass metrics. With propagation loss included, the levels are well below those of concern for marine animals at ranges beyond several meters.

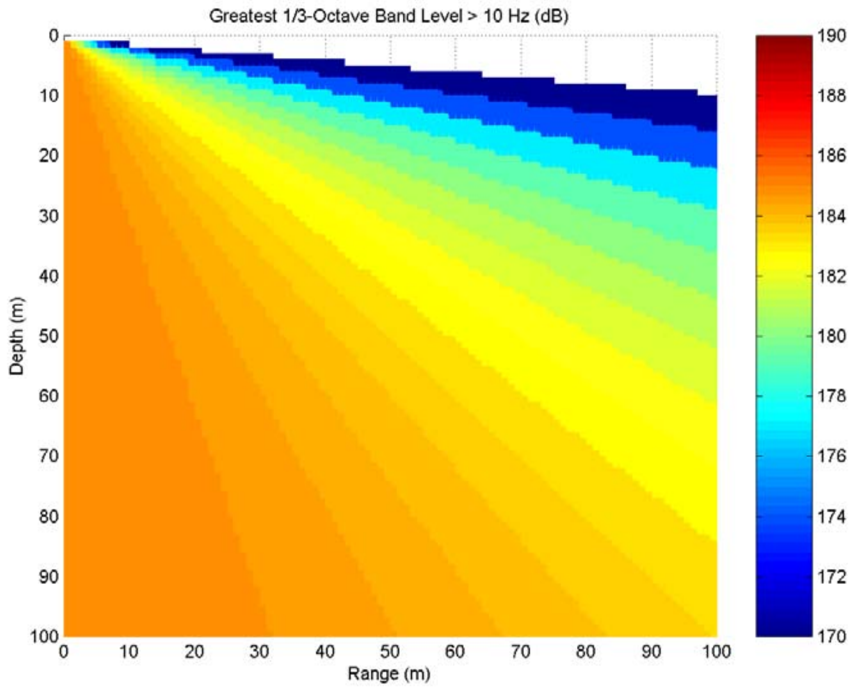

Figure E-26. 105 mm HE Pressure Release Surface 1/3- Octave Band EFD (No Spreading)

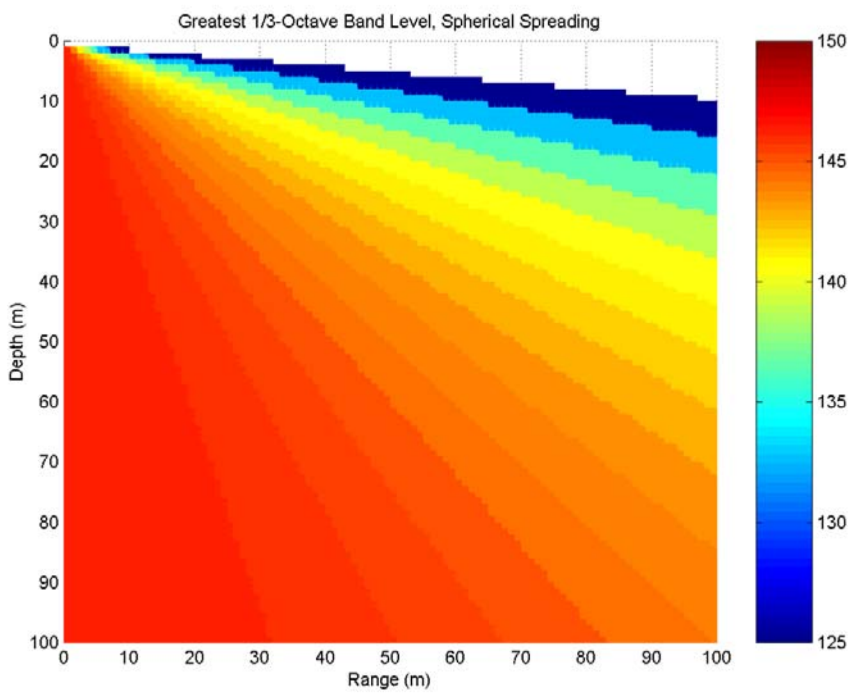

Figure E-27. 105 mm HE Pressure Release Surface 1/3- Octave Band EFD (Spherical Spreading)

The calculated zones of influences for the three metrics, peak pressure, Total EFD and Pressure Release for the Greatest 1/3 Octave Band are presented in the tables below.

Table E-8. Calculated Zone of Influence (m) using Peak Pressure

Expendable	160 dB	170 dB	180 dB	190 dB	200 dB
105 mm FU	1,584,893,000	158,489,300	15,848,930	1,584,893	158,489.3
105 mm TR	2,754,229,000	27,542,290	2,754,229	275,422.9	27,542.29
40 mm	512,861,400	51,286,140	5,128,614	512,861.4	51,286.14
25 mm	91,201,100	9,120,110	912,011	91,201.1	9,120.11

Table E-9. Calculated Zone of Influence (m) using Total Energy Flux Density

Expendable	160 dB	170 dB	180 dB	190 dB	200 dB
105 mm FU	513	162	51.3	16.2	5.1
105 mm TR	140	44	14.0	4.4	1.4
40 mm	219	69	21.9	6.9	2.2
25 mm	61	19	6.1	1.9	0.6

Table E-10. Calculated Zone of Influence (m) using Pressure Release Greatest 1/3 Octave Band

Expendable	160 dB	170 dB	180 dB	190 dB	200 dB
105 mm FU	195.0	44.2	14.0	4.4	1.4
105 mm TR	38.0	12.0	3.8	1.2	0.4
40 mm	59.6	18.8	6.0	1.9	0.6
25 mm	16.4	5.2	1.6	0.5	0.2

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APPENDIX E REFERENCES

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APPENDIX F

CALCULATING UNDERWATER NOISE EXPOSURE FOR PROTECTED MARINE SPECIES

CALCULATING UNDERWATER NOISE EXPOSURE FOR PROTECTED MARINE SPECIES

Summary of ZOI for Typical Metrics and Thresholds

In general a zone of influence (ZOI) is the minimum volume region outside of which no animals will be affected based on a given noise metric and threshold. For simplicity, zones of influence are often described as cylinders centered at the explosion with a constant radius over all depths. In this case, the ZOI radius selected is set to the greatest affected range over the entire water column. The ZOI radius for a particular event is determined by the metric and threshold selected for each animal species and source type. Assuming a cylindrical ZOI, the expected number of animals affected (ENA) by a single explosion is computed as:

$$ENA = \pi R_{ZOI}^{2} \rho \text{ where}$$
$$\rho = \text{animal density (animals/ km}^{2}\text{)}$$
$$R_{ZOI} = \text{zone of influence radius (km)}$$

Equation F.1

For example, assume an animal density of 0.1 animals/km and a level B harassment metric of peak pressure with a threshold of 12 psi. Based on spherical spreading, the ZOI radius for the 105 mm HE shell is 500 m and the ENA = 0.0785 animals.

Number of Expected Exposures for Multiple Explosions

When more than one explosion occurs, estimating the average number of animals harassed becomes complicated by source and animal spatial and temporal effects. Often computations are further complicated by thresholds that depend on the duration or number of exposures for each animal. The general case of moving animals, moving sources and exposure varying thresholds is difficult to solve analytically and Monte Carlo approaches are often used. Certain cases, however, can be solved analytically.

Consider the case where an AC-130 Gunship fires at a target on the ocean surface. Assume 99 percent of the shells fall into a circle around the target with a radius of 5 meters and that firing continues uninterrupted for a period of T minutes. The ordnance fired may be a mix of rounds, but all 105 mm HE rounds are assumed. Equation F.2 is used to compute the expected number of animals affected for an event of duration T, assuming T > Δt:

$$ENA = \rho \pi R_{ZOI}^{2} \frac{T}{\Delta t} \text{ where}$$
$$\Delta t = \text{average time each animal stays in ZOI}$$

Equation F.2

For cases where T ≈ Δt, ENA can bounded as follows:

$$\rho \pi R_{ZOI}^2 \le ENA \le \max\left(\rho \pi R_{ZOI}^2 , \rho \pi R_{ZOI}^2 \frac{T}{\Delta t} \right)$$

Equation F.3

The quantity Δt is non-trivial to compute depending on the assumed animal motion. If animals are assumed to travel in straight lines with an average velocity v_a then Δt is easily computed as Equation F.4:

$$\Delta t = \frac{R_{ZOI}\pi}{2v_a} \quad \text{(straight line motion)}$$

Equation F.4

For example, if:

R_{ZOI} = 260' + 500 m = 0.580 km
ρ=0.1 animals/km^2
v_a = 3.5 kts = 0.108 km/min
T = 30 min

Then T ≈ Δt and ENA can be bounded as follows:

$$0.106 \le \text{ENA} \le 0.376$$

The actual value of ENA for this from Monte Carlo simulation is 0.127 animals. Based on Monte Carlo simulation, ENA values tend to be somewhat lower for random animal motion constrained to turns of ± 45° where a new turn is allowed every few seconds.

In addition to the estimate of animals affected in the ZOI, some additional number of animals may be affected by the 1 percent of shells that land beyond the normal 5 meter radius target area. If the impact point of these shells is truly unconstrained, then they must be treated as single explosions and added to the total ENA in the natural way. For example, if 60 shells are fired in T=30 min, then 0.01*60*ENA (single explosion) = 0.047 animals must be added to the total. A better approach, depending on the particulars of the case, might be to set an outside limit for all shells and to increase the ZOI radius accordingly. Over the period of one year, there are many firing missions flown. Precedents indicate that ENA estimates must be added for each mission that occurs in a single calendar year.

APPENDIX G

NOISE CRITERIA AND THRESHOLDS FOR MARINE SPECIES

NOISE CRITERIA AND THRESHOLDS FOR MARINE SPECIES

UNDERWATER EXPLOSIONS

Criteria and thresholds for impact of noise on protected marine species form a complex topic in which there is little agreement within the scientific community, much less among regulators. As apparent in what follows, there are very wide ranges of possibilities, and the implications are profound.

The most reasonable approach to evaluating criteria and thresholds is to review precedent and the science behind it. This allows informed choices for EGTTR. Below is a summary of the most important precedents and technical views. Note that the topic requires a basic knowledge of underwater sound metrics and units. See Appendix H for introductory materials on these topics.

Range of Criteria and Thresholds

For this report, "criteria" for injury or harassment are stated in terms of the impact on the animal by the noise field, as opposed to properties of the noise field itself (described by the "thresholds"). Criteria used in the past include: mortality, slight lung injury, onset of serious GI injuries, temporary hearing loss, avoidance of an area, interruption of vocalizations, masking of communications. For a given criterion (e.g., eardrum rupture in a whale), a threshold describes the sound field properties that are believed to cause the injury or harm (e. g., impulsive noise field with energy flux density in excess of 1 J/m^2).

Criteria and thresholds for compliance with MMPA and ESA are controversial topics, and have been since 1994. There are at least two reasons for this: there are very few measurements of the impact of sound on protected species and the laws themselves are difficult to interpret. Especially problematic is "harassment" (under the MMPA and ESA), which involves criteria based on behavioral reactions. The result is a wide range of acoustic thresholds for harassment, with precedents documented in each formal risk assessment approved by regulators.

Consider examples from recent risk assessments (mostly from Navy, the Defense Advanced Research projects Agency [DARPA], and the seismic exploration industry -- where the majority of underwater sound assessments are conducted) (Table G-1).

Table G-1. Examples of Criteria and Thresholds for Impact on Marine Mammals

TYPE OF NOISE	CRITERION	THRESHOLD
Single Impulse	Onset of Severe Lung Injury - 1% Mortality for Calf Dolphin	Positive Impulse near surface of 25 psi-ms for explosive-like waveform
Single Impulse	Ear Drum Rupture (Injury)	Energy Level of 205 dB
Single Impulse	Ear Drum Rupture (Injury)	Peak Pressure of 150 psi (240 dB)
Single Impulse	Permanent Threshold Shift in Hearing	RMS Pressure Level of 190 dB
Single Impulse	Temporary Threshold Shift	RMS Pressure Level of 180 dB
Single Impulse	Temporary Threshold Shift	Energy Level of 190 dB for Small Explosive
16 Impulses	Temporary Threshold Shift	Energy Level of 170 dB for Small Explosive

Decibel quantities in the table are referred to 1 μPa for pressure metrics, and 1 μPa^2-s for energy metrics.

"Standards"

For a single impulsive signal, the criteria and thresholds of the *SEAWOLF* Shock Trial FEIS (1998) have become the "standard" for Navy and have been found acceptable by the regulator (NOAA/NMFS Final Rule, 1998). The approach uses several references: the Lovelace data, the Ridgway TTS results, and Ketten (1995). Note that the HESS committee recommendations are not inconsistent with those of *SEAWOLF,* but are different. Also, the *CHURCHILL* draft FEIS in process will likely have somewhat different criteria and thresholds, and NMFS may recognize them as new "standards."

For multiple impulsive exposures, corresponding standards have not been agreed upon. One approach proposed by ONR and others during the NMFS Criteria Workshop (1998) uses a 17 log N rule for lowering the threshold for TTS - i.e., the harassment threshold for a single exposure is reduced by 17 log N for N exposures. Others have proposed 10 log N and 5 log N rules, based on equal energy and other arguments. Because there are no data for the marine mammal case, such rules have been inspired by "exchange rate" models for human and animal hearing degradation in air (see, for example, NIOSH, 1998).

Since the recent Eglin AFB and Fort Kamehameha actions, NMFS is seeking to formalize standards for impact from explosives. Meetings with Navy began in December 2000 and results will be considered for the EGTTR PEA, as they become available.

Criteria for Injury (Non-Auditory) from Underwater Impulsive Noise

For impulsive noise, criteria for physical injury are derived largely from the Lovelace Foundation tests of the 1960s and 1970s (e.g., Yelverton et al., 1973 and Yelverton, 1981) and the applications of the Navy's Underwater Explosives Research and Development (UERD) group published in the 1970s and 1980s (e.g., Goertner, 1978). Specific injuries to submerged terrestrial animals from small explosives were delineated and became the traditional list for marine mammal injuries in water. These include lung hemorrhage, gastrointestinal tract injury, and eardrum rupture. The common factor is the presence of air or other gases, and the impact of the pressure wave as it encounters the large mismatch in impedance.

Criteria for injury from impulsive noise that are used in modern compliance documents are with few exceptions based on the above research. Thus, for example, the Navy's *SEAWOLF* Shock Trial FEIS (1998) lists the following criteria for injury (Table G-2):

Table G-2. *SEAWOLF* Criteria

CRITERIA FOR INJURY -- FROM *SEAWOLF* FEIS (1998)
Lethality from high peak pressure
Lethality due to cavitation
Extensive lung hemorrhage (50% mortality) for a calf dolphin of 12.2 kg.
Onset of extensive lung hemorrhage (1% mortality) for a calf dolphin of 12.2 kg.
Brief physical discomfort
Onset of slight lung hemorrhage for a calf dolphin of 12.2 kg.
50% tympanic membrane rupture
Tactile Perception

The above list of criteria for the pending *CHURCHILL* FEIS (Department of the Navy, 2001) is the same.

As discussed below in the sections on thresholds, the bold-faced criteria have been endorsed for the *SEAWOLF* case by NOAA/NMFS, and have been used by Navy as a "standard" for risk assessments involving explosives. Specifically for *SEAWOLF*, the 1 percent mortality criterion is used to estimate risk of mortality, and the 50 percent tympanic membrane rupture criterion is used to estimate risk of injury.

The Air Force has recently used different criteria for in-water effects of explosive tests (Eglin AFB mine clearance tests, NOAA/NMFS [1998b]). The criterion used for injury is based directly on Yelverton's (instead of the Goertner model, derived from Yelverton's data) estimates for the level at which no marine animal (including small fish) is expected to be injured. This is significantly more stringent (more conservative) than the *SEAWOLF* criterion for injury. As noted below, a much more conservative version of the *SEAWOLF* threshold for harassment was also used for the Eglin "take" permit request.

Criteria for Auditory Injury under MMPA

Although Permanent Threshold Shift (PTS) has apparently not been used explicitly as a criterion in any DOD compliance documents to date, scientists and regulators seem to agree that PTS should in some cases be treated as Level A (injurious) harassment. In fact, NMFS has noted that even Temporary Threshold Shift (TTS) may have injury implications (Final Rule for *SEAWOLF*, 1998).

It is likely that future risk estimates will have to include PTS in the injury category. Just as for TTS as a harassment criterion (discussed below), the extent and severity of the hearing damage must be taken into consideration. For example, the bandwidth and center frequency of the frequency band over which hearing is degraded are certainly relevant. No guidance has been published, but the topic received attention at the NMFS Criteria Workshop (NOAA/NMFS, 1998a). At that time it was proposed that whenever TTS can occur, PTS can also occur, through extended exposures or greater intensities. Specific thresholds for these criteria are discussed later in this report.

Behavioral Changes as Harassment Criteria

Criteria for behavioral changes used in risk assessments over the past several years have generally been derived from observations of reactions to sound rather than from fundamental behavioral science. While displacement from habitats or interruption of feeding may be the changes intended in the development of the 1994 MMPA Amendment, the practical matter of setting thresholds for given behaviors has led to the use of observed reactions. Most observations of large whales have been limited to avoidance, changes in vocalization, or breathing/diving behaviors. For small odontocetes and for pinnipeds (in water), the observations have been broader, but generally not measured under controlled situations.

The most ambitious studies of the reactions of whales to sound have been the ATOC Marine Mammal Research Program (MMRP) (see NRC, 2000, for references and a summary of results) and the LFA-SRP, both addressing low-frequency sound and with emphases on mysticetes. Observations of behavioral reactions were a by-product in the TTS studies of Ridgway et al. (1997), Schlundt et al. (2000), and Kastak et al. (1999). Other data most cited are those of

Richardson, Malme, McDonald, Ljungblad, and others, as summarized in Richardson et al. (1995).

Discussions of the ONR Workshop (1999) and the NMFS Criteria Workshop (NOAA/NMFS, 1998a) clearly indicated the lack of working criteria (and corresponding thresholds) for MMPA harassment (Level B). Long-term impact on populations and "significant" reactions to barely detectable sounds, not to mention impacts on prey species, were mentioned as possible criteria for the future. Several scientists have noted that there could well be circumstances in which barely audible sounds could cause significant reaction. Subsequently, thresholds derived from the LFA-SRP and ATOC MMRP were based on low levels of exposure and reactions that were of debatable significance in the context of the MMPA (see, NRC, 2000 for a discussion).

Determination of criteria and thresholds is perhaps the most serious technical issue for MMPA compliance. The range of thresholds for harassment found in current risk assessments is wider now than it has ever been in the past (e.g., from 120 dB to 220 dB for non-impulsive noise).

The acceptance by the regulators of TTS as harassment criterion for *SEAWOLF* was a major step toward resolving the issue (at least for discrete noise pulses). However, the interim nature of the use of TTS as the sole indicator of Level B harassment became apparent in the Federal Register notice for *SEAWOLF* (1998).

Malme et al. (1984), Ljungblad et al. (1982), Richardson et al. (1986), and Ljungblad et al. (1988) emphasized avoidance in their observations of baleen whale reactions to airgun, ship, and machinery noises. These observations remain important data points today in the establishment of thresholds for harassment.

In conducting TTS tests on dolphins (discussed below), Ridgway et al. (1997) observed significant behavioral reactions from the animals at levels much lower than those required to cause measurable masked threshold shifts. As a result, since 1997 some compliance documents have used the levels that cause the behavioral reactions in Ridgway's tests as thresholds for harassment from a continuous pulse of short duration. The Ridgway results are usually applied to all small odontocetes, but also sometimes to all marine mammals (e.g., most Littoral Warfare Advanced Development [LWAD] assessments).

Hearing Threshold Shifts as Criteria for Impact on Marine Mammals and Sea Turtles

Harassment of marine mammals includes disruption of behavioral patterns, including sheltering, feeding, breathing, breeding, and migration. Various thresholds for the amount of noise it takes to cause harassment have been hypothesized. Because marine mammals depend so much on their hearing, noises that degrade hearing sensitivity may be disruptive or even lethal. The effects of noise include permanent threshold shifts (PTS), temporary threshold shifts (TTS), masking of predator noises, masking of communications, interference with search for food, annoyance, etc.

Certain marine mammals are known to depend on their hearing for everything from protection to feeding, mating, and communicating. Essentially all cetaceans (whales and dolphins) are in this category, as are sirenians, and some pinnipeds.

Because most of the indicators of harassment interpreted for the Marine Mammal Protection Act (MMPA) are difficult to measure and quantify (masking, interference, avoidance), the Navy and NOAA/NMFS have focused on one of the indicators which can be objectively measured: temporary loss of hearing sensitivity, i.e., TTS. [In the *CHURCHILL* draft FEIS (Department of the Navy, 2000), there are lengthy arguments on the rationale for using TTS as the sole criterion for Level B harassment. In that case, the criterion is worded as: "disruption of hearing-based behaviors."]

Historically, TTS has been an important metric for human hearing, and for many years has been studied for terrestrial animals as well, (e.g., Clark, 1991). For underwater sound and marine mammals, TTS was not used at all until about 1995 (see NOAA/NMFS Federal Register announcement). The topic is discussed at length in Richardson et al. (1995) and Ketten (1995). Nonetheless, there were no direct measurements of the relationship between underwater noise and TTS in marine mammals through 1996. Once the results of the tests of Ridgway et al. (1997) were announced (as early as 1996), Navy compliance documents began to use the TTS criterion. For impulsive noise, the first major Navy compliance document to use TTS as criterion for harassment was the *SEAWOLF* FEIS (SEAWOLF Shock Trial FEIS, 1998). In that case, it was the sole criterion for Level B harassment, and NMFS (1998) commented on it in its Final Rule of 1998. TTS was not used as a criterion for harassment in the first drafts of the *SEAWOLF* EIS (1996), nor was it used as criterion in the DDG 53 LOA (1995) or the SSQ-110 EA (Naval Air Systems Command, 1995). For non-impulsive noise, TTS was used as criterion for Navy applications as early as 1998.

The Ridgway et al. (1997) paper documents temporary shifts in the masked threshold on the order of 5 dB for bottlenose dolphins subjected to 1-second tones. In applying the Ridgway result, the subject compliance documents are thus implicitly adopting the criterion of the Ridgway tests: a small (5 dB) shift in the masked threshold, where the masking field has spectrum level on the order of 25 dB above the absolute hearing threshold. (See Schlundt et al., 2000, for the recent journal article on the TTS tests.)

Neither for the *SEAWOLF* FEIS, nor other assessments using TTS as criterion, are the degree or extent of TTS specified as part of the criterion. In fact, conditions stated for the *SEAWOLF* FEIS are that the energy threshold be applied to 1/3-octave bands and to different parts of the spectrum for mysticetes and odontocetes (the former limited to the band above 10 Hz and the latter to the band above 100 Hz). These details are included in the NMFS Federal Register notice.

Of additional interest is the fact that most compliance documents do not link the criterion for TTS to any specific portions of the frequency spectrum of hearing of the species in question. In particular, hearing loss at a single frequency or a small band of frequencies (e.g., 10 to 100 Hz or 3000 to 3500 Hz) is treated as having the same significance as the loss of hearing across a wide band. Threshold shifts of 5 to 10 dB are considered significant by Ridgway et al. (1997), Kastak et al. (1999), and others.

Criteria for Injury and Harassment of Sea Turtles under ESA

Just as the Lovelace Foundation measurements are the basis for current criteria and thresholds for non-auditory physical injury to mammals, fish, and sea birds from impulsive sound, turtle injury criteria and thresholds are based on a few observations (see, e.g., the *SEAWOLF* FEIS, 1998, for a summary). Thresholds for injury were based on various physical impacts, but not graduated as for the mammal injury criteria.

Criteria for harassment under ESA are even less well defined than those for mammals. In fact, for lack of a better approach, the criteria (and thresholds) used in compliance documents for harassment of sea turtles under ESA are generally the same as those used for marine mammals. In fact, TTS has been used as a criterion for harassment of sea turtles in the *SEAWOLF* FEIS (1998), which applies to explosive sources. The energy threshold for sea turtles used in the *SEAWOLF* FEIS is the same as that used for odontocetes in the FEIS. PTS is not addressed.

Thresholds for Marine Mammal Injury from Underwater, Impulsive Noise

Criteria for injury of marine mammals by impulsive sources were discussed above. For some criteria in common use, numerical thresholds are discussed below. Table G-3 below lists the thresholds for single exposures to impulsive noise (mostly based on explosive noise) for a variety of criteria.

Table G-3. Criteria and Thresholds for Injury and Harassment of Marine Mammals for Impulsive Sources as Used in Recent Compliance Documents

REFERENCE	CRITERION	THRESHOLD
SEAWOLF FEIS (1998)	Lethality from high peak pressure	Peak pressure 1400 psi (9660 kPa)
SEAWOLF FEIS (1998)	Lethality due to cavitation	Maximum horizontal extent of bulk cavitation region
SEAWOLF FEIS (1998)	Extensive lung hemorrhage (50% mortality) for a calf dolphin of 12.2 kg.	Modified positive impulse: 99.5 psi-msec (687 Pa-sec)
SEAWOLF FEIS (1998)	Onset of extensive lung hemorrhage (1% mortality) for a calf dolphin of 12.2 kg.	Modified positive impulse: 55.1 psi-msec (380 Pa-sec)
SEAWOLF FEIS (1998)	Brief physical discomfort	Partial impulse: 3.3 psi-msec (22.8 Pa-sec) within 0.035 msec
CHURCHILL draft FEIS (2000)	Onset of slight lung hemorrhage for a calf dolphin of 12.2 kg.	Modified positive impulse : 28.1 psi-msec (194 Pa-sec)
SEAWOLF FEIS (1998)	50% eardrum (tympanic membrane) rupture, for an animal at bottom (152 m)	EFD: 1.17 in-lb/in^2 (20.44 mJ/cm^2) (205 dB* EFD Level)
CHURCHILL draft FEIS (2000)	50% eardrum (tympanic membrane) rupture	Peak Pressure > 150 psi (239 dB)**
SEAWOLF FEIS (1998)	Tactile Perception	Pressure > 15 psi (104 kPa) and EFD > 0.01 in-lb/in^2 (0.18 mJ/cm^2)
Florida Straits LOA(1994)	Safety radius is twice range for which there is onset of slight lung hemorrhage for 100 kg mammal	Threshold for onset of slight lung hemorrhage for a 100 kg mammal is 25 psi-ms
Eglin AFB (1998)	“Safe” from physical injury	Positive impulse < 5 psi-ms

EFD is Energy Flux Density * dB re 1 μPa^2-s ** dB re 1 μPa^2-s/Hz

Thresholds for TTS and Harassment of Marine Mammals by Impulsive Noise

Whereas there has been some consistency among compliance documents of the past ten years for thresholds for physical injury, there has been very little consistency in thresholds for (Level B) harassment of marine mammals and endangered species. Consider, for example, Table G-4.

Table G-4. Examples of Thresholds for Harassment and TTS by Explosives

Document	Source of Threshold: Threshold Level	Peak Pressure (dB re 1 μPa)	EFD (dB re 1 μPa^2 s)
DDG 53 LOA (1995)	Richardson et al (1995): 160 to 180 dB SEL for Harassment. But EFD *spectrum* level of 160-180 dB actually used for risk estimates.	*(220-240)*	185-205 [b]
DDG 53 LOA (1995)	As interpreted in the *SEAWOLF* FEIS (1998): 160 dB Peak Pressure for Harassment.	160	(125)
SSQ-110 (1995)	Harassment for Single Shot	*(211)*	176
SEAWOLF FEIS(1998)	Ketten (1995) for TTS: 5 to 15 psi Peak Pressure. [12 psi used for FEIS]	211-221 [219]	*(176-186) [184]*
Richardson et al. (1995)	Richardson et al. (1995) auditory DRC for PTS	214-244	*(179 –209)*
SEAWOLF FEIS(1998) [b]	Richardson et al. (1995) auditory DRC for PTS, modified for *SEAWOLF* FEIS [d]	241-250	*(206 –215)*
SEAWOLF FEIS(1998)	Ridgway (1997) and Extrapolation by Helweg and Gaspin. TTS at 182 dB[a] for odontocete band (above 100 Hz)	*(232)*	197 [a]
SEAWOLF FEIS(1998)	Ridgway (1997) and Extrapolation by Helweg and Gaspin. TTS at 182 dB [a] for mysticete band (above 10 Hz)	*(222)*	187 [a]

( ) Italicized numbers in parentheses have been extrapolated - based on an ideal shot of moderate size under ideal conditions. In that case, the peak pressure level in the band is about 30 to 40 dB greater than the EFD level, provided that the reference unit for time is the second.

[a] The threshold listed in the FEIS is 182 dB (r e 1μPa2 s) for the largest 1/3rd octave band level within the hearing band (above 10 Hz for mysticetes and above 100 Hz for odontocetes). This is about 5 to 10 dB smaller than the comparable total band level, depending on shot size, depth, range, etc. The values in the table are examples.

[b] DDG 53 LOA document uses 160-180 dB energy spectrum level as threshold for harassment. For the low band and the approximate spectrum of the shots used, the equivalent level in the low band (up to 1000 Hz) is about 205 dB (re 1μPa2 s)

[c] The SEAWOLF FEIS (1998) disagreed with the DRC of Richardson et al. (1995)

[d] Richardson et al. (1995) estimated thresholds for PTS based on the amount that the peak pressure level of an impulse exceeds the human hearing threshold. This is a "dynamic range" argument in which the observed range for humans in air is about 164 dB (log measure of a dimensionless ratio). Recall that the NRC(1996) paper suggests a range of 155 dB on the basis of human hearing. If dolphins had the same hearing range, then they would reach PTS at about 164 dB above their absolute hearing thresholds (40 to 70 dB re 1 μPa for a pure tone in white noise in the best hearing bands). Peak pressures of 214 to 244 dB (re 1 μPa) are thus proposed as possible thresholds for PTS.

Technical View - Ketten (1995): Marine Mammal Injury and Harassment from Explosives

Besides the precedents listed above and the discussions about Ridgway and Lovelace, there are additional technical sources that have played an important role in the evolution of criteria and thresholds. Among them are papers of Ketten, discussed here, and those of the HESS committee, discussed in the next subsection.

Ketten (1995 and 1998) has been used as a source of information for criteria and thresholds for several compliance documents, including the *SEAWOLF* Shock Test FEIS (1998). The table of thresholds, shown in Subsection 4.1, indicates TTS at peak pressures from impulsive noise of 5-15 psi (211 to 220 dB re 1 μPa).

A TTS threshold for peak pressure of 12 psi (219 dB) was used in the *SEAWOLF* FEIS. The threshold is applied to the total peak pressure over all frequencies and is not adjusted for hearing sensitivities of a given species. Note well that this is a *dual threshold* used in combination with the energy threshold; harassment is assumed to occur if either threshold is exceeded. The evolution of the dual thresholds is documented in the FEIS, and follows recommendations based on independent investigations. No connection between the two thresholds on the basis of experimental data or theory is suggested.

The comparisons between peak pressure and energy levels for typical explosive signals show that the peak pressure level of 200 to 220 dB given in the assessment of Malme et al. (1984, for air-gun avoidance) is consistent with Ketten's peak levels for TTS. In addition, extrapolated energy thresholds for the Ketten 12 psi (EFD levels near 180 dB) are not inconsistent with the *SEAWOLF* FEIS (1998) energy threshold for TTS (182 dB in 1/3 octave bands) or the SSQ-110 EA (1995) energy threshold for harassment (176 dB). However, the consistency of the two *SEAWOLF* thresholds is absent for many cases of smaller shots — a very important concern in establishing standards.

The Ketten threshold is based on rough estimates for large explosives (1,200 and 10,000 pounds) and is designed for direct path propagation. The metric is peak pressure (ambiguous for multipath arrivals) and the threshold is 12 psi (about 220 dB re 1 μPa).

Navy has questioned the use of this threshold for small explosives, as have the regulators. Moreover, to be consistent with the energy based threshold, it seems that the peak pressure in the greatest 1/3 octave band should be the metric. For the shots of interest in this EA, the equivalent threshold is about 232 dB.

Until the regulators endorse and define this dual criterion for small shots, it may not be appropriate to apply it in this formal risk assessment.

Technical View - HESS Committee Findings for Thresholds

During the 1998 meeting, representatives of the Minerals Management Service (MMS) summarized the results of the HESS (High Energy Seismic Survey) Panel. As it was described, the selection of thresholds for harassment occupied much of the committee's efforts. The conclusion was driven by the recommendation of Dr. Darlene Ketten, but agreed upon by all panel members. The threshold, for impulse sound, is an *rms pressure level* of 180 dB re 1 μPa. This level is to be applied to all mammals and impulses.

Note that for the 180 dB threshold, no allowance is made for the frequency spectrum of the sound or the hearing sensitivities of the animals. It also is linked to exposures to airgun-generated noise, which is both of high level and persistent over time. In addition it is important to recognize that in most cases the rms pressure level lies between the energy flux density level (with "second" as the time reference) and the peak pressure level. As discussed at the MMS meeting by Dr. John Richardson, a typical relationship of levels for airgun pulses at range might be 170 dB (re 1 μPa^2-s) energy, 180 dB rms pressure (re 1 μPa), and 195 dB (re 1 μPa) peak pressure.

During informal coordination meetings with NOAA Fisheries (NMFS Protected Species; 5/23/02 and 08/15/02), however, topics of Level B harassment assessment and/or approach to estimating potential behavioral modifications or responses for marine mammals were discussed. The scientific information necessary to adopt a threshold criteria for assessing behavioral modifications is currently under debate and uncertain. One recommendation (but not necessarily, nor exclusively the only) for a reasonable assessment criteria, might consider a level of 6 dB below TTS (182 dB re 1 uPa^2-s) as a threshold to assess potential behavioral responses. The EGTTR Programmatic Biological Assessment utilizes the 176 dB re 1 uPa^2-s as a behavioral Level B harassment criteria.

Thresholds for Impact of Underwater Impulsive Noise on Sea Turtles

For recently approved compliance documents, the thresholds of Young (1991) and Klima et al. (1988) are most often used for injury (Table G-5). The peak pressure thresholds are all based on the same data, and are consistent. Range thresholds are for ideal conditions and explosives.

Table G-5. Criteria and Thresholds for Injury and TTS for Single Impulsive Noise Event – Sea Turtles

EFFECT	TURTLE SIZE	METRIC	THRESHOLD	REFERENCE
50% Lethal	Large	Peak Pressure	150 psi (241 dB [a])	Klima (88)
50% Lethal	Small	Peak Pressure	20 psi (223 dB [a])	Klima (88)
"safe"	Large	Peak Pressure	50 psi (231 dB [a])	Klima (88)
"safe"	Small	Peak Pressure	5 psi (211 dB [a])	Klima (88)
"safe"	N/A	Range	200 $W^{1/3}$ feet [c]	O'Keeffe and Young (84)
"safe"	N/A	Range	560 $W^{1/3}$ feet [c]	Young (91)
"safe"	N/A	Peak Pressure [b]	50 psi (231 dB [a])	O'Keeffe and Young (84) [b]
"safe"	N/A	Peak Pressure [b]	15 psi (221 dB [a])	Young (91) [b]
Injury (except TTS)	N/A	Range	560 $W^{1/3}$ feet [c] Young (1991)	*SEAWOLF* FEIS (1998)
TTS	N/A	Greatest EFD[d] Level in 1/3 Octave Band above 100 Hz	182 dB (re 1 μPa^2-s)	*SEAWOLF* FEIS (1998)

[a] dB re 1 μPa
[b] Peak Pressure metric deduced from range metric using similarity formula for explosive.
[c] This formula designed for explosives, where W is charge weight in pounds.
[d] EFD is energy flux density.

Note that the harassment threshold used in the *SEAWOLF* FEIS is for TTS and is the same as that used for odontocetes (except sperm whales). Bold-faced entries in the table are the thresholds used in *SEAWOLF*, and the ones used in most Navy risk assessments involving explosives. Note also that an "equivalent" threshold is a peak pressure of 15 psi (221 dB).

Thresholds for Impact of Underwater, Impulsive Noise on Birds and Fish

The principal sources cited in compliance documents for effects of explosive energy on fish, birds and invertebrates are Yelverton et al. (1973), Yelverton (1981) and Young et al. (1992b).

Mortality and injury tables for impulsive sound have been established by experiment, and are given in terms of two metrics: peak pressure and positive impulse (Yelverton et al., 1973 and Yelverton, 1981). These thresholds were derived from tests using explosives and terrestrial animals and fish in water.

The table below (Table G-6) is typical of what has been used in risk assessments. Note that the preferred metrics are positive impulse and peak pressure.

Notice also that the difference in sound strength between "safe" and 50 percent lethal is typically a factor of three to five (in pressure or impulse). This amounts to a difference of only 10 to 15 dB. Note also that Yelverton (1981) recommends a "safe" exposure level for all but the smallest marine animals of 5 psi-ms (the same as for a small fish or diving bird). The thresholds listed have been used in Navy and Air Force compliance documents for impulsive sources. References follow (Table G-7).

Table G-6. Thresholds for Mortal and "Safe" Exposures to Impulsive Noise for Fish, Birds, Shrimp, and Crabs

MARINE ANIMAL	METRIC	50% MORTALITY	'SAFE' STRENGTH
Bird on Water Surface	Positive Impulse	130-150 psi-ms (900-1035 Pa-s)	30 psi-ms (207 Pa-s)
Diving Bird	Positive Impulse	45 psi-ms (310 Pa-s)	6 psi-ms (41 Pa-s)
Shrimp and Crabs	Peak Pressure	50-200 psi (231-243 dB re 1 μPa)	15 psi (221dB re 1 μPa)
Fish (100 g)	Positive Impulse	20 psi-ms (138 Pa-s)	5 psi-ms (35 Pa-s)
Fish (1000 g)	Positive Impulse	50 psi-ms (345 Pa-s)	10 psi-ms (69 Pa-s)

Table G-7. Historical References for Criteria and Thresholds for Physical Injury Caused by an Explosive Sound Source for a Single Event - Fish, Birds, Shrimp, Crabs

EFFECT	MARINE ANIMAL	METRIC (S)	THRESHOLD (S)	REFERENCE
50% Lethal	Shrimp, Crabs	Peak Pressure	50 to 200 psi (231 to 243 dB*)	Yelverton (1981)
"Safe"	Mammals, Fish, Birds, Turtles, Some Invertebrates	Peak Pressure and Positive Impulse	5 psi (211 dB*) and 5 psi-ms	Young (1991) , Goertner (1982)
50% Lethal	Fish (0.1 kg)	Positive Impulse	20 psi-ms	Yelverton (1981)
50% Lethal	Fish (1 kg)	Positive Impulse	50 psi-ms	Yelverton (1981)
50% Lethal	Diving Bird	Positive Impulse	45 psi-ms	Yelverton (1981)
"safe"	Diving Bird	Positive Impulse	6 psi-ms	Yelverton (1981)

* dB re 1 μPa

Perhaps most important is the estimate of "safe" (from physical injury) positive impulse for birds, small turtles, small fish, and all marine mammals of 5 psi-ms [derived by Young (1991) from Yelverton (1981)]. The corresponding "safe" impulse for human divers is 2 psi-ms (Christian and Gaspin, 1974). Unfortunately, the interpretation and calculation or measurement of positive impulse is not necessarily straightforward for impulsive sounds that do not have the characteristic waveform of an explosive in a free field. Propagation effects (such as multipath) and different waveforms (e.g., N waves of sonic booms) are examples. As noted earlier, for marine mammals and sea turtles, the Goertner modified positive impulse is the metric - and is markedly different from the positive impulse used here.

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APPENDIX H

METRICS AND UNITS FOR ACOUSTIC FIELD DESCRIPTION

METRICS AND UNITS FOR ACOUSTIC FIELD DESCRIPTION

The purpose of this appendix is to provide the reader with background on the metrics and units of sound in air and in water used in the risk assessment for the EGTTR. For reasons of tradition and convention, these metrics and units are quite complicated and can be very confusing (even for veteran professionals).

Besides the very definitions of static pressure, overpressure, sound, acoustic wave, and energy flux density, there are additional complications caused by different treatments of impulsive and non-impulsive noise, by different treatments of sound in air and sound in water, and by the source of many errors - the decibel scale.

This appendix also addresses the comparison of noise in air and noise in water.

FUNDAMENTAL ACOUSTIC QUANTITIES

Sound

Paraphrasing Beranek (1986), define *sound* as a disturbance propagated through an elastic medium that causes a change in pressure or a displacement of particles. As Pierce (1989) points out, "...the term *'sound'* implies not only the phenomena in air responsible for the sensation of hearing, but also whatever else is governed by analogous physical principles." Hence, *ultra-* and *infra-sound*, *underwater sound*, *sound in solids*, and *structure-borne sound* are included. *Sound* is strictly mechanical wave motion.

Acoustics

"Acoustics" is the science of *sound*, including its production, transmission, and effects. "*Sound*" here has the broad interpretation given above. [ANSI S1.1960 (R1976)]

Acoustic Phenomena: *Acoustic* disturbances are usually regarded as small-amplitude perturbations to an ambient state. For a fluid, the ambient state defines the medium through which the disturbance propagates and is characterized by pressure, density and fluid velocity when the perturbation is absent (Pierce, 1989). In this context, the total pressure is the sum of the ambient pressure and the acoustic pressure. Likewise for the density.

Non-linear Acoustics: When the perturbations to the ambient state have finite amplitude, the "acoustics" approximations to the fundamental equations do not apply. Since the equations are no longer linear, the finite-amplitude processes are called *non-linear acoustic* processes. Examples are sonic booms, underwater explosive shock waves, and parametric sources (e.g., Beyer, 1974, and Chapter 4). Non-linear acoustics is considered a branch of acoustics.

Density

For a static, homogeneous volume of matter, *density* is the mass per unit volume. In seawater, the average *density* is about 1026 kg/m^3, or 1.026 g/cm^3. In air, *density* varies substantially with altitude and with time. A typical value at sea level and 20 degrees C is 1.225 kg/m^3 or 0.001225 g/cm^3 (e.g., List, 1984)

Pressure

In a fluid (gas or liquid), pressure at a point is defined as follows. For an arbitrarily small area containing the point, the *pressure* is the normal force applied to the small area divided by the size of the small area.

Note: For a fluid at rest and under *pressure*, the force against any area within or bounding the fluid is normal to the area. Because *pressure* is a force applied to a unit area, it does not necessarily generate energy. *Pressure* is a form of stress, and as such has no direction assigned to it. It is a scalar quantity.

Pressure has units of force/area. The SI derived unit of pressure is the pascal (Pa) defined as one N/m^2. Alternative units are many (lbs/ft^2, lbs/in^2, bars, inches of mercury, etc.); some are listed at the end of this report.

Static Pressure

At a point in a fluid (gas or liquid), the *static pressure* is the pressure that would exist if there were no sound waves present (paraphrase from Beranek, 1986). For a fluid at rest and under pressure, the force against any area within or bounding the fluid is normal to the area.

Recall the familiar rule that pressure in the ocean increases by one atmosphere every 10 m of depth. One atmosphere is about 10^5 Pa, 1 bar, 14.5 lb/in^2, etc.

In the atmosphere and under water, the static pressure is the result of gravity acting on the mass of the medium. Because forces are balanced, no net energy results under static conditions.

Acoustic Pressure

Without limiting the discussion to small amplitude or linear waves, we can define *acoustic pressure* as the residual pressure over the "average" static pressure caused by a disturbance. As such, the "average" *acoustic pressure* is zero. Here the "average" is usually taken over time.

Peak Pressure almost always refers to the maximum of the absolute value of the pressure observed at a point in space over time.

Mean-Square Pressure (Equation H.1) is usually defined as the short-term time average of the squared pressure:

$$\frac{1}{\tau}\int_{T}^{T+\tau} p^2(t)dt,$$

Equation H.1

where p(t) is the acoustic pressure and τ is on the order of several periods of the lowest frequency component of the time series.

RMS Pressure is then the square root of the mean-square pressure.

Impedance

Specific Acoustic Impedance (Z_s) is the complex ratio of the effective sound pressure at a point of an acoustic medium or mechanical device to the effective particle velocity at that point. The SI-derived units are $N\bullet s/m^3 = Pa\bullet s/m$, called an "acoustic rayl" or "rayleigh." (Beranek, 1986)

Specific Acoustic Resistance and Reactance are, respectively, the real and imaginary parts of Z_s, the specific acoustic impedance.

Characteristic Impedance: The characteristic impedance of a surface has the same definition as the specific acoustic impedance except that the pressure wave is assumed to be planar. In that case, the average pressure and average particle velocity have ratio ρc, where ρ is the fluid density and c the sound speed.

Acoustic Intensity (Acoustic Power Density)

Acoustic intensity is energy transported per unit area and time in the direction of propagation. Alternate measures include energy flux (Pierce, 1989) and power density. In the general case, *intensity* is the *vector* quantity:

$$\mathbf{I} = p\mathbf{u},$$

Where p is pressure and **u** is particle velocity (e.g., Crocker and Jacobsen, 1997, or Fahy, 1995)

Under conditions consistent with the acoustic wave equation, the *intensity* (I) can be found from:

$$I = pu$$

where p is pressure and u is the component of the particle velocity in the direction of propagation. Units are those of power per unit area (or pressure times velocity), with SI-derived values: $Pa\bullet m/s = W/m^2$.

In the case of plane waves, $p = (\rho c)u$ (see 2.11). Hence, the *intensity* (Equation H.2) is the familiar:

$$I = p^2/\rho c$$

Equation H.2

Some acousticians call I (as defined above) the *instantaneous intensity*.

Equivalent Plane Wave Intensity

As noted by Bartberger (1965) and others, it is general practice to measure (and model) pressure (p) or rms pressure (p_{rms}), and then infer an intensity from the formula for plane waves in the direction of propagation:

$$\text{Intensity} = (p_{rms})^2/\rho c.$$

Such an inferred intensity should properly be labeled as the *equivalent plane-wave intensity* in the *propagation direction*.

Power Spectrum for Pressure Signal

For pressure acoustic pressure p(t) (Equation H.3), the *power spectrum* is

$$S(\omega) = \lim_{T \to \infty} E\left\{ \frac{1}{2T} \left| \int_{-T}^{T} p(t) e^{i\omega t} dt \right|^2 \right\}.$$

Equation H.3

It has units of squared pressure per unit frequency, or Pa^2/Hz for SI.

Spectrum Level at frequency f is the total sound pressure level in a 1-Hz band about f. It is meaningful only for sounds having a continuous spectrum (i.e., signals with some sound in all neighboring frequency bands) (after Urick, 1983).

Band Level refers to the level in a specified frequency band, such as an octave band (Urick, 1983).

Particle Velocity

Particle Velocity (Acoustics): The instantaneous velocity of a given infinitesimal part of a medium, with reference to the medium as a whole, due to the passage of a sound wave.

Note: For a plane propagating wave, the *particle velocity* has the same direction vector as the normal to the wave front. In that case, the particle velocity is equal to the pressure normalized by the impedance.

DEFINITIONS RELATED TO SOUND SOURCES – PROJECTORS

Source Intensity and Source Level

Define *source intensity*, $I(\theta,\phi)$, as the intensity of the projected signal referred to a point at unit distance from the source in the direction (θ,ϕ). (θ,ϕ) is usually unstated; in that case, it is assumed that the source intensity is the maximum over all directions.

Define *source level* (Equation H.4) as

$$SL(\theta,\phi) = 10 \log [I(\theta,\phi)/I_o],$$

Equation H.4

where I_o is the reference intensity (usually that of a plane wave of rms pressure 1 μPa). The reference pressure and reference distance must be specified. The reference direction should be stated if it is not that of maximum intensity. Note that in air, source levels are generally referenced to a plane wave of rms pressure 20 μPa.

Source Directional Response, Directivity, and Beam Pattern

For an acoustic source, assume source intensity can be expressed as a function $I(\theta,\phi)$ specifying the plane-wave intensity emitted in (vertical, azimuthal) direction (θ,ϕ). The intensity or decibel expression of $I(\theta,\phi)$ is the *source directional response*. Where $I(\theta,\phi)$ is normalized to the value I_o for which $I(\theta,\phi)$ is greatest, then

$$B(\theta,\phi)=I(\theta,\phi)/I_o$$

is the source's *directivity function,* which has maximum value of 1. The decibel version is the *beam pattern*. Note that the assumption that the source emissions can be expressed as a sum of plane waves is equivalent to a spatial stationarity (homogeneity) assumption.

DEFINITIONS RELATED TO IMPULSIVE SOURCES AND TRANSIENT SIGNALS

Each one of the quantities in this subsection has been used in formal compliance documents to define an injury or harassment threshold for marine life.

Peak Pressure

For pressure time series p(t), $0 \le t \le T$, from an impulsive source or of a transient nature, define the *peak pressure* as $P_{max} = \max\limits_{0 \le t \le T} p(t)$. The peak pressure is almost always used to measure maximum positive pressure or peak amplitude.

Impulse for Pressure

In the case of a pressure wave, p(t), the *impulse* (Equation H.5) is defined as

$$\text{impulse} = \int_T p(t)\, dt,$$

Equation H.5

where the integral is over the duration of the pressure wave. Commonly used units for *pressure impulse* are Pa•s and psi•ms.

Note that because of the definition of the (acoustic) pressure disturbance, the time-averaged acoustic pressure must be zero. Hence the impulse of the disturbance must also be zero.

Positive Impulse

Weston (1960) and others use *positive impulse* (Equation H.6) as a characteristic of the pressure field for an explosive source. For pulse p(t) with p(t) ≥ 0 over 0 ≤ t ≤ T (and p(t) ≤ 0 at the ends of the interval), define

$$\text{positive impulse} = \int_0^T p(t)dt.$$

Equation H.6

Common units are Pa•s and psi•ms.

Energy Flux Density

For transient signals from impulsive or other sources, instantaneous intensity will fluctuate and (average) intensity will be sensitive to averaging intervals. Common practice [Urick (1983), Weston (1960), Cole (1948), Pierce (1989)] is to use an energy (vice power) measure. The natural choice is the *energy flux density* (EFD) (Equation H.7) defined as:

$$\int_0^T p(t)\,u(t)\,dt$$

Equation H.7

where p(t) is the signal pressure, u(t) is the signal particle velocity in the direction of propagation, and [0,T] is the signal duration (T may be ∞). Notice that EFD (Equation H.8) is the time integral of instantaneous intensity. For plane waves,

$$\text{EFD} = \frac{1}{\rho c}\int_0^T p^2(t)\,dt,$$

Equation H.8

where ρc is the impedance. SI units are J/m^2.

Energy Spectrum

For pressure p(t), sufficiently smooth and bounded on -∞ ≤ t ≤ ∞, the Fourier transform $\Im$ of p(t) exists. Define $\frac{2\left|\Im_p(f)\right|^2}{\rho c}$ as the *energy spectrum* of p(t). It has SI units of $J/(m^2\ Hz)$.

Note that the *energy spectrum* differs from the *power spectrum* in that the latter averages the transform in time. As pointed out, for a time series of finite duration T, the *energy spectrum* has value T times that of the *power spectrum*.

DECIBELS

Following Ross (1987), decibels were originally defined in the 1920's by workers in the electronic communications industry. For two measurements of power, P and Q, the log of the ratio (log P/Q) was given units of *bels*, named after Alexander Graham Bell. Later, to avoid dealing with fractions of bels, workers turned to the decibel (dB):

$$10\log(P/Q).$$

For pressure (or voltage), whose square is proportional to power, the decibel (Equation H.9) is given by:

$$10 \log(p^2/p_o^2) = 20 \log(p/p_o),$$

Equation H.9

where p_o is the reference pressure, usually indicated as "dB re p_o."

Thus, for example, an rms pressure of 100 μPa is equal to 40 dB re 1 μPa, or 14 dB re 20 μPa .

Many of the conventions and references derive from early work on human hearing. For example, the standard reference pressure for dBs in atmospheric acoustics is now 20 μPa, based on the smallest pressure that the human ear can detect at 1000 Hz. The popular standard of the past was 0.0002 μbar = 0.0002 dyn/cm^2 , which equals 20 μPa.

The word "level" usually indicates decibel quantity (e.g., SPL, spectrum level). For decibel expression of certain quantities, it is generally true that the reference quantity has the same units as the quantity expressed. However, shortcuts are traditionally taken when stating the reference. Table H-1 below includes some of the more common conventions.

Table H-1. Commonly Used Expressions for Noise Level

Expression or Quantity	Actual Reference [Example]	Reference in Common Use [Example]
Sound Pressure Level (SPL) $= 10 \log \left(\frac{\text{Pressure}^2}{(\text{Ref. Pressure})^2} \right)$	(Ref. Pressure)^2 [e.g., 1μPa^2 or 1μbar^2]	Ref. Pressure [e.g., 1 μPa, 1 μbar, 20 μPa]
Intensity Level $= 10 \log \left(\frac{\text{Intensity}}{\text{Ref. Intensity}} \right)$	Ref. Intensity [e.g., 1 W/m^2]	Ref. Pressure [e.g., 1 μPa] Interpreted as "relative to the intensity of a plane wave of pressure 1μPa"
Spectrum Level $= 10 \log \left(\frac{\text{Spectral Density}}{\text{Ref. Spectral Density}} \right)$	Ref. Spectral Density = Ref. Pressure^2/(Frequency Band) or Ref. Intensity/Band [e.g., 1μPa^2/Hz]	Ref. Pressure / (Ref. Band) ^{½} [e.g., 1μPa/√Hz]
Source Level = 10 log (Source Intensity at Reference Distance in Direction of Propagation/Ref Intensity)	Reference Intensity at Ref. Distance, in Direction of Propagation [e.g., 1 W/m^2 at 1 m]	Reference Pressure at Reference Distance [1μPa at 1 m]. As for intensity, the interpretation is of intensity of a plane wave of pressure 1 μPa.
Energy (Flux) Density Level $= 10 \log \left(\frac{\text{Energy Flux Density}}{\text{Ref. Energy Flux Density}} \right)$	Ref. Energy Flux Density = Ref. Pressure^2 Time/Impedance [e.g., 1 (W/m^2)•s]	Reference (Pressure)^2 Time [e.g., μPa^2 s]

Note that in this report references in "common use" will usually be employed.

METRICS AND UNITS FOR NOISE IN AIR

Metrics and units for noise in air are generally different from those used in water – a result of the fact that the emphasis in air is on human hearing. Thus, for example, the reference pressure in air is 20 μPa (rather than the 1 μPa reference used in underwater sound), which corresponds to the minimum pressure for a pure tone that can be detected by a healthy human ear. Use of this makes the threshold of hearing for humans, at the best frequency, equal to 0 dB.

Weighted Sound Levels

For sound pressure measurements in air related to hearing, it is common practice to weight the spectrum to reduce the influence of the high and low frequencies so that the response is similar that of the human ear to noise. *A-weighting* is the most common filter, with the weight resembling the ear's responses. Other popular weightings are B and C. Table H-2 gives a sampling of the filter values for selected frequencies.

Table H-2. Popular Sound Pressure Weighting Values for Selected Frequencies

Frequency (Hz)	A-Weighting (dB)	B-Weighting (dB)	C-Weighting (dB)
10	-70	-38	-14
20	-50	-24	-6
40	-35	-14	-2
80	-23	-7	-1
160	-13	-3	0
320	-7	-1	0
640	-2	0	0
2000	+1	0	0
5000	+1	-1	-1
10,000	-3	-4	-4
12,000	-4	-6	-6
20,000	-9	-11	-11

Decibel levels based on these weighted are usually labeled: dBA or dB(A) for A weighting, etc.

Sound Exposure Level (SEL)

For a time-varying sound pressure p(t), *sound exposure level* (Equation H.10) is computed as

$$\mathrm{SEL} = 10\log\left[\frac{1}{t_0}\int_0^T p^2(t)\,dt \Big/ p_0^2\right],$$

Equation H.10

where t_0 is 1 second, T is the total duration of the signal (in the same units as those of t_0, namely seconds) and p_0 is the reference pressure (usually 20 µPa).

SEL is thus a function of p(t), T, and the reference pressure. When the impedance of the medium of interest is approximately constant, then SEL can be viewed as the total energy level for the time interval from 0 to T. It has explicit reference units of p_0 for pressure with implicit units of seconds for time.

When p(t) is A-weighted, then the measure is called the *A-weighted SEL* or *ASEL*. Likewise for other weightings.

Equivalent Sound Level (L_{eq})

The *equivalent sound level (L_{eq})* (Equation H.11) is defined as the A-weighted sound pressure level (SPL) averaged over a specified time period T. It is useful for noise that fluctuates in level with time. L_{eq} is also sometimes called the *average sound level (L_{AT}),* so that $L_{eq} = L_{AT}$. (see, e.g., Crocker, 1997)

If $p_A(t)$ is the instantaneous A-weighted sound pressure and p_{ref} the reference pressure (usually 20 µPa), then

$$L_{eq} = 10 \log \left\{ \left(\frac{1}{T} \int_0^T p_A{}^2(t)dt \right) \Big/ p_{ref}^2 \right\}.$$

Equation H.11

It is thus equivalent to an average A-weighted intensity or power level.

Note that since the averaging time can be specified to be anything from seconds to hours, L_{eq} has become popular as a measure of environmental noise. For community noise, T may be assigned a value as high as 24 hours or more.

Day-Night Level (L_{dn} or DNL)

Following Magrab (1975), L_{dn} (Equation H.12) was introduced by the EPA in 1974 to provide a single-number measure of community noise exposure over a specified period. It was designed to improve L_{eq} by adding a correction of 10 dB for nighttime levels to account for increased annoyance to the population.

L_{dn} is calculated as a weighted average of intensities:

$$10^{L_{dn}/10} = (0.625)10^{L_d/10} + (0.375)10^{(L_n+10)/10}$$

Equation H.12

COMPARING NOISE IN AIR AND NOISE IN WATER

Table H-3 offers a comparison of the physical properties of noise in the media of air and water.

Table H-3. Typical Values of Medium Properties

Property	Water	Air (20°C, sea level)	Ratio (water/air)
Density	1000 kg/m^3	1.225 kg/m^3	816.3
Sound Speed	1500 m/s	344 m/s	4.36
Impedance	1.5×10^6 kg/m^2•s	421.4 kg/m^2•s	3559.6
Static Pressure	(1 + 0.1 Depth (m)) atm.	1 atm.	1 + 0.1 Depth (m)

Intensity in Air and in Water for Given Pressure Level

For plane-wave pressure p in air, the corresponding intensity is in air is

$$I_a = p^2/(\rho c)_a .$$

For the same value of pressure p in water, the intensity is much less:

$$I_w = p^2/(\rho c)_w \ll I_a,$$

since

$$(\rho c)_w >> (\rho c)_a.$$

In fact,

$$I_a/I_w = (\rho c)_w / (\rho c)_a \approx 3600.$$

For the same pressure levels, intensity in air is about 3600 times greater than that in water.

Likewise for the particle velocities:

$$v_a/v_w = (\rho c)_w / (\rho c)_a \approx 3600.$$

For example, if the rms pressure in air is 1.2 10^9 µPa (an SPL of about 181 dB re 1µPa), then the corresponding plane-wave intensity in air is about 3600 W/m^2. If the rms pressure in water is also 1.2 10^9 µPa, then the intensity in water is only about 1 W/m^2.

The tables (H-4 and H-5) below show pressure levels and intensities for some typical sound conditions.

Table H-4. Pressure Levels and Intensities of Typical Underwater Sounds

Sound in Water	SPL in Water (dB re 1µPa)	SPL in Water (dB re 20 µPa)	Intensity in Water (W/m^2)
Ambient Noise Spectrum Level at 20 kHz (light winds)	40	14	6.6 10^{-15}
Hearing Threshold for Dolphin at 20 kHz	40	14	6.6 10^{-15}
Hearing Threshold for Human at 1000 Hz	66	40	2.6 10^{-12}
Ambient Noise Spectrum Level at 50 Hz (typical open ocean)	85	59	2 10^{-10}
Range of Harassment Thresholds for Baleen Whales (1 sec. tone at 50 Hz)	120 – 180	94-154	6.6 10^{-7} to 0.7
Range of Harassment Thresholds for Dolphins (1 second tone at 20 kHz)	120 –192	94-166	6.6 10^{-7} to 10
Merchant Ship Source Spectrum Level at 50 Hz (re 1 m)	140 - 190	114 - 164	6.6 10^{-5} to 6.6
Hearing Threshold for Dolphin at 100 Hz	140	114	6.6 10^{-5}
ATOC Source Level at 1 m	195	169	20
Source Level for Fish-Finder at 1 m	225	199	1000
High-Power-Sonar Source Level at 1 m	240	214	6.6 10^{5}

Table H-5. Pressure Levels and Intensities of Typical in Air Sounds

Sound in Air	SPL in Air (dB re 1µPa)	SPL in Air (dB re 20 µPa)	Intensity in Air (W/m^2)
Threshold of Human Hearing at 1 kHz	26	0	9.6 10^{-13}
Very Quiet Living Room	66	40	9.6 10^{-9}
Normal Speech	86	60	9.6 10^{-7}
Jet Airliner at 10 m	130	104	0.02
Threshold of Human Feeling at 1 kHz	146	120	1.0
Jet Airliner Source Level (re 1 m)	150	124	2.4
Human Threshold of Pain	166	140	95
Intense (10 psf) Sonic Boom	174	148	600

Intensity in Air and in Water

Unlike pressure, intensity depends on the acoustic impedance of the medium. Thus, for example in Table H-6, under the assumption of plane waves, the same pressure (first three columns) causes different intensities in water and in air (last two columns):

Table H-6. Comparison of Intensity of Sound in Water and Air

Pressure (rms)	SPL (re 1 μPa)	SPL (re 20 μPa)		Intensity in Water (W/m^2)	Intensity in Air (W/m^2)
0.017 μPa = (1/60) μPa	-35.6 dB	-61.6 dB		$1.9\ 10^{-22}\ W/m^2$	$6.7\ 10^{-19}\ W/m^2$
1 μPa = 10^{-5} dyn/cm^2	0 dB	-26 dB		$6.7\ 10^{-19}\ W/m^2$	$2.4\ 10^{-15}\ W/m^2$
20 μPa = 0.0002 μbar	26 dB	0 dB		$2.7\ 10^{-16}\ W/m^2$	$9.6\ 10^{-13}\ W/m^2$
1200 μPa = 60 (20 μPa)	61.6 dB	35.6 dB		$9.6\ 10^{-13}\ W/m^2$	$3.4\ 10^{-9}\ W/m^2$
1 μbar = 0.1 Pa = 10^5 μPa	100 dB	74 dB		$6.7\ 10^{-9}\ W/m^2$	$2.4\ 10^{-5}\ W/m^2$
2.04 10^7 μPa	146.2 dB	120.2 dB		$2.8\ 10^{-4}\ W/m^2$	1 W/m^2
1 psf = 4.8 10^7 μPa = 48 Pa	153.6 dB	127.6 dB		0.0015 W/m^2	5.5 W/m^2
1.2 10^9 μPa = 1.2 kPa	181.8 dB	155.8 dB		1 W/m^2	3600 W/m^2
1 psi = 6.9 10^9 μPa = 6.9 kPa	196.8 dB	170.8 dB		31.8 W/m^2	$1.1\ 10^5\ W/m^2$
3.2 10^{10} μPa = 32 kPa = 66.7 psf	210 dB	184 dB		660.7 W/m^2	$2.4\ 10^6\ W/m^2$
3.2 10^{12} μPa = 3200 kPa	250 dB	224 dB		$6.6\ 10^6\ W/m^2$	$2.4\ 10^{10}\ W/m^2$

Intensity Level

It is nearly universal practice to use SPL in place of intensity level. This makes sense as long as impedance is constant. In that case, intensity is proportional to short-term-average, squared pressure, with proportionality constant equal to the impedance.

When the impedance differs significantly in space or time (as in noise propagation from air into water), the intensity level must specify the value of the impedance in the reference.

Intensity Levels in Air and in Water

Because plane-wave intensity is equivalent to the average squared pressure normalized by impedance, treatment of intensity in different media requires care. The table (H-7) below shows the relationship of SPL to intensity in air and in water. The same relationships are illustrated for energy flux density in Tables H-8 and H-9.

Table H-7. SPL Relationship to Intensity in Air and in Water

Sound Pressure Level (SPL)	Intensity Level In Water	Intensity Level In Air
X dB re 1 μPa	(X – 181.8) dB re 1 W/m^2	(X – 146.2) dB re 1 W/m2
Z dB re 20 μPa = (Z – 74) dB re 1 μbar	(Z – 155.8) dB re 1 W/m^2	(Z – 120.2) dB re 1 W/m2
(Y – 35.8) dB re 1 μPa	(Y – 217.6) dB re 1 W/m^2	(Y – 182.0) dB re 1 W/m2
Z dB re 1 psi = (Z + 16.8) dB re 1 kPa = (Z + 196.8) dB re 1 μPa	(Z + 15) dB re 1 W/m^2	(Z + 50.6) dB re 1 W/m2
X dB re 1 psf = (X – 43.2) dB re 1 psi = (X + 153.6) dB re 1 μPa	(X - 28.2) dB re 1 W/m^2	(X + 7.4) dB re 1 W/m2
(Y – 15) dB re 1 psi = (Y + 1.8) dB re 1 kPa = (Y + 155.8) dB re 20 μPa	Y dB re 1 W/m^2 = (Y – 40) dB re 1 W/cm^2 = (Y – 37) dB re 1 psi-in/s	(Y + 35.6) dB re 1 W/m2
(Z – 7.4) dB re 1 psf = (Z – 50.6) dB re 1 psi = (Z + 146.2) dB re 1 μPa = (Z + 120.1) dB re 20 μPa	(Z – 35.6) dB re 1 W/m^2	Z dB re 1 W/m2

Table H-8. Energy Flux Density (EFD) Metrics in Air and in Water

[Pressure (rms)]^2 [Time]	EFD In Water	EFD In Air
1 μPa^2 s	(6.7) 10^{-19} J/m^2	(2.4) 10-15Jm2
1 μbar^2 s = [0.1 Pa]^2 s	(6.7) 10^{-9} J/m^2	(2.4) 10-5 J/m2
[20 μPa]^2 s = [0.0002 μbar]^2 s	(3) 10^{-16} J/m^2	(1.0) 10-12 J/m2

Table H-9. Energy Flux Density (EFD) Levels in Air and in Water

(Pressure^2 •Time) Level	EFD Level In Water	Level In Air
X dB re 1 μPa^2 s	(X – 181.8) dB re 1 J/m^2	(X – 146.2) dB re 1 J/m^2
Y dB re 1 μbar^2 s = (Y + 100) dB re 1 μPa^2 s	(Y – 81.8) dB re 1 J/m^2	(Y – 46.2) dB re 1 J/m^2
Z dB re 20 μPa^2 s = (Z – 74) dB re 1 μbar^2 s	(Z – 155.8) dB re 1 J/m^2	(Z – 120.2) dB re 1 J/m^2
(X + 61.8) dB re 1 μPa^2 s = (X+ 35.8) dB re 20 μPa^2 s	(X – 120) dB re 1 J/m^2	
(Y – 35.6) dB re 1 μPa^2 s		(Y – 182.0) dB re 1 J/m^2
Z dB re 1 psi^2 s = (Z + 16.8) dB re 1 kPa^2 s = (Z + 196.8) dB re 1 μPa^2 s	(Z + 15) dB re 1 J/m^2	(Z + 50.6) dB re 1 J/m^2
X dB re 1 psf^2 s = (X + 43.2) dB re 1 psi^2 s = (X + 153.6) dB re 1 μPa^2 s	(X – 28.2) dB re 1 J/m^2	(X + 7.4) dB re 1 J/m^2

SI UNITS

The International System of Units or SI (System International d'Unites) was established in 1960 and is recognized as the standard throughout the world. In the United States, both the American National Standards Institute (ANSI) and the Department of Defense have adopted SI. Information about SI is published by technical societies. The SI has seven **base units** from which all other units are derived (Table H-10). The base units are as follows:

Table H-10. Base Units of the International System (SI) of Units

Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electrical Current	ampere	A
Thermodynamic Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

Units derived from the seven base units usually have SI-sanctioned names. Table H-11 lists examples of **SI derived units** relevant to this report:

Table H-11. Examples of SI Derived Units

Derived Quantity	Equivalent SI Quantities	Derived Unit (Symbol)	Equivalent SI/ Derived Units
Speed	Length/Time	---	m/s
Acceleration	Length/(Time)^2	---	m/s^2
Area	Length^2	---	m^2
Volume	Length^3	---	m^3
Force	Mass • Acceleration	Newton (N)	N = kg•m/s^2
Pressure	Force/Area = Mass/(Length • Time^2)	Pascal (Pa)	Pa = N/m^2 = kg/m•s^2
Work, Energy, Heat	Force • Length = (Pressure • Area) Length	Joule (J)	J = N•m = kg•m^2/s^2 = Pa•m^3 = (J/s)s = W•s
Power	Energy/Time = (Pressure • Area) • Length/Time	Watt (W)	W=J/s = N•m/s = kg•m^2/s^3 = Pa•m^3/s
Energy Flux Density	Energy/Area = Pressure • Length	---	J/m^2 = (W/m^2)s = Pa•m = [Pa^2/(Pa•s/m)]s
Acoustic Intensity	Pressure • Speed = Power/Area	---	Pa•m/s = (N/m^2)(m/s) = W/m^2
Plane Wave Intensity	(Pressure)^2/Impedance = Power/Area	---	Pa^2/Pa•s/m) = Pa•m/s = W/m^2
Density	Mass/Volume	---	kg/m^3
Characteristic Impedance	Density • Speed = (Pressure)/(Speed)	---	(kg/m^3)(m/s) = kg/m^2•s = (N/m^2)(s/m) = (Pa)/(m/s)
Energy Flux Density Spectrum	(Energy/Area)/Frequency = (Power/Area)(Time/Frequency) = (Intensity)(Time/Frequency)	---	(J/m^2)/Hz = (W/m^2)(s/Hz) = (Pa•m/s)(s/Hz) = (Pa•m)/Hz = N/m•Hz

SOME CONVERSION FORMULAS

Length (Distance)

1 m = 100 cm = 39.37008 inches = 3.28084 ft
1 km = 1000 m = 1093.613 yds = 0.6213712 miles
1 fathom = 2 yds = 1.829 m
1 nmi = 2025.4 yds = 6076.1 ft = 1852 m = 1.15 statute mile
1 kyd = 1000 yds = 914.4 m

Pressure

1 Pa = 1 N/m^2 = 1 J/m^3 = 1 $kg/m{\bullet}s^2$ = 10^6 μPa = 10 dyn/cm^2 = 10 μbar
20 μPa = 0.0002 μbar = $2.9{\bullet}10^{-9}$ psi
1 psi = 144 psf = $6.895{\bullet}10^9$ μPa = 6.895 kPa = 0.068 atm
1 atm = 1.01325 bar = 0.1021 psf = 14.69595 psi = $1.01325{\bullet}10^{11}$ μPa
1 kPa = 1000 Pa = 10^9 μPa = 0.145 psi = 20.88 psf

Sound Pressure Level

For pressure p, the *sound pressure level* (SPL) is defined as follows:

$$SPL = 20 \log (|p| / p_0) \text{ dB re 1 } p_0,$$

where p_0 is the reference pressure (usually 1 μPa or 20 μPa or 1 μbar).

If SPL = X dB re 1 μPa, then SPL = (X–26) dB re 20 μPa and SPL = (X–100) dB re 1 μbar.

Other relationships:
SPL = Y dB re 20 μPa = (Y+26) dB re 1μPa = (Y–171) dB re 1 psi
= (Y–128) dB re 1 psf.

For example, if the pressure is 1 psi, then
SPL = 0 dB re 1 psi = 197 dB re 1 μPa = 171 dB re 20 μPa
= 43 dB re 1 psf = 97 dB re 1 μbar.

Acoustic Impulse

1 Pa•s = 0.001 kPa•s = 1000 Pa•ms = 1 kPa•ms
1 psi•ms = 144 psf•ms = 6.895 Pa•s
1 psi•s = 6.895 kPa•s

Acoustic Impedance in Water:

Water Density (4°C) = $\rho_w \approx 1\ g/cm^3 = 10^3\ kg/m^3 \approx 1.94\ slug/ft^3 \approx 62.43$ lb (mass)/ft^3

Sound Speed = $c_w \approx 1500$ m/s = $1.5{\bullet}10^5$ cm/s ≈ 4920 ft/s ≈ 59040 in/s

Impedance of Water = $\rho_w c_w \approx 1.5{\bullet}10^6\ kg/s{\bullet}m^2 = 1.5{\bullet}10^6$ rayl = $1.5{\bullet}10^5\ g/s{\bullet}cm^2$
= $1.5{\bullet}10^{12}$ μPa•(s/m) = $1.5{\bullet}10^5$ (dyn/cm^2)(s/cm) ≈ 9544.8 slugs/ft^2•s
≈ $3.072{\bullet}10^5$ lb(mass)/ft^2•s

Acoustic Impedance in Air:

Standard Density of Air (Sea Level, 15°C)
= $\rho_a \approx 1.225\ kg/m^3 \approx 0.0839\ slug/m^3 \approx 0.00237\ slug/ft^3$
≈ 2.701 lbs(mass)/m^3 ≈ 0.0764 lb(mass)/ft^3

Nominal Sound Speed in Air (Sea Level, 0 C°)
$= c_a \approx 344$ m/s $= 3.44 \cdot 10^4$ cm/s = 1128.6 ft/s

Impedance of Air
$= \rho_a c_a \approx 421.4$ kg/s•m^2 = 421.4 rayl = 42.14 (dyn/cm^2)•(s/cm)
$= 4.214 \cdot 10^8$ µPa•(s/m) ≈ 2.674 slug/ft^2•s ≈ 86.804 lb(mass)/ft^2•s

Comparison of Impedances in Air and in Water

Sound Speed Ratio $= c_w/c_a \approx 4.36$
Density Ratio $= \rho_w/\rho_a \approx 816.33$

Impedance Ratio $= \rho_w c_w / \rho_a c_a \approx 3559.6$
Impedance Ratio (dB) $= 10 \log (\rho_w c_w / \rho_a c_a) \approx 10 \log (3559.6) \approx 35.5$ dB

Acoustic Intensity

1 W/m^2= 1 J/(s•m^2) = 1 N/m•s = 1 Pa•(m/s) = 10^6 µPa•(m/s)
1 psi•in/s = 175 W/m^2 = 1.75 10^8 µPa•(m/s)
1 lb/ft s = 14.596 J/m^{2}s = 14.596 W/m^2
1 W/m^2 = 10^7 erg/m^{2}s = 10^3 erg/cm^{2}s

Acoustic Energy Flux Density

1 J/m^2 = 1 N/m = 1 Pa•m = 10^6 µPa•m = 1 W•s/m^2
1 J/m^2 = 5.7 10^{-3} psi•in = 6.8 10^{-2} psf•ft
1 J/cm^2 = 10^4 J/m^2 = 10^7 erg/cm^2
1 psi•in = 175 J/m^2 = 1.75 10^8 µPa•m

Energy (Flux Density) Level (EFDL) Referred to Pressure^2 Time

Note that the abbreviation EFDL is not in general usage, but is used here for convenience.
Just as the usual reference for intensity level is pressure^2 (and not intensity itself), the reference often (but not always) used for EFDL is *Pressure^2 • Time*. This makes sense when the impedance is constant.

Some examples of conversions follow:

EFDL = X dB re 1 µPa^2•s = (X - 26) dB re (20 µPa)^2 •s = (X - 197) dB re 1 psi^2•s
EFDL = Y dB re 1 erg/cm^2 = (Y + 52) dB re 1 (dyn/cm^2)^2•s = (Y + 152) dB re 1 µPa^2•s
EFDL = Z dB re (1 dyn/cm^2)^2•s = (Z + 100) dB re 1 µPa^2•s

Energy (Flux Density) Level (EFDL) Referred to Energy Metrics

EFDL is often stated in reference to a nominal value in energy flux density units (such as J/m^2, erg/cm^2, psi•in). Such a practice is very rare for intensity. Nonetheless, the acoustics literature (especially the older literature) suggests that this reference may be used as often as the one given above (pressure^2 × time). The two references differ by a factor equal to the impedance, and hence require a specification of the medium. (Some examples using both references are given in B-16e and B-16f.)

EFDL = X dB re 1 J/m^2 = X dB re 1 Pa•m = X dB re 1 W•s/m^2
= X dB re 1 N/m = (X + 60) dB re 1 μPa•m
= (X – 22.4) dB re 1 psi•in = (X – 11.7) dB re 1 psf•ft
= (X + 30) dB re 1 dyn/cm

Note on Energy Flux Density

Energy Flux Density or EFD (as opposed to intensity or mean-square pressure) is the usual integrated metric for underwater impulsive signals. It is essentially the same as Sound Exposure Level (SEL) over exposure time equal to the full signal duration.

EFD is defined as the integral over time of the pressure times the particle velocity in the direction of propagation. For plane or spherical waves (the usual cases), the EFD can be calculated as the time integral of the squared pressure, normalized by the acoustic impedance (density times sound speed). EFD has units of *J/m^2*.

Whereas the acoustic intensity (like normalized mean square pressure) makes sense as a metric for continuous signals in which the mean square is not very sensitive to averaging time, the intensity of an impulsive signal will depend on both the beginning and end points of the integration time. The EFD, on the other hand, has no time averaging function and integrates over "all" time (i.e., the total time when the signal of interest is present). The EFD for a pure tone of infinite duration (with well-defined and constant intensity) does not exist (has arbitrarily large value).

Acoustic Power Spectrum

1 W/m^2-Hz = 1 J/(s m^2 Hz) = 1 N/m = 10^6 μPa-m
1 W/m^2-Hz = 5.7 10^{-3} psi-in = 6.8 10^{-2} psf-ft
1 psi-in = 175 W/m^2-Hz
1 hp/m^2-Hz = 746 W/m^2-Hz

Acoustic Energy Spectrum

To help visualize the frequency dependence of a transient signal, and to allow calculation of the band energy levels as thresholds, the energy spectrum is the natural choice. It is calculated as the fourier transform of the unaveraged auto-correlation function, normalized by the impedance. It can also be calculated directly as the squared modulus of the fourier transform of the pressure, but without time averaging and with normalization.

Whereas the intensity or power spectrum has units of (W/m^2)/Hz, the energy spectrum has units of (W•s/m^2)/Hz or (J/m^2)/Hz, sometimes written as W•s^2/m^2. In decibels, the usual approach is analogous to that for intensity, the reference quantity is usually the non-normalized product of squared pressure and time, per band. The usual expression is

dB re 1 μPa^2•s/Hz.

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APPENDIX I

MARINE MAMMAL STRANDING ANALYSIS

MARINE MAMMAL STRANDING ANALYSIS

DATA COLLECTION

Information on the stranding of marine mammals within the Gulf of Mexico has been collected by both U.S. Government Agencies and private organizations for over twenty years. The most active private organization in this effort is the Marine Mammal Stranding Network (MMSN) that promotes research and provides assistance to the rescue and reporting of stranded animals. The fact that the MMSN is chiefly a volunteer organization may lead to more intensive data gathering efforts in urban areas over more natural areas as well as seasonal variation. This information has been compiled by the Minerals Management Service (MMS) into the GulfCet I and II databases. This database contains records on individual strandings with information on the location, species, date and comments on the animal. The location of the strandings has been summarized into the National Marine Fisheries Service's (NMFS) statistical zones. The NMFS Zones 8 and 9 are within the Eglin Gulf Test and Training Range (EGTTR) and will be analyzed with a greater level of scrutiny than the remainder of the Gulf of Mexico. Only the records after 1990 within this database have been used due to the lack of consistency in the location data in previous years.

CAUSES OF STRANDING AND MORTALITY

The stranding of marine mammals occurs for numerous reasons with the vast majority of the causes leading up to individual incidents remaining unknown. Some of the natural causes of strandings include illness, parasites, infant mortality, predation, and red tide. The identified anthropogenic causes of mortality and stranding include net fishing by-catch, intentional wounding, and toxins. Figure I-1 shows the distribution of these strandings within the Gulf of Mexico.

The physical location where a stranded animal is found does not necessarily correlate with the cause of the strandings. Water currents and the animal itself may lead the animal a long distance from the area where the malady occurred. The water currents within the Gulf change on a seasonal basis making it difficult to determine the location where the animal became disabled.

GEOGRAPHIC DISTRIBUTION

Figure I-1 shows that 30 percent of strandings occurred near Galveston Bay while 8 percent of the strandings occurred within Zones 7 and 8 that encompass the Florida Panhandle. A further investigation shows that over this ten-year period one animal was stranded per 1.7 miles of coastline within the Florida Panhandle while the Gulf-wide average is 2.0 miles. This appears to be within tolerances to be considered within the Gulf-wide average and far from the extreme for a statistical zone of one animal per less than a half mile of coastline. Figure I-2 displays the strandings data for the Study Area normalized on the miles of coastline within the statistical zone. NMFS statistical zones are illustrated in Figure I-3.

The number of animals stranded in 1999 is equal to combined values of 1994 – 1998. This increase coincides with a red tide bloom. The toxins produced by red tide have been shown to cause incapacitation and mortality of marine mammals.

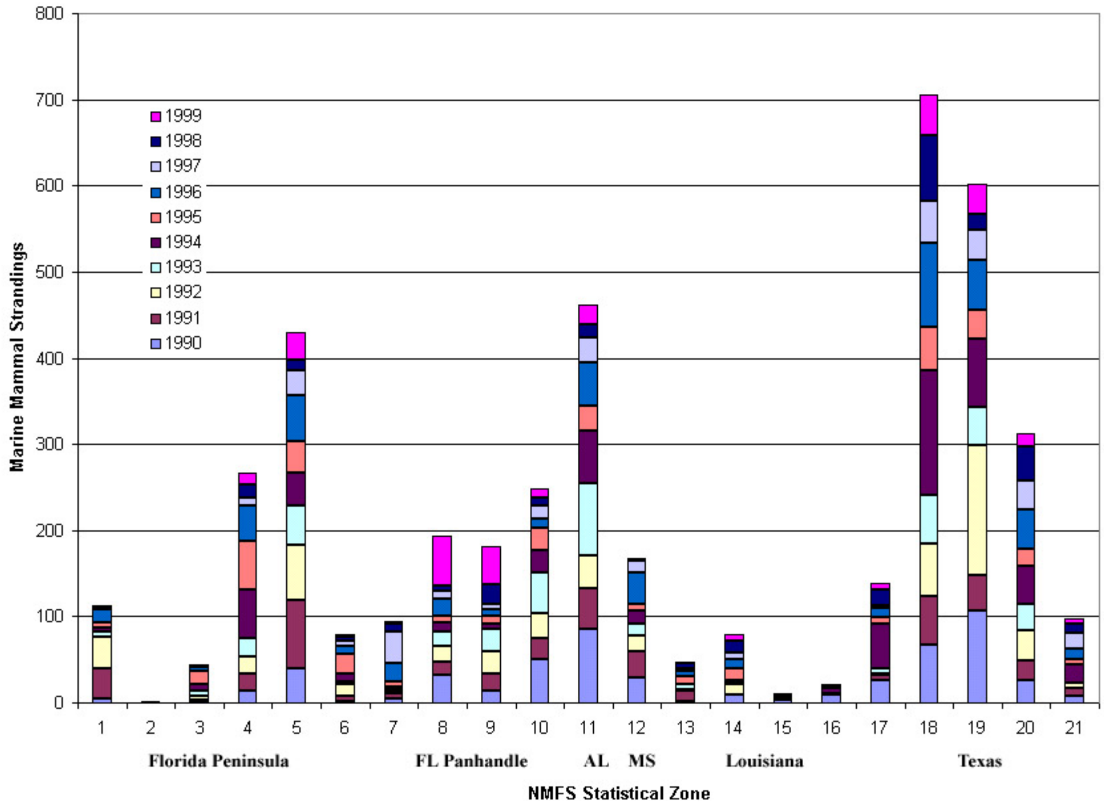

Figure I-1. Marine Mammal Stranding for the Years 1990 to 1999 by NMFS Statistical Zone

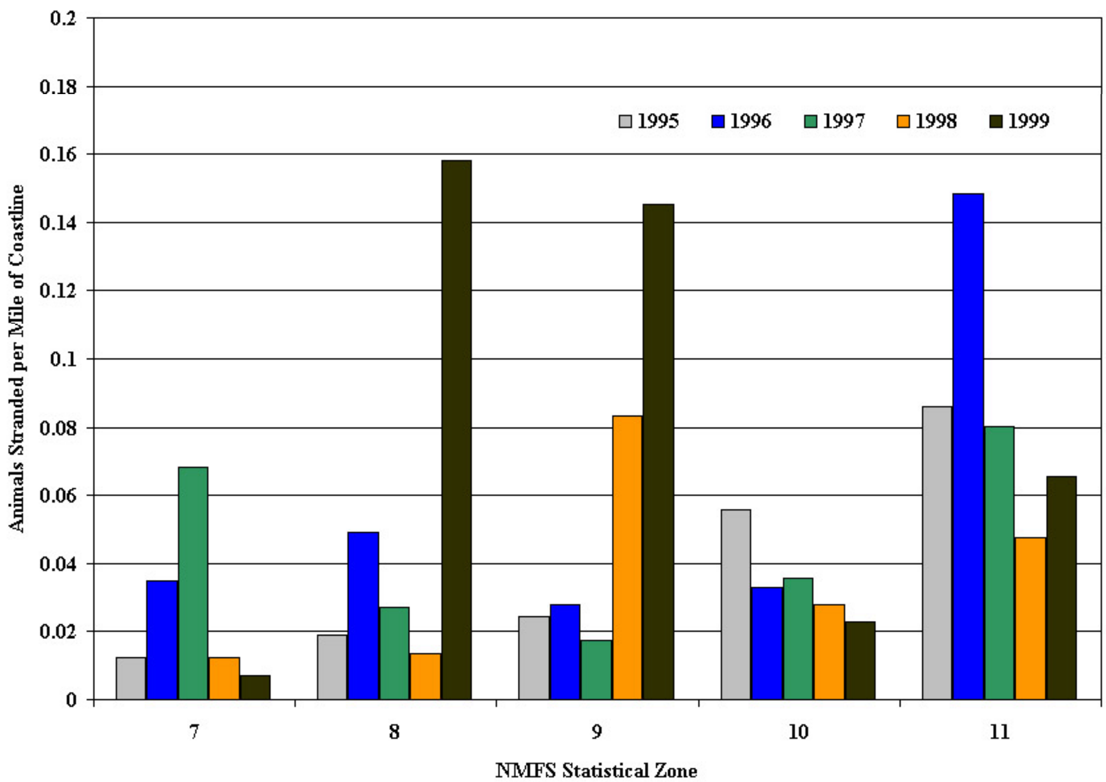

Figure I-2. Marine Mammal Stranding Density for the Years 1995 to 1999 by NMFS Statistical Zone

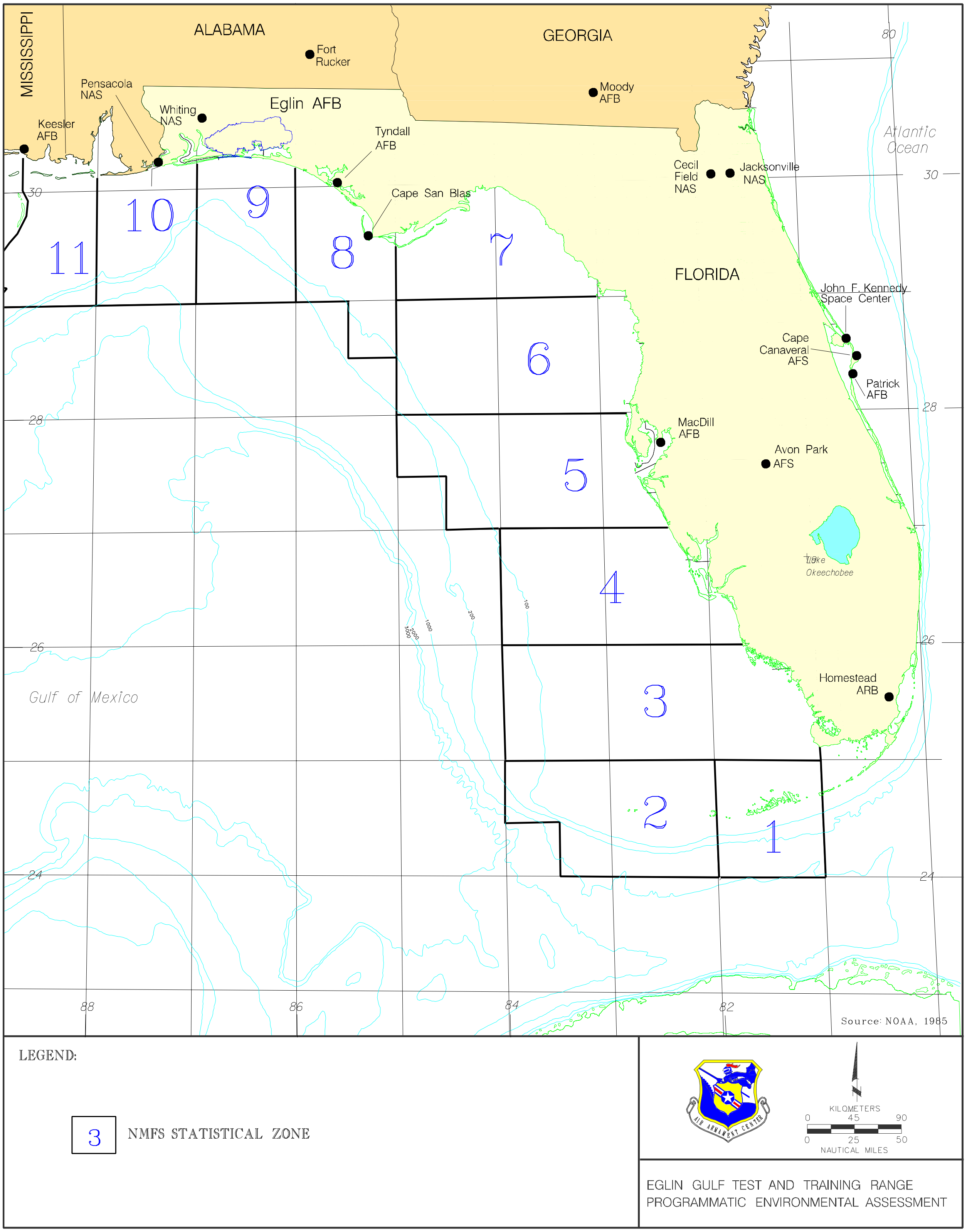

Figure I-3. NMFS Statistical Zones

The yearly distribution of strandings within the Florida Panhandle is displayed in Figure I-4. A marked increase in strandings is seen in this area in 1999 relative to the previous years.

Seasonal Distribution

An evaluation of the data also reveals a marked clustering of stranding events in the late winter and early spring. Figure I-5 shows the number of stranding events that have occurred in the Gulf Mexico over the last ten years. As the figure shows, approximately 50 percent of the strandings occur during the months of February, March and April. In March alone more strandings occur

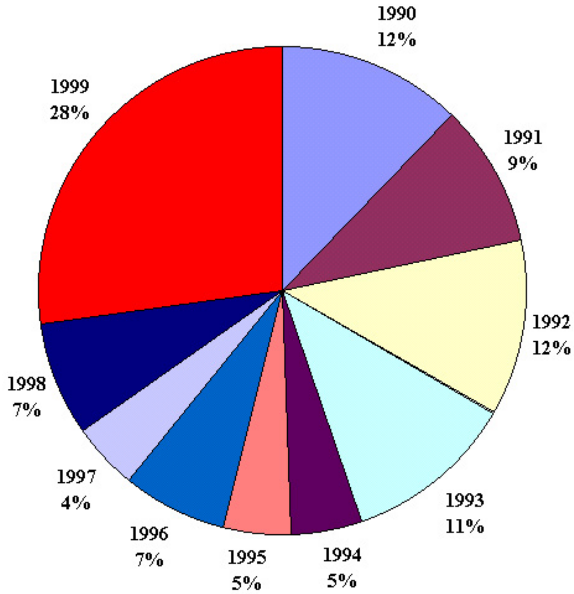

Figure I-4. Distribution of Marine Mammal Strandings in Zones 8 and 9

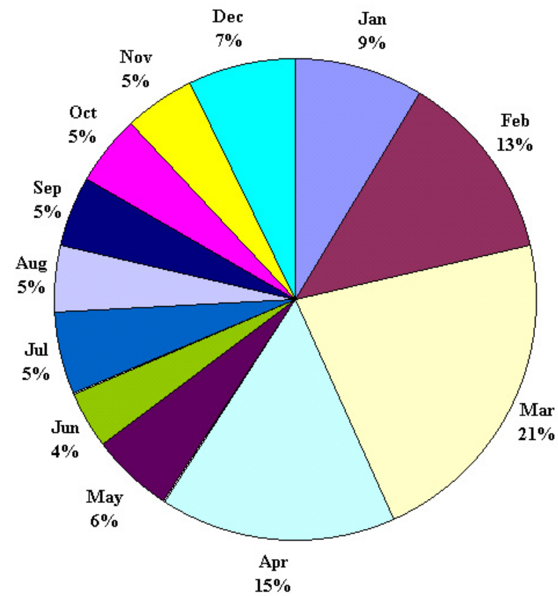

Figure I-5. Monthly Distribution of Marine Mammal Strandings in the Gulf of Mexico

than in the months of June, July, August, and September combined. A search of the literature did not reveal a reason for this trend. The reasons for this trend could vary from natural, anthropogenic, a function of changes in data gathering efforts, or a combination of these factors.

Conclusions

The evaluation of the GulfCet Datasets and a search of the literature did not allow for or illustrate a cause and effect relationship for the majority of the stranding incidents. Further research may allow for more definitive statements regarding the possible human impacts on the populations within the Gulf.

Further geographic refinement of the population densities that have been presented in Section 3 of this document would be helpful in determining how stranding incidents relate to animal density. Additionally, an increase in the effort to necropsy stranding mortalities and evaluation of the existing necropsy information would provide the crucial information necessary to determine if any mitigation is necessary to protect marine mammals.

Further investigation could also be undertaken to reallocate strandings that do have an identified cause associated with them to sub-categories, thereby showing a clearer view of the distribution of unknown strandings. Possible subcategories could include: 1) anthropogenic causes, 2) natural causes, 3) young dolphins, 4) unknown. Young dolphins should be broken into a separate category due to the higher natural mortality rates in these individuals. A study conducted in the Sarasota area showed that more than 50 percent of calves born to mothers younger than 15 years old die before reaching independence. Therefore the probabilities are that a stranded dolphin of less than or equal to one meter has died of natural causes.

APPENDIX J

MEMO ON THE USE OF DRONE AIRCRAFT CONTAINING MAGNESIUM-THORIUM ALLOYS

24 06 9605141021
ENVIRONMENTAL POLLUTION AND CONTROL

DEPARTMENT OF THE A...
HEADQUARTERS AIR FORCE MEDICAL OPERATIONS AGENCY
BROOKS AIR FORCE BASE, TEXAS

6 Oct 1994

MEMORANDUM FOR HQ AFMC/SGB
46 TW/XP
475 WEG/CC

FROM: HQ AFMOA/SGPR
8901 18th Street
Brooks AFB, TX 78235-5217

SUBJECT: Use of Drone Aircraft Containing Magnesium-Thorium Alloys

The USAF Radioisotope Committee recently received a response, from the US Nuclear Regulatory Commission (NRC), to our 12 May 94 letter that requested guidance on drone operations over the Gulf of Mexico range. In their response, the NRC concurred with the Air Force position on this issue. The NRC response consisted of the following statement:

"In your letter dated May 12, 1994, you requested our concurrence with your position that the loss in the Gulf of Mexico of drone aircraft containing magnesium-thorium alloys does not constitute a threat to the environment and should be allowed to continue even though this material is not recoverable.

We concur with your analysis based on the fact that this program supports weapons testing and evaluation, the high corrosion rate of magnesium-thorium materials results in rapid dispersal of the material, and the retrieval of such material constitutes a greater safety concern than its abandonment *in situ*."

On the basis of this response, we have determined that drone operations may continue without additional radiological restrictions.

If you have any comments or questions regarding this issue, please feel free to contact me at DSN 240-3331 or by fax at DSN 240-4382.

JOSEPH F. DONNELLY, Lt Col, USAF, BSC
Chief, USAF Radioisotope Committee Secretariat
Office of the Surgeon General

cc:
96 MDG/SGB
ASC OL/YOT
USNRC Region IV

APPENDIX K

AIRSPACE LETTER OF AUTHORIZATION

JACKSONVILLE CENTER, HOUSTON CENTER, MIAMI CENTER, TRAINING AIR WING SIX, AND AIR FORCE DEVELOPMENT TEST CENTER

LETTER OF AGREEMENT

EFFECTIVE: May 2, 1991

SUBJECT: EGLIN WATER TEST AREAS

1. PURPOSE. The following agreement between the Jacksonville, Houston, and Miami Centers, Training Air Wing Six (TRAWING 6), and Air Force Development Test Center (AFDTC), Eglin Air Force Base, covers procedures for the conduct of missile, probe, and drone operations within the Eglin long range missile, probe, and drone areas, hereafter referred to as the Eglin Water Test Areas (EWTA).

2. CANCELLATION. This agreement cancels and supersedes the Jacksonville Center, Houston Center, Miami Center, Training Air Wing Six, and Eglin Armament Division Letter of Agreement, Subject: Eglin Water Test Areas, effective March 31, 1986.

3. SCOPE.

a. EWTA includes all airspace in Warning Areas W-151, W-155B, W-168, W-174, W-470, and the airspace subdivided into six (6) areas and described in Annex 1 and depicted in Annex 2. AFDTC will conduct random missile, probe, and/or drone operations in the EWTA that includes airspace utilized by civil and military aircraft.

b. Operations to be conducted within the EWTA will be one or a combination of the following:

(1) Ground-launched or air-launched missile/probes which will impact within the EWTA and are hazardous to nonparticipating aircraft at all altitudes within the EWTA.

(2) Drone operations which are hazardous to nonparticipating aircraft within a block of altitudes in the EWTA.

(3) In the event a drone is damaged during a joint ground/air-launched missile, probe, or drone operation, the control of the drone could become erratic or lost. Such malfunctions may involve all airspace within the EWTA.

4. LIAISON. AFDTC designates the 3246 TESTW/DOSO (ROCC) as the liaison for activity conducted in the EWTA.

5. PROCEDURES.

a. ROCC shall:

(1) Precoordinate with the Central Altitude Reservation Facility (CARF) to resolve any potential schedule conflicts between the planned activity and altitude reservations on file with CARF.

(2) Precoordinate with FACSFAC Pensacola (SEABREEZE) for those portions of EWTA in W-155B. SEABREEZE will confirm the airspace released with the Jacksonville CENTER Mission Coordinator.

EDITORIAL CHANGE

REV 3: March 25, 1999

(3) When the activity cannot be contained within W151, W470, and W155B, transmit a request to Jacksonville, Houston, and Miami Centers, SEABREEZE, and CARF at least two (2) working days (Monday through Friday) prior to the proposed EWTA activity. This notice shall include:

(a) A description of the involved areas.

(b) The altitudes/flight levels to be activated.

(c) Type operations to be conducted above FL240.

(d) The period of use. EWTA airspace above FL240 shall not be scheduled for periods to exceed 4 hours. At FL240 and below, no one period or block time shall exceed 12 hours. There shall be a minimum of 3 hours between successive blocks to permit utilization of the airspace by nonparticipating aircraft.

(4) Notify immediately, via interphone, the Jacksonville Center mission position of the following information:

(a) Additional airspace required in the event of in-flight drone emergency.

(b) Termination of activities prior to scheduled NOTAM time.

b. <u>JacksonvilleCenter shall:</u>

(1) No later than 24 hours prior to the activation of the EWTA, to ensure adequate public notification, forward:

(a) To Gainesville AFSS a Notice to Airmen for domestic dissemination.

(b) To NFDC, with the Central Flow Control Facility as an info addressee, a Notice to Airmen for international dissemination.

(2) Relay, via interphone, to Houston and Miami mission positions, subsequent information such as cancellation and/or time ROCC advises termination of activity in EWTA if prior to scheduled NOTAM time.

(3) Relay, via interphone to the ROCC, all information received from the Houston and Miami Centers.

c. <u>The Houston and Miami Centers shall:</u>

(1) Forward to Jacksonville Center all information pertinent to their respective areas for inclusion in the NOTAM issued by Jacksonville Center.

EDITORIAL CHANGE

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(2) When the countdown status indicates a known IFR enroute flight will not clear the EWTA, immediately forward full details via interphone to the Jacksonville Center mission position for relay to the ROCC.

(3) Whenever a drone malfunction occurs, block the IFR altitudes and airspace within the EWTA as specified by Jacksonville Center until all emergency operations in the EWTA have been terminated.

6. RESPONSIBILITIES.

a. The Federal Aviation Administration will, within the limits of capability, provide the ROCC all information received by FAA with respect to the identification and position of aircraft within and adjacent to the firing area. In providing such information, the FAA cannot accept responsibility for its accuracy or completeness, since there may be aircraft operating in the airspace concerned unknown to FAA facilities and in the case of known aircraft, FAA facilities are dependent on flight crews for the accuracy and promptness of position reports.

b. The ROCC, upon receipt of information from the Jacksonville Center regarding an aircraft whose diversion has not been accomplished, shall take such emergency action as may be appropriate.

Original Signed By

Air Traffic Manager
Jacksonville Center

Original Signed By

Chief of Staff
Air Force Development Test Center
Eglin Air Force Base, Florida

Original Signed By

Air Traffic Manager
Houston Center

Original Signed By

Air Traffic Manager
Miami Center

Original Signed By

FAA NAVLO
Naval Air Station Pensacola

Original Signed By

Commander, Training Air Wing Six
NAS Pensacola, Florida

Original Signed By

FAA ATREP
Eglin Air Force Base, Florida

EDITORIAL CHANGE

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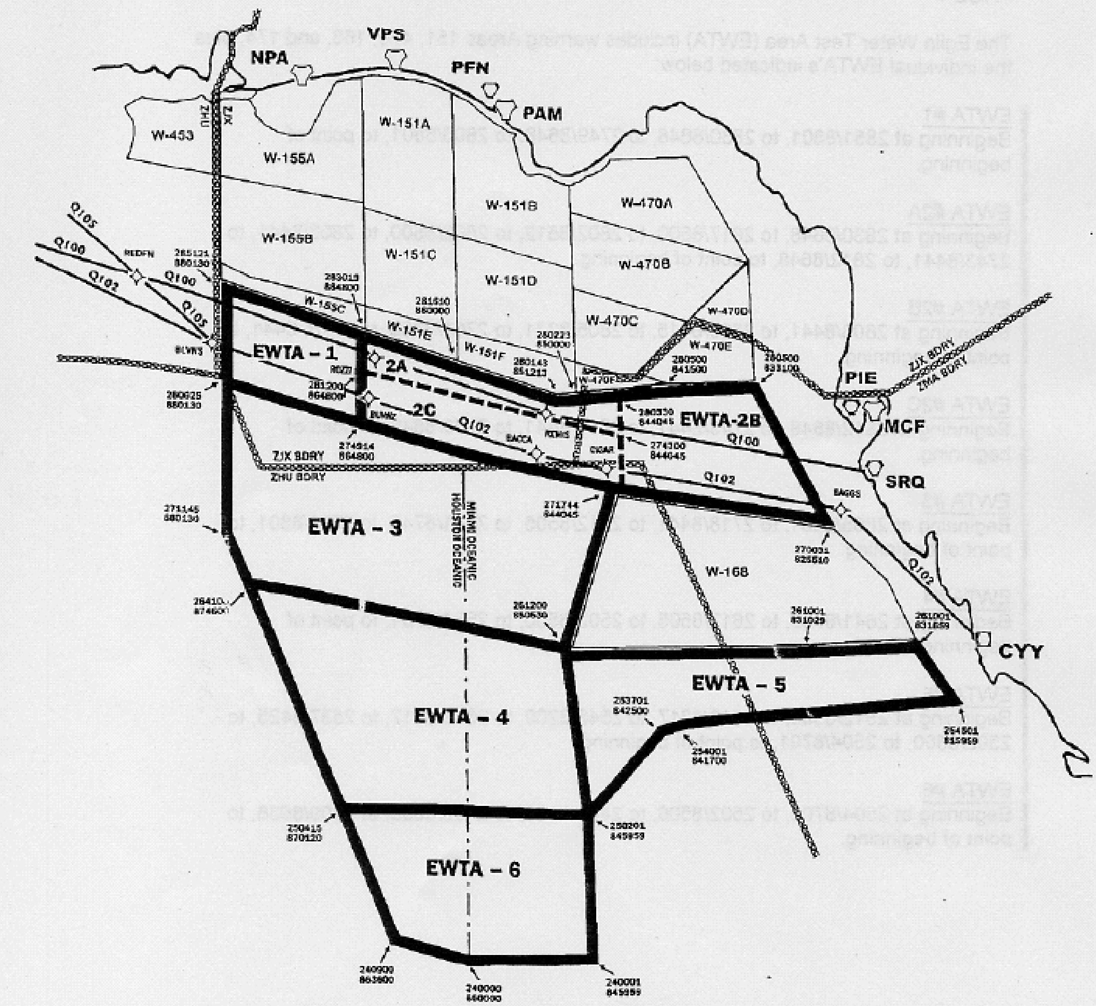
JACKSONVILLE CENTER, HOUSTON CENTER, MIAMI CENTER, TRAINING AIR WING SIX, and AIR FORCE DEVELOPMENT TEST CENTER

LETTER OF AGREEMENT

ANNEX 2

EFFECTIVE: MAY 2, 1991
REV. 4: JANUARY 11, 2002

EGLIN WATER TEST AREAS



NOTE: THE EGLIN WATER TEST AREAS (EWTA) INCLUDES WARNING AREAS W151, W470, W168, and W174, PLUS EWTA 1-6.

JACKSONVILLE CENTER, HOUSTON CENTER, MIAMI CENTER,
TRAINING AIR WING SIX, AND AIR FORCE DEVELOPMENT TEST CENTER

LETTER OF AGREEMENT

ANNEX 1 EFFECTIVE: May 2, 1991
PAGE 1

The Eglin Water Test Area (EWTA) includes warning Areas 151, 470, 168, and 174, plus the individual EWTA's indicated below:

EWTA #1
Beginning at 2851/8801, to 2830/8648, to 2749/8648, to 2806/8801, to point of beginning.

EWTA #2A
Beginning at 2830/8648, to 2817/8600, to 2802/8512, to 2802/8500, to 2803/8441, to 2743/8441, to 2812/8648, to point of beginning.

EWTA #2B
Beginning at 2803/8441, to 2805/8415, to 2805/8331, to 2701/8255, to 2718, 8441, to point of beginning.

EWTA #2C
Beginning at 2812/8648, to 2743/8441, to 2744/8441, to 2749/8648, to point of beginning.

EWTA #3
Beginning at 2805/8801, to 2718/8441, to 2612/8505, to 2641/8746, to 2712/8801, to point of beginning.

EWTA #4
Beginning at 2641/8746, to 2612/8505, to 2502/8500, to 2504/8701, to point of beginning.

EWTA #5
Beginning at 2612/8505, to 2610/8217, to 2545/8200, to 2540/8417, to 2537/8425, to 2502/8500, to 2504/8701, to point of beginning.

EWTA #6
Beginning at 2504/8701, to 2502/8500, to 2400/8500, to 2400/8600, to 2409/8636, to point of beginning.

REV 5: January 11, 2002