OCS EIS/EA
MMS 2005-013

Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf

Programmatic Environmental Assessment

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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FINDING OF NO SIGNIFICANT IMPACT

Programmatic Environmental Assessment of Structure-Removal Operations on the Gulf of Mexico Outer Continental Shelf

The programmatic environmental assessment (EA) to evaluate the potential environmental impacts of structure-removal activities on the Gulf of Mexico (GOM) Outer Continental Shelf (OCS) has been completed. The evaluation encompasses all structure-removal operations (i.e., platform removals and well, pipeline, and mooring severances) under the regulatory authority of the Minerals Management Service (MMS). The EA has resulted in a Finding of No Significant Impact (FONSI). Based on this EA, we have concluded that the structure-removal activities evaluated in the EA will not significantly affect the quality of the human environment. Preparation of an environmental impact statement is not required.

The activities analyzed in the EA include vessel and equipment mobilization, structure preparation, nonexplosive- and explosive-severance activities, post-severance lifting and salvage, and site-clearance verification. The impact-producing factors of structure removals considered in the EA include seafloor disturbances, air emissions and water discharges, pressure and acoustic energy from explosive detonations, and space-use conflicts with other OCS users. Based on established significance criteria, the results of the impact analyses are that structure-removal activities are not expected to result in significant adverse impacts to any of the potentially affected resources. Potentially adverse but not significant impacts were identified for marine mammals and negligible to potentially adverse but not significant impacts were identified for sea turtles. In addition, no potentially-significant impacts were identified for air and water quality; fish, benthic, and archaeological resources; or other OCS pipeline, navigation, and military uses.

The MMS currently requires operators engaged in activities on the OCS, including structure-removal activities, to comply with a number of lease stipulations, Notices to Lessees, and other mitigation measures designed to reduce or eliminate impacts to sensitive environmental resources from impact-producing factors such as vessel or aircraft traffic, anchoring, and trash and debris. These mitigation measures are required under the OCS Lands Act, the Endangered Species Act (ESA), and the Marine Mammal Protection Act (MMPA) to ensure environmental protection, consistent environmental policy, and safety. As part of the impact analyses completed in the Structure-Removal Operations EA, a wide range of newly-developed, feasible mitigation measures were evaluated (Alternative A) as well as *status quo* mitigation means (Alternative B). In addition, a potential restriction on all explosive-severance activities conducted during structure-removal operations (Alternative C) was analyzed as an alternative to further reduce the potential for impacts to sea turtles and marine mammals.

Under the proposed action (Alternative A), the mitigation measures outlined in Appendix F of this EA will be required for all structure-removal operations in all water depths in the Western and Central Planning Areas and the currently-available lease sale area of the Eastern Planning Area of the GOM. The mitigation includes measures to reduce or negate potential impact-producing factors related to (1) support vessel mobilization/demobilization, (2) progressive transport, (3) site-clearance trawling, and (4) explosive-severance activities.

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DISCLAIMER

This programmatic environmental assessment (PEA) was prepared by the Minerals Management Service (MMS), Gulf of Mexico OCS Region (GOMR) to fulfill National Environmental Policy Act (NEPA) requirements permitting the decommissioning and removal of structures on the Outer Continental Shelf (OCS) in accordance to regulations promulgated under the OCS Lands Act (OCSLA).

We have reviewed this document internally to ensure its objectivity, utility, and integrity. The information we provide in this document is presented in an accurate, clear, complete, and unbiased manner. We presume any peer-reviewed information to have acceptable objectivity and integrity. With regard to any other additional information used and referenced in this document, we strive to assure transparency of information so that a qualified member of the public could undertake an independent analysis.

Approval does not signify that the contents necessarily reflect the views and policies of MMS, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

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ABBREVIATIONS AND ACRONYMS

1D one-dimensional
3D three-dimensional
AIM Acoustic Integration Model
ALDEM Alabama Department of Environmental Management
AML above mudline
API American Petroleum Institute
APM Application for Permit to Modify
ARA Applied Research Associates
AWJ abrasive water jet
BML below mudline
BO Biological Opinion
BOP blowout preventer
B.P. before present
CAA Clean Air Act
CAA Cooperating Agency Agreement
CAAA Clean Air Act Amendments
CEI Coastal Environments, Incorporated
CEQ Council on Environmental Quality
CES Center for Energy Studies
CFR Code of Federal Regulations
CO carbon monoxide
COE U.S. Army Corps of Engineers
CPA Central Planning Area
CSA Continental Shelf Associates
CSC conical-shaped charge
C.V. coefficient of variation
CWA Clean Water Act
CZARA Coastal Zone Act Reauthorization Amendments
CZMA Coastal Zone Management Act
CZMP Coastal Zone Management Program
CZPA Coastal Zone Protection Act
dB decibel
DDNP diazodinitrophenol
DOC Department of Commerce (also: USDOC)
DOD deep ocean disposal
DOD Department of Defense
DOI Department of the Interior (U.S.) (also: USDOI)
DP Dynamic positioning
DWC diamond water cutter
EA environmental assessment
EEZ Exclusive Economic Zone
EFD energy flux density
EFH essential fish habitat
Eh oxidation reduction potential
EIS environmental impact statement
EMAP-E Environmental Monitoring and Assessment Program for Estuaries
EPA Eastern Planning Area
ESA Endangered Species Act
ESI Explosive Service International
EWTA Eglin Water Test Areas
FGBNMS Flower Garden Banks National Marine Sanctuary
FMC Fishery Management Council
FMP Fishery Management Plan
FONSI Finding of No Significant Impact
FR Federal Register
FWS Fish and Wildlife Service
GIWW Gulf Intracoastal Waterway
GMFMC Gulf of Mexico Fishery Management Council
GOM Gulf of Mexico
GRN Gulf Restoration Network
H_2S hydrogen sulfide
HAPC habitat areas of particular concern
HMS highly migratory species
HMX homocyclonite
HNIW hexanitrohexaazaisowurzitan
ID inner diameter
IPF impact producing factors
ITM Information Transfer Meeting
ITS Incidental Take Statement
JRC Jet Research Center
LADEQ Louisiana Department of Environmental Quality
LADNR Louisiana Department of Natural Resources
LSC linear-shaped charge
LSU Louisiana State University
MAFLA Mississippi, Alabama, and Florida
MAI Marine Acoustics, Incorporated
MARPOL International Convention for the Prevention of Pollution from Ships
MFCMA Magnuson Fishery Conservation and Management Act
mg/l milligrams per liter
min minutes
MMC Marine Mammal Commission
MMPA Marine Mammal Protection Act
MMS Minerals Management Service
MODU mobile offshore drilling unit
MOPU mobile offshore production unit
MPS Marine Protected Species

MSDS	material safety data sheet
MWA	military warning area
NAAQS	National Ambient Air Quality Standards
NARP	National Artificial Reef Plan
NAVSWC	Naval Surface Warfare Center (also: NSWC)
NEPA	National Environmental Policy Act, as amended
NFEA	National Fishing Enhancement Act
NG	nitroglycerin
NGC	nitroglycol
NM	nitromethane
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
nmi	nautical miles
NO_x	nitrous oxides
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant and Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NRHP	National Register of Historic Places
NSTC	National Science and Technology Council
NSWC	Naval Surface Warfare Center (also: NAVSWC)
NTL	Notice to Lessees and Operators
OCD	Offshore Coastal Dispersal
OCRM	Office of Ocean and Coastal Restoration Management
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act, as amended
OD	outer diameter
OOC	Offshore Operators Committee
OSHA	Occupational Safety and Health Act
P&A	plugging and abandonment
PAH	polycyclic aromatic hydrocarbon
PBR	Potential Biological Removal
PBX	plastic bonded explosive
PCB	polychlorinated biphenyl
PEA	programmatic environmental assessment
PETN	pentaerythritol tetranitrate
pH	potential of hydrogen
PM	particulate matter
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PROP	Platform Removal Observer Program
PSD	prevention of significant deterioration
psi	pounds per square inch
PTS	permanent threshold shift
PVC	polyvinylchloride
PWSA	Ports and Waterways Safety Act
RDX	cyclonite
RHA	Rivers and Harbors Act
ROV	remotely-operated vehicle
RTR	Rigs-to-Reefs
SAIC	Science Applications International Corporation
SEA	site-specific environmental assessment
SEAMAP	Southeastern Area Monitoring and Assessment Program
SEPLA	Suction-embedded plate anchor
SERO	Southeast Regional Office
SIP	State Implementation Plan
SME	subject-matter-expert
sp.	species
SO_x	sulfur oxides
TED	turtle excluder device
TEPE	take estimate per event
TLP	tension leg platform
TM	tympanic-membrane
TNT	trinitrotoluene
TSB	Twachtman, Snyder, and Byrd
TSS	total suspended solids
TSS	Traffic Separation Scheme
TTS	temporary threshold shift
TVOC	total volatile organic compounds
U.S.	United States
U.S.C.	United States Code
USCG	U.S. Coast Guard
USDOC	U.S. Department of Commerce (also: DOC)
USDOI	U.S. Department of the Interior (also: DOI)
USEPA	U.S. Environmental Protection Agency
USS	United States Ship
UWC	UnderWater Calculator
VOC	volatile organic compounds
WBNERR	Weeks Bay National Estuarine Research Reserve
WPA	Western Planning Area
WTA	Water Test Area

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1. THE PROPOSED ACTION

1.1. INTRODUCTION

The Minerals Management Service (MMS) is mandated under the Outer Continental Shelf Lands Act (OCSLA) to manage leasing, exploration, development, and production of mineral resources on the Federal Outer Continental Shelf (OCS). The Secretary of the Interior (Secretary) oversees the OCS program and is required to balance orderly resource extraction with protection of the human, marine, and coastal environments. The Secretary must also ensure that the U.S. Treasury and general public are given a reasonable return for the resources discovered and produced on public lands.

The MMS has prepared this programmatic environmental assessment (PEA) to determine the potential impacts that may result from decommissioning activities related to the explosive and nonexplosive severing of seafloor obstructions (i.e., wellheads, caissons, casing strings, platforms, mooring devices, etc.) and the subsequent salvage and site-clearance operations that may be employed. Decommissioning operations generally occur after lease expiration, when the well or facility is deemed economically unviable, or when the physical condition of the structure becomes unsafe or a navigation hindrance. The area of the proposed action includes all water depths in the Central and Western Planning Areas (CPA and WPA) and the current sale area available in the Eastern Planning Area (EPA) of the Gulf of Mexico (GOM). Therefore, by tiering from the most recent Multisale environmental impact statement (EIS) for the CPA/WPA (USDOI, MMS, 2002) and the EPA EIS (USDOI, MMS, 2003), this PEA concentrates on environmental effects and issues specific to decommissionings.

1.2. PURPOSE OF AND NEED FOR THE PROPOSED ACTION

The primary purpose of the proposed action, Alternative A—Structure-Removal Operations with "Dynamic" Severance Options (Chapter 2.2.1), is to provide the operator/removal applicant with the means necessary to sever and remove all objects from the seafloor safely and with minimal degradation to the environment while adhering to the decommissioning guidelines of the OCSLA regulations, binding lease agreements, and other enforceable OCS-related laws. The proposed action also serves a secondary purpose for MMS by providing measures to ensure that nothing will be exposed on the seafloor after a decommissioning that could interfere with navigation, commercial fisheries, or future oil and gas operations in the area.

During the exploration, development, and production operations involved with mineral extraction on the GOM OCS, the seafloor around activity areas becomes the repository of temporary and permanent equipment and structures. In compliance with Section 22 of MMS's Oil and Gas Lease Form (MMS-2005) and OCSLA regulations (30 CFR 250.1710—*Wellheads/Casings* and 30 CFR 250.1725—*Platforms and Other Facilities*), operators need to remove seafloor obstructions from their leases within one year of lease termination or after a structure has been deemed obsolete or unusable. These regulations also require the operator to sever bottom-founded objects and their related components at least 5 m below the mudline (30 CFR 250.1716(a)—*Wellheads/Casings* and 30 CFR 250.1728(a)—*Platforms and Other Facilities*). The opportunity does exist for the abandonment-in-place of certain seafloor obstructions (30 CFR 250.1716(b)(3)—*Wellheads/Casings* and 30 CFR 250.1728(b)(3)—*Platforms and Other Facilities*); however, the obstructions are limited to water depths greater than 800 m and would be addressed on a case-by-case basis.

1.3. BASIS FOR PREPARING THE EA

1.3.1. Background

The MMS previously addressed removal operations and the potential impacts of severing methodologies (nonexplosive/explosive tools) in a PEA prepared in 1987 (USDOI, MMS, 1987). The scope of the decommissioning activities analyzed in the document was limited to traditional, bottom-founded structures (i.e., well protectors, caissons, and jacketed platforms) and did not address well abandonment operations; activities similar in nature, but monitored and reported a separate section of the OCSLA regulations. In addition, since the majority of removal operations took place in water depths less than 200 m (656 ft), only the shelf areas of the CPA/WPA were addressed by the proposed action.

In 1988, MMS requested a "generic" consultation from the National Marine Fisheries Service of the National Oceanographic and Atmospheric Administration (NOAA Fisheries) pursuant to Section 7 of the Endangered Species Act (ESA) concerning potential impacts on endangered and threatened species associated with explosive-severance activities conducted during structure-removal operations. Much like the PEA, the consultation's Biological Opinion (BO) was limited to the best scientific information available and concentrated primarily on the majority of structure removals (water depths <200 m). The Incidental Take Statement (ITS) was therefore limited to the five species of sea turtle found on the shallow shelf. Reporting guidelines and specific mitigation measures are outlined in the ITS and include (1) the use of a qualified NOAA Fisheries observer, (2) aerial surveys, (3) detonation delay radii, (4) night time blast restrictions, (5) charge staggering and grouping, and (6) possible diver survey requirements.

In 1989, the American Petroleum Institute (API) petitioned NOAA Fisheries under Subpart A of the Marine Mammal Protection Act (MMPA) regulations for the incidental take of spotted and bottlenose dolphins during structure-removal operations (i.e., for either explosive- or nonexplosive-severance activities). The Incidental Take Authorization regulations were promulgated by NOAA Fisheries in October 1995 (60 FR 53139, October 12, 1995), and on April 10, 1996 (61 FR 15884), the regulations were moved to Subpart M (50 CFR 216.141 *et seq.*). Effective for five years, the regulations detailed conditions, reporting requirements, and mitigative measures similar to those listed in the 1988, ESA Consultation requirements for sea turtles. After the regulations expired in November 2000, NOAA Fisheries and MMS advised operators to continue following the guidelines and mitigative measures of the lapsed subpart pending a new petition and subsequent regulations. At industry's prompting, NOAA Fisheries released Interim regulations in August 2002, which expired on February 2, 2004. Operators continue to follow the Interim conditions until NOAA Fisheries promulgates new regulations.

1.3.2. Need for this EA

Decommissioning methodologies and regulatory requirements have evolved since the 1987 PEA was prepared. New and improved explosive and nonexplosive severing devices enhance cutting efficiency, allow for operations in greater water depths, and help reduce possible impacts to the environment. Operators and removal contractors are taking advantage of the increased availability of remotely operated vehicles (ROV) for use in explosive charge setting and mechanical cutter deployment, thereby reducing the risk to divers in many situations. At the same time the impending severing targets are increasing in size and complexity.

Technological improvements in exploration, drilling, and production equipment have allowed industry to take advantage of new deepwater prospects (>200 m; 656 ft) in the GOM. The advancements that make deepwater activities possible have led to an assortment of seafloor tethering and production structures that may require severing and extensive removal activities under certain circumstances. Some of these deepwater structures include subsea strut and skirt piles, suction-pile anchors, subsea well structures, pipelines, subsea foundations and templates, tension leg platform (TLP) tendons, and mooring lines or cables.

The push into deep water expands the area of the proposed action beyond that evaluated in 1987. The expanded area introduces additional environmental factors that have yet to be analyzed for the possible impacts from severing operations. For example, protected, threatened, and endangered species that may be present near deepwater structures; most notably, the sperm whale. Over the past 15 years, more information has become available on sperm whale population density estimates, sperm whale behavior, how marine animals are impacted by sound in the sea. In response to these changes and a request by NOAA to provide some information that would facilitate their proposed rulemaking, MMS decided to prepare a new programmatic National Environmental Policy Act (NEPA) document to address all water depths in the Gulf of Mexico OCS, new decommissioning operations technology, and new marine protected species (MPS) information. Relying on a better understanding of the affected environment, recent developments in explosive shock wave and sound propagation modeling, and analyses using the best available scientific information, this PEA will meet three primary needs for the MMS by;

- aiding in the permitting, management, and planning of future structure-removal operations,

- ensuring that adequate environmental reviews are conducted on all decommissioning proposals that would help support human health and safety while simultaneously protecting the sensitive marine environment, and
- serving as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) (future, site-specific environmental assessments (SEAs) may reference appropriate sections of this PEA to reduce reiteration of issues and effects, allowing analyses to focus on specific issues and effects related to the removal activity).

Shortly after MMPA incidental-take regulations (Subpart M; 50 CFR 216.141 *et seq*.) expired in November 2000, the rulemaking staff from NOAA Fisheries officially requested that MMS petition for the next issuance of incidental-take regulations under Subpart I (50 CFR 216.104). MMS agreed, with the understanding that industry/severance contractors would provide MMS with some of the specific decommissioning information, as requested, for the petition document. The petition information needs include a description of the decommissioning activities that have the potential to result in incidental taking of marine mammals, the duration of activities, and the suggested means of mitigating potential takes and accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species.

During a January 2002, Explosive Removal Workshop in New Orleans, Louisiana, MMS announced that the agency would use this PEA as the primary component of its Subpart I petitioning package. NOAA Fisheries has entered into a Cooperating Agency Agreement (CAA; Chapter 5.4) with the MMS for this PEA. This will enable NOAA Fisheries to adopt the PEA more-efficiently into the NEPA process of the MMPA rulemaking, ultimately expediting the development, review, and publication of both the PEA and the new take regulations. In addition to meeting most of the operational information needs of Subpart I with a detailed description of the proposed action, MMS will address new impact thresholds/criteria approved by NOAA Fisheries (69 FR 21819, April 22, 2004) in the PEA's analyses, take-estimate calculations, and mitigating development for MPS.

This PEA will also become the primary instrument for formal, ESA, Section 7 consultation (50 CFR 402.14) on explosive-severance activities. Pending the outcome of the PEA's impact analyses, the consultation is expected to address the possible impacts of explosive severing on all native sea turtles and sperm whales in the GOM. The MMS's goal is to have the new biological opinion incorporate reasonable and prudent mitigation measures that mirror or compliment the new MMPA regulations. Once MMPA incidental take regulations are implemented, NOAA Fisheries will then be able to exempt MMS and operators from incidental take of sperm whales under the ESA.

1.3.3. Decisions to be Made Based on this PEA

Taking into account all of the factors involved with decommissioning activities described in this PEA (Chapter 1.4), the MMS decisionmaker will determine if the proposed action (Alternative A—*Removal Operations with "Dynamic" Severance Options*; Chapter 2.2.1) or the alternatives (Alternative B—*Removal Operations with "Generic" Severance Options*; Chapter 2.2.2/Alternative C—*Removal Operations with Nonexplosive Severance Options*; Chapter 2.2.3) would result in significant impacts to the analyzed resources and/or whether an EIS would need to be prepared.

1.4. Description of the Proposed Action

1.4.1. Background

During every stage of exploration, development, and production of oil, gas, and mineral (sulfur) operations, structures are set on or into the seafloor to aid with and/or facilitate well operations and protection, drilling and production platform emplacement, vessel moorings, pipeline installation, and subsea equipment deployment. To satisfy the regulatory requirements and lease agreements for the eventual removal of these structures, decommissioning operations employ a wide range of activities that oversee any topsides removal (decking and structure above the waterline), seafloor severing, component lifting and loading, site-clearance verification work, and final transportation of the structure back to shore for salvage or to an alternate OCS site for reuse or reefing.

MMS will analyze all of the applicable activities related to GOM decommissioning operations as a single proposed action. The information found in the following description and used in the PEA's analyses was gathered from multiple sources. In preparation of developing the scope of this PEA, the MMS funded several reports (i.e., TSB and CES, LSU, 2004; Kaiser et al., in preparation) to synthesize critical information on current severing technology, decommissioning methodologies, and removal forecasting trends. A shock wave and sound propagation model for determining impact zones for marine protected species was created by Applied Research Associates (ARA), Inc. (Dzwilewski and Fenton, 2003). Other information on logistics and cutting tools was provided to MMS directly from the salvage and severing contractors (DEMEX, 2003). More detailed information dealing with the specific descriptions of structure types, target locations, severing technologies, possible self-mitigation, sediments, and biological conditions will be addressed by SEA's prepared for subsequent, removal-permit applications.

1.4.2. Location

The area of the proposed action that is analyzed in this PEA consists of all water depths of the Central and Western Planning Areas (CPA and WPA) and a portion of the Eastern Planning Area (EPA) offered under Lease Sale 181 in 2001 (Figure 1-1). Water depths in the area of the proposed action range from 4 to 3,400 m (13-11,155 ft), with the majority of existing facilities and wells (Figure 1-2) found within the CPA, concentrated on the upper shelf waters (<200 m; 656 ft) off of Louisiana.

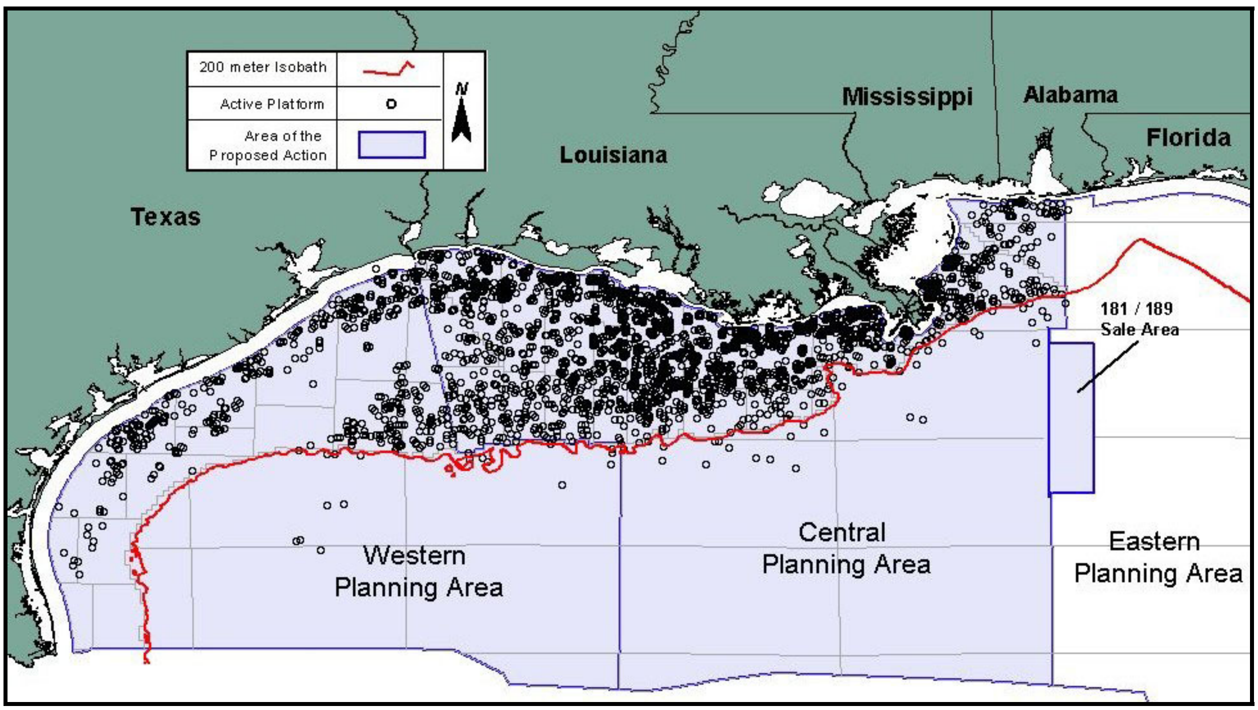


Figure 1-1. Area of the Proposed Action Showing Active Platform Distribution.

For the purposes of this PEA, water depths >200 m (656 ft) are categorized as deepwater or slope. It is the proposed action where deep-diving toothed whales (i.e., beaked whales and the sperm whale) may be present. Due to the presence of these animals and the surveying/monitoring conditions they necessitate, the 200 m isobath serves the purpose of delineating mitigation scenarios for explosive-severing activities (Appendix F). Operations in these water depths often require specialized methodologies and equipment to overcome deepwater conditions. Additional information on deepwater structures that may require severing and decommissioning operations can be found in Chapter 1.4.5, and descriptions of all of the Northern GOM marine mammals are addressed in Chapter 3.2.1.

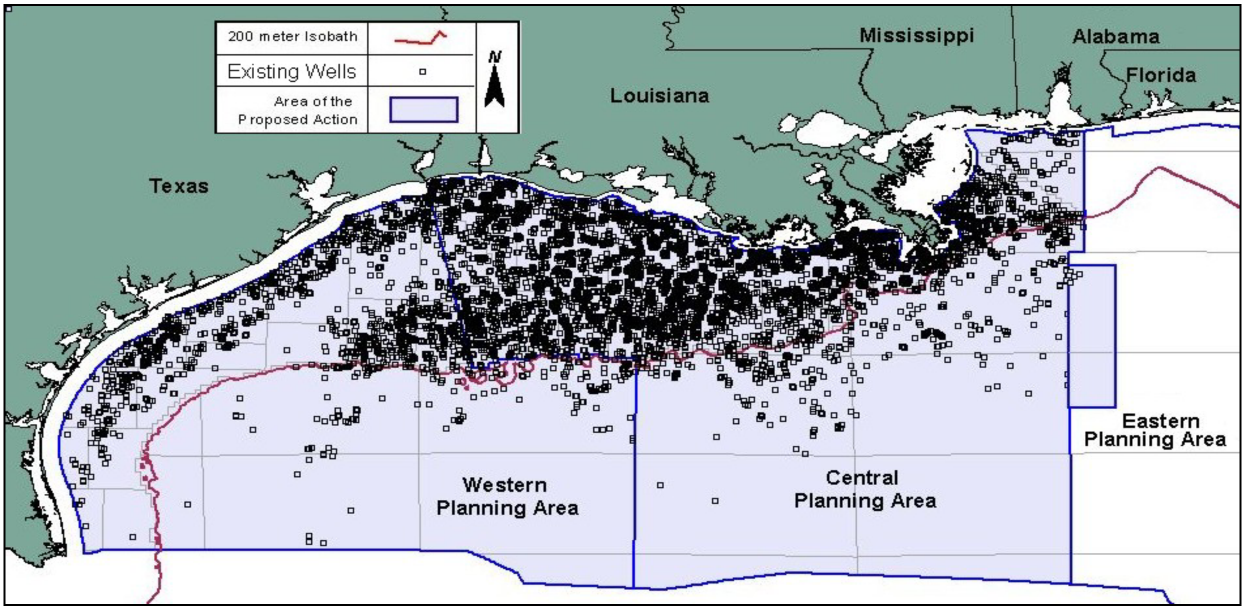
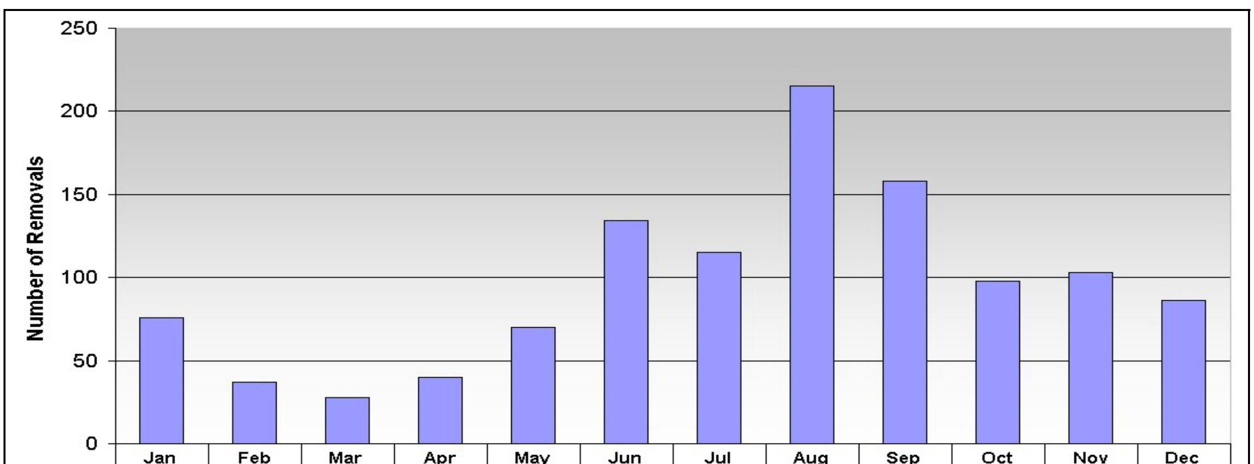


Figure 1-2. Area of the Proposed Action Showing Existing Well Distribution.

1.4.3. Decommissioning "Season"

Operators often schedule most of their removal projects from June to December (approximately 80%; Figure 1-3) to take advantage of the generally calm seas and optimal weather in the northern GOM (TSB and CES, LSU, 2004). Other factors industry considers when scheduling removals are related to budgets and competition over shared resources. Generally, companies tend to schedule profit-depleting operations towards the end of their economic calendar. Income generating activities such as facility installations take highest priority; occurring early on in the fiscal year. In addition, installation activities regress decommissionings further since both operations compete for the same management groups, resources (e.g., service/lift vessels, support equipment, etc.), and available labor (TSB and CES, LSU, 2004).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Removals	76	37	28	40	70	134	115	215	158	98	103	86
% of Total	6%	3%	2%	3%	6%	12%	10%	19%	14%	8%	9%	8%

Figure 1-3. "Seasonal" Trends of Removal Operations from 1994-2003 (Source: MMS Data).

1.4.4. Removal Forecasting

There are currently over 4,000 bottom-founded, “traditional” structures (e.g., jacketed platforms, caissons, and well protectors) and 29,500 well-related structures in the area of the proposed action. To address the programmatic nature of this document, cumulative assessments, and the subsequent use of this material in a MMPA rulemaking and ESA Consultation documentation, MMS has to consider how many of these structures may be removed annually and during the next five-year, MMPA regulatory period. During the past 10 years (1994-2003), there has been an average of 156 platform removals per year, with over 60 percent using explosive severing tools (Table 1-1). During the same period, the number of platform installations has been slightly lower, with an average of 116 structure commissionings taking place per year. This trend is becoming more common as new structure sitings move into the deepwater GOM fields, and the numerous facilities in the maturing, shallow-shelf fields are aging and requiring removal.

In addition to deriving annual estimates from historical averages, MMS contracted Louisiana State University’s (LSU) Center for Energy Studies (CES) to prepare a report, *Modeling Structure Removal Processes in the Gulf of Mexico* that would address MMS’s removal forecasting needs (Kaiser et al., in preparation). Since previous studies and environmental reports distinguish explosive severing activities as having the greatest potential to harm marine protected species, the report concentrates on the estimated number of platform removals that may employ explosive cutting. Because an operator’s appraisal of when and how to decommission a specific structure involves several complex factors, the main components of the report consist of “optimistic” and “pessimistic” model sets (platform life expectancy, probabilistic removal, and binary-choice severance selection models) and a section that provides a statistical description of decommissioning operations based upon historical data.

Table 1-1

Platform Installations and Removals from 1994 to 2003 (Source: MMS Data)

Platform Commissionings											
Structure Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	*Average per Year*
Jacketed Platforms	56	45	68	68	77	55	74	79	44	35	60 (52%)
Caissons	30	34	36	42	49	35	62	72	40	45	45 (39%)
Well Protectors	15	20	14	9	3	0	0	1	9	14	9 (7%)
Other Structures	1	1	2	2	4	2	2	4	2	4	2 (2%)
Total/Year	102	100	120	121	133	92	138	156	95	98	116
Platform Decommissionings											
Severing Method	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	*Average per Year*
Nonexplosive	44	42	101	79	48	67	52	48	42	55	58 (37%)
Explosive	120	120	55	113	42	80	102	69	165	118	98 (63%)
Total/Year	164	162	156	192	90	147	154	117	207	173	156

To forecast a structure’s overall potential for removal, the platform life expectancy model focuses on factors such as its configuration, installation and initial production dates, and setting (location on the OCS and water depth). The framework of severance selection modeling was much more difficult to engineer because many of the important factors involved with choosing a severing methodology are not observable and impossible to incorporate into a model. These unquantifiable variables include the direct and indirect costs, human safety concerns, environmental issues, the potential 'cost of failure,' the operator and contractors' experiences and preferences, scheduling, and the configuration and reliability of the cutter itself. The difficulty posed by these factors was taken into account when CES developed its binary-choice severance selection model. The modeling runs were sorted into five-year forecasting periods starting in 2002 (the year the study was contracted). The projections from the "pessimistic" and "optimistic" forecasting models were reviewed to determine annual averages and ranges for each of the five-year periods, and the results are presented in Table 1-2.

Ultimately, the correlation between unquantifiable decision factors and the discernible variables is inexact, and the level at which potential removal candidates can be linked to severing methodologies accurately is somewhat speculative (Kaiser et al., in preparation). Additional factors regarding public and political concerns and unpredictable, regulatory restrictions increase the complexity of forecasting any removal operation requiring explosive severing tools. Based upon the best-available information from the CES forecasting study and the average, annual percentage rate of severances derived from historical data (i.e., 37% nonexplosive and 63% explosive), MMS projects the following annual removal activities:

Structure Removals Using Nonexplosive Cutters: 55-94/Year
Structure Removals Using Explosive Cutters: 94-160/Year
Total Removals: 149-254/Year

The proposed action incorporates five blasting categories for explosive-severance operations (see Chapter 2.2.1). Depending upon the configuration/deployment (below-mudline (BML) or above-mudline (AML)) and the area of operation (<200 m or >200 m), there are 20 separate explosive severing scenarios that could be utilized by an operator. A breakdown of the annual projections for each scenario as they are applied to traditional structures can be found in Appendix A.

Table 1-2

Projected Number of Structure Removal Operations Using Explosive Severing Tools

Forecasting Model I ("Pessimistic")					
Forecast Period	Caissons	Well Protectors	Jacketed Platforms	Forecast Period Total	Annual Average for Period
2002-2006	111	73	288	472	94
2007-2011	152	63	386	601	120
2012-2016	114	46	382	542	108
2017-2021	99	37	276	412	82
Forecasting Model II ("Optimistic")					
Forecast Period	Caissons	Well Protectors	Jacketed Platforms	Forecast Period Total	Annual Average for Period
2002-2006	199	105	494	798	160
2007-2011	232	106	502	840	168
2012-2016	134	63	371	568	114
2017-2021	28	0	205	233	47

Annual Range for Forecast Period For Projected Structures Removed Using Explosive Severing Tools	
2002-2006	94—160
2007-2011	120—168
2012-2016	108—114
2017-2021	47—82

From *Modeling Structure Removal Processes in the Gulf of Mexico* (Kaiser et al., in preparation).

Well removal activities are much more difficult to quantify and forecast. Unlike platform removals, which are almost always planned, permitted, and conducted under a distinct operation, well removals could occur as a minor, subsequent project under a permanent well plugging and abandonment (P&A) activity or left after P&A work to be an ancillary target during an associated platform removal operation. Historical data is also difficult to acquire because these two activities are managed and documented by two separate groups; platform removals via MMS's Regional permitting (the Office of Structural and Technical Support in New Orleans, Louisiana) and P&A activities via MMS's District Office permitting (in New Orleans, Lake Charles, Houma, and Lafayette, Louisiana, and Lake Jackson and Corpus Christi, Texas).

If an operator chooses to remove the wells (i.e., conductors, casing stubs, etc.) with an associated platform, they are noted in the Regional *Structure Removal Permit Application*, which is recorded in MMS's database noting the proposed severance methodology. If the operator removes the wells during a P&A operation, the removal is reported to the respective District in an *Application for Permit to Modify* (APM/Form MMS-124). The MMS is currently developing ways to capture this information into its database for well removal activities. The MMS database can provide accurate data on the number of wells P&Aed each year (Table 1-3), and a breakdown of the number of severing scenarios projected for well severings is also found in Appendix A (Table A-5).

Table 1-3

Permanent Well Abandonments from 1994 to 2003 (Source: MMS Data)

Well Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	*Average per Year*
Exploratory	308	232	330	406	240	341	386	317	338	363	326 (61%)
Development	197	165	240	278	215	191	239	223	134	192	207 (39%)
Relief	0	0	4	0	0	1	0	0	0	0	~1 (<1%)
Total/Year	505	397	574	684	455	533	625	540	472	555	534

1.4.5. Target Structures

After accepting the task of petitioning NOAA Fisheries for new incidental-take regulations on behalf of industry, MMS met with a group of severing subcontractors and operator representatives to request information on the types of targets that would require severing during decommissioning operations now and within the next MMPA rulemaking cycle (~2004-2009). The following sections describe the targets that were identified by industry, grouped into categories as they relate to wells, platforms, moorings, and miscellaneous structures.

1.4.5.1. Well-Related Targets

1.4.5.1.1. Wellheads and Conductors (Surface-Accessible)

A well is a series of casings (interlocking steel tubing) set into the seafloor through which the initial drilling and later production operations are conducted. Wells and well-related structures are the most prolific structures on the GOM OCS, and their distribution is shown on Figure 1-2. The outer casing or conductor could be up to 48 in (122 cm) in diameter and is fixed to the surrounding formation with cement forced down and through the drill pipe. Successive casings become narrower in diameter as the well deepens, with each subsequent string set into the previous with a wedge of cement called a "shoe." A blowout preventer (BOP) is mounted to one of the inner casings at the seafloor (or mudline) to facilitate drilling operations. When a platform is used for shallow-water production activities, the conductor is extended to a lower deck of the facility where specialized production fittings (Christmas trees) can be attached to the casing head. This assembly of casing "strings," casing or tubing heads, and specialized equipment makes up the wellhead.

As previously mentioned, in the case of a dry hole, ceased production, or within one year of lease termination, the wellhead, conductor, and all well-related equipment are required to be severed and removed at least 15 ft (4.6 m) below the mudline. As discussed in Chapter 1.4.4 (Removal Forecasting), P&A activities first serve to permanently-abandoned wells by "plugging" the wellbore and all perforated sections of the casing string with 100's of feet of cement as per instructions found at 30 CFR 250.1715. Following testing, the wellhead can then be severed and removed immediately (reported via an APM) or left for future removal operations (proposed in the Structure Removal Permit Application).

The wellheads and conductors discussed in this section are open to the ocean surface and often tied to existing platform-related structures, which may or may not require similar removal operations. Some well severing operations call for the severing of the smaller, internal casings that are subsequently pulled out (via crane or heavy lift vessel) to allow for access to the larger, outer casings or conductor. In the case where the inner casing is plugged or obstructed, the severing contractor may need to jet or remove the mud from around the exterior of the casing string to allow for external cutting devices.

Some decommissioning operations require that wells be removed from within free standing or braced caissons, while leaving the well-supporting structure. After some wells are initially drilled and completed, operators frequently install a large-diameter caisson (most >48 in x 1½-in wall thickness) over the well to protect it from boat, storm, and debris damage (NRC, 1996). During the life of the well, the caisson often takes on other duties (i.e., equipment storage or support, pipeline termination point, etc.) and may need to remain in place long after an unproductive well is required to be removed. Though conducted totally within the caisson, the well-severing procedures are similar to those discussed previously for conductors open to the sea. However, the thick-walled caisson acts as a protective curtain, and in the case of an explosive severance, it effectively acts as its own mitigation tool, keeping marine life away from the area of detonation while simultaneously containing and attenuating the resultant shock and sound waves. The minimal potential for impact often relegates these well-severing activities to extended P&A operations.

1.4.5.1.2. Subsea Wellheads and Conductors

Structurally the same as surface-accessible wellheads and conductors, these subsea structures do not possess conductor casings that connect them to the ocean surface. Subsea wellheads are subject to the same regulations and requirements for plugging, abandoning, and removal, but they often require modified removal operations. In the case of explosive severing, the charge must be set using a diver or ROV either internal or external to the target. If the wellhead is being severed after the drilling of a dry hole, operators will most often use the drilling unit on hand to lower a mechanical or abrasive water jet cutter down the drill string to sever the structure. Like their surface-accessible counterparts, subsea wellheads may also require external severing operations depending on conditions and logistics.

1.4.5.1.3. Subsea Production Devices

Much like the production equipment found tied to conductors on surface structures (Christmas trees), subsea production devices consist of valve assemblies designed to help produce the well, test the system, or shut-in operations if warranted. Subsea trees are assembled completely topside and then lowered to a foundation embedded in the seafloor by the drilling vessel. Once set, the production device is clamped to the casinghead using mechanical or hydraulic controls. Standard decommission procedures for these devices would generally employ the control mechanism(s) used to secure the tree to the casinghead; but, in the case of a mishap or emergency, severing operations may be necessary to disconnect the device from the casinghead or riser or to remove a portion of the tree. The severing device would cut either internally or externally depending on the design of the tree and the type of mishap.

1.4.5.2. Platform-Related Targets

1.4.5.2.1. Jacketed Platforms

Consisting of one or more above waterline decks tied atop a submerged tubular frame, jacketed platforms are the most common non-well structures found in the GOM. There are currently over 2,375 jacketed platforms in place on the OCS, making up about 60 percent of all bottom-founded, surface structures. Brought on location in sections, the platforms are secured to the seafloor by piles driven through the jackets legs, which may number anywhere from 3 to 12 or more with leg and pile diameters spanning from around 18 in (46 cm) to over 96 (244 cm) in (NRC, 1996). Commonly called conventional piles, these pilings are driven tens to hundreds of feet into the seabed and are often grouted or cemented to the surrounding jacket leg for added stability. Once leveled, the deck assemblies, collectively called topsides, are welded to the tops of the piles protruding from the jacket legs with additional bracing where necessary. Most jacketed platforms are typically placed above previously drilled exploration wells to support their production, additional drilling operations, and equipment housing. Though not as common, some platforms are not associated with any well operations and are instead used to support generator, berthing, and storage facilities (DEMEX, 2003).

Conventionally piled structures make up the majority of jacketed platforms on the OCS (Figure 1-4), but in situations where additional load support and/or storm protection is needed, support bracing and sleeves are added to the lower jacket to accept skirt piles. Similar to conventional pilings, the skirt piles are driven deep into the seabed to pin the bracing and jacket; however, the subsea termination of the sleeves requires the use of submersible piling hammers and in many cases ROV's for guidance and observation (CSA, 2004). Skirt pilings may also be grouted to their surrounding sleeves depending upon environmental conditions and platform requirements. In many circumstances, platforms use both conventional piles through the jacket legs in addition to braced skirt pilings to compensate for extreme load weights and stresses.

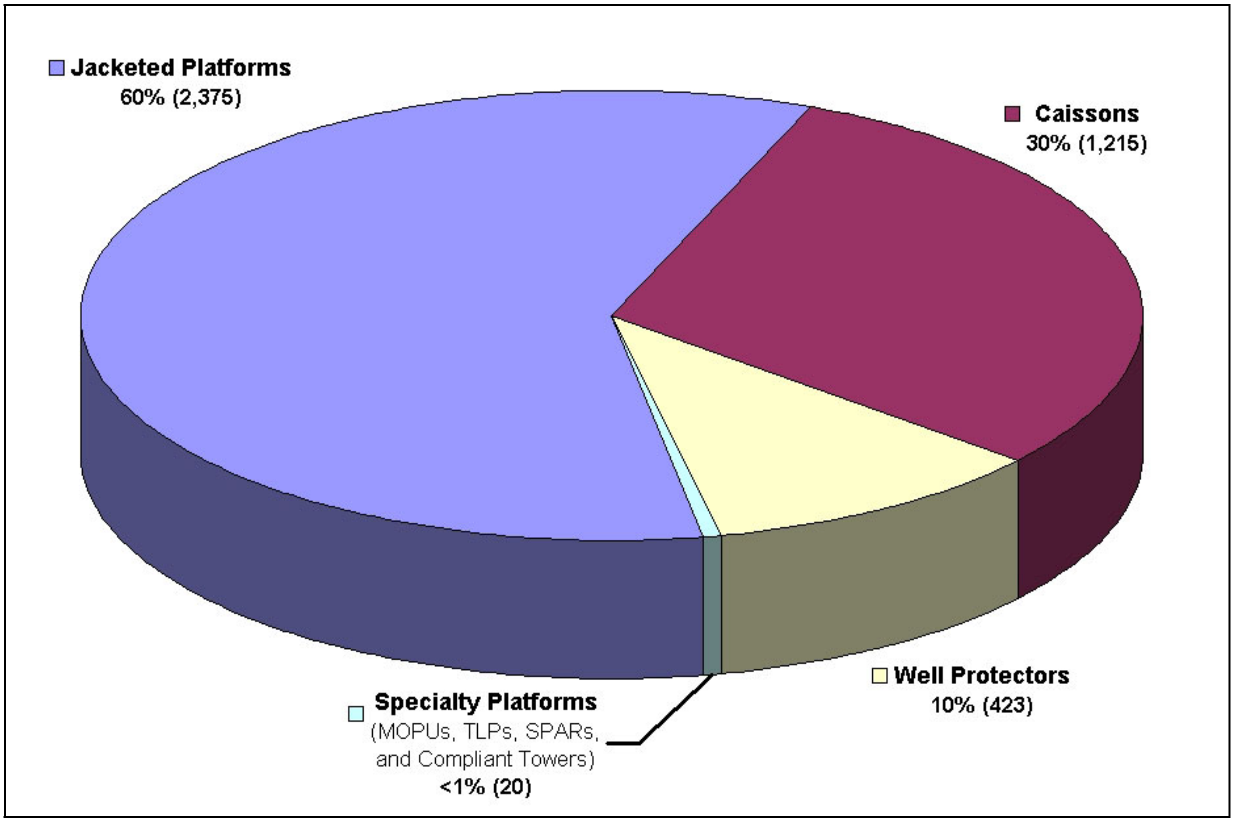


Figure 1-4. Existing Platform-Related Structures on the GOM OCS (Source: MMS Data).

Decommissioning operations for jacketed platforms are generally the reverse of installation procedures. Once lift vessels and associated barges are on location, the previously cleaned and prepped topsides are cut from the jacket by welders and lifted onto a load barge. The pilings are jetted out to the necessary depth to remove any debris or embedded sediments. Any conventional piles, accessible through the jacket legs, can then be severed internally using either nonexplosive cutters or explosive severing charges lowered to the proper cut depth via ropes and/or tackle. The same severing methodologies can be employed for any skirt pilings; however, subsea conditions require the assistance of divers or ROV's for cutter placement. If necessary, the seafloor around the jacket leg/pile assembly could be removed or jetted away to a depth greater than the intended cutting zone to provide access for an external severing device or divers. If the piles were severed using a nondeforming cutter (i.e., mechanical, diamond wire, abrasive water jet cutters, explosive shape charges, etc.), the piles can be pulled out through the legs before the jacket is lifted and placed on a load barge. If the piles were grouted or deformed from severing (typically from bulk explosive cutters), the jacket will often require lifting with the piles in place. Procedures may vary depending on platform design, water depths, and possible reefing options.

1.4.5.2.2. Caissons

Caissons are the second most prolific (30%) surface structures installed in the GOM with over 1,215 structures located primarily on the shallow shelf. Simpler in design and fabrication than traditional jacketed platforms, most caissons consist of a steel pipe of a single diameter that generally ranges from 36 (91 cm) to 96 in (244 cm) (NRC, 1996). The caisson pipe is driven over existing wells to an adequate depth that will allow for shoring against varying sea states. Though primarily installed for well protection, some caissons may also be used as foundations for equipment and terminations points for pipeline operations. In locations with multiple wells and/or deeper water depths, tapered caissons may be employed. The tapered caisson employs a large diameter pipe at and below mudline (10-15 ft), which tapers to a smaller diameter in the water column and at the surface. Depending on the level and type of operation, some caissons may also use conventional or skirt piles to enhance their structural support, with the resulting tripod structure utilizing the caisson as the main leg of the structure. Like conventional platforms, decommissioning operations for caissons depend upon the design of the structure and marine conditions. Large-diameter, shallow-water caissons are commonly cut by divers using torches and arc cutters. When conditions warrant, caissons can also be severed internally or externally using a wide array of explosive and/or nonexplosive cutting devices.

1.4.5.2.3. Well Protectors

Similar to conventional platforms, well protectors consist of small piled jackets (with legs generally less than 36 in), which may or may not support decking. Used primarily to safeguard producing wells and their associated production trees from boat damage and debris, the design of most well protectors tends to avoid the large tubulars and deck reinforcements often necessary for supporting drilling and production equipment. There are currently over 420 well protectors deployed in the shallow shelf areas of the GOM (<60 m), accounting for around 10 percent of all bottom-founded, surface structures. The severing and removal processes for well protectors are similar to those employed in decommissioning larger jacketed platforms, though often less time consuming and much smaller in scale.

1.4.5.2.4. Horizontal and Diagonal Jacket Members

Because of the increasing complexity of platform designs and the growing need for multi-staged salvage operations, contractors are often required to sever horizontal and diagonal members (bracings) on the submerged platform jackets. These braces provide support and stiffening to the jacket assembly, creating a tubular "web" between the platform legs. Diagonal and horizontal cuts on the members allow the jacket to be divided into sections. The decreased weight of the prepared section permits decommissioning contractors to take advantage of smaller lift vessels. Since standard fabrication procedures do not allow for access to the interiors of the members, external cuts must be made (Broussard, personal communication, 2004). Most often, divers are used to sever the submerged members using torches and arc cutters, but several types of mechanical cutters such as guillotine saws, diamond wire cutters, abrasive water jet systems, and hydraulic snips are available and commonly used with diver or ROV assistance. Industry has also indicated that they would like to start using small, external shaped charges to perform member severing. Designed to match tubular dimensions and thicknesses, the shaped charge devices can be deployed with divers or ROV's (DEMEX, 2003).

1.4.5.3. Mooring Related Targets

1.4.5.3.1. Cables, Chains, and Mooring Lines

As industry moves into increasingly deeper waters outside of the range of bottom-founded structures, the need for moored drilling and production facilities has grown greater than ever. With the exception of several dynamically positioned vessels, deepwater drilling operations most often use moored semisubmersibles. Coupled with the growing number of tension leg platforms (TLP's), spars, and mobile offshore production units (MOPU's; converted semisubmersible drilling rigs), operators and contractors have to contend with new demands for quick-disconnect and line severing tools that may be necessary during emergencies and decommissioning operations when the anchor cannot be retrieved.

Some of the mooring systems used in deepwater operations have quick-disconnect technology built into their designs. Using several varieties of exploding bolts, electromechanical couplings, and/or hydraulic-actuated connections, these release mechanisms can be controlled from the vessel and triggered at short notice. In situations where the mooring system disconnects were not employed or become disabled, severing contractors have several mechanical and explosive cutting tools at their disposal for shearing cables, lines, and chains from their moorings.

Mechanical cutters such as wheel and guillotine saws, hydraulic shears, and diamond wire cutters can be deployed using ROV's, allowing the cuts to be performed as close to the anchors as possible. In much the same way, small explosive shaped-charge devices can be positioned onto the mooring targets by ROV's. These external cutters are generally designed with hydraulic/electric actuators and hinge systems that allow the shaped charge to be "clamped" over the target and then detonated after the ROV is removed to a safe distance. Together, these effective severing methods and the deep-diving capabilities of the ROV's allow for full recovery of the lines/cables/chains, which could present a future hazard to commercial fishing gear and navigation.

Industry has also indicated that the same severing methodologies could be used during pipeline or facility deployment activities. During commissioning operations, structures are often bridled with slings and lowered into position above their installation sites. When conditions do not allow for safe load releases using conventional tools or divers, shaped charges can be rigged onto the slings and detonated when the structure is in place or positioned over its foundation (DEMEX, 2003).

1.4.5.3.2. Suction Pile Anchors

Though designed for release from the seafloor during repositioning activities or decommissionings, suction pile anchors that cannot be dislodged or removed may require explosive or mechanical severing. In most instances, lodged suction pile anchors can be treated much the same as the previously mentioned skirt piles. External charges and mechanical cutters may be used, but the tubular design of suction piles would also allow internal severing devices to be placed within the structure. Since the piles often have a diameter of greater than 48 in, an internal explosive charge will have to be large enough to compensate for the reduced hydrostatic head (DEMEX, 2003). A device similar to a suction pile, a suction follower, is used during installation of suction embedded plate anchors (SEPLA). The SEPLA is mounted at the lower section of the suction follower and driven into the seafloor as the follower is drawn down under its own weight and via water displacement within the pile (Dove et al., 1998). If the suction follower cannot be retrieved, severing options similar to those used for standard suction pile anchors can be used.

1.4.5.4. Other Obstructions

1.4.5.4.1. Pipelines

Pipelines are the primary means of transporting produced hydrocarbons from offshore oil and gas fields to onshore processing centers and distribution points. There are currently over 25,000 mi of pipeline in the GOM, which consist of webs of small-diameter gathering lines that link individual production facilities to much larger-diameter trunklines for transport to shore (USDOI, MMS, 2001a). In addition to decommissioning-related severing, industry has also indicated that there is a need for pipeline cutting services throughout the life of the structure (DEMEX, 2003). If a pipeline string becomes entangled or dropped to the seafloor during pipeline installation or maintenance operations, external severing devices will be needed to help in its recovery and repositioning. Marine conditions and water depths often forbid the use of divers; therefore, in many instances, external shaped charges and nonexplosive tools such as hydraulic shears, guillotine saws, and diamond wire cutters can be been deployed from ROV's.

1.4.5.4.2. Cement Structures and Foundations

Cement or concrete formed structures and foundations have been used in oil and gas operations in the GOM for several decades. In some older fields on the shallow shelf, cement piles are used to support structures and facilities similarly to the more common steel piles and tubulars. In the more recent deepwater fields, complex cement foundations have been employed to secure moorings, tendons, and riser assemblies of floating drill vessels and production facilities (i.e., TLP's, spars, etc.). The majority of these cement foundations are designed to use multiple steel piles for anchoring the structure to the seabed, and in most cases, the piles could be severed in the same manor as subsea skirt piles (Chapter 1.4.3.2.1).

For removal operations involving cement or concrete piles, most contractors would attempt to perform the below mudline cuts with external severing devices since their solid design would not allow access for internal cutters. The nature of the targets and cutting conditions often limit cutting options to diamond wire cutters and explosives. After jetting around the structure sufficiently for a 15-ft BML cut, the target can then be reached by a diamond wire cutter or fitted with explosive charges. Cement can also be present around the base of jackets in large masses. This often happens when steel piles are grouted (cemented) to their surrounding jackets or skirt bracings and cement is unintentionally released into the water column (e.g., "packers" fail). In decommissioning or site-clearance operations, the amorphous shapes of the slabs necessitate explosive charges to break up the concrete for complete removal. In these situations, the explosives could be placed inside the slab via drilled access holes or saddled above or below the target (DeMarsh, personal communication, 2003).

1.4.6. Pre-Severing Operations

The first step in a structure-removal operation is the development of a decommissioning plan and schedule. It is the responsibility of a project management team to assess the nature of the operation, taking into consideration, among other things, the target structure(s), marine conditions, available services (e.g., lift vessels, severing subcontractors, etc.), and initial operator preferences. The management group could be within the company, an independent 3rd party team, or a specialized unit within a decommissioning contractor group (i.e., a "turn-key" company) that offers a complete removal package (TSB and CES, LSU, 2004). Depending on the operation, bid proposals are sought, and once all contractors and subcontractors are selected, the management team sets schedules and secures all of the required permits and licenses. Any requisite preparatory work commences on and near the structure, which could include pipeline flushing and securing, equipment removal, tank/deck cleaning, and survey work. When set, all of the necessary personnel (e.g., welders, equipment operators, severing technicians, etc.), vessels (e.g., derrick/jack-up barge, tugs, load barges, etc.), and support equipment (e.g., severing tools, ROV's, etc.) are mobilized on station at the structure site.

Once the lift vessel is on location and positioned, personnel and equipment are staged to begin preliminary work on the structure. For subsea targets such as casing stubs, divers or ROV's are used to assess the target, conduct any necessary surveys, and assist in either deploying or conducting the BML severing methodology. For surface structures such as caissons and jacketed platforms, a temporary gangway is secured to allow the cutting crews and riggers access to the structure. Depending on the size and design of the platform, modules such as generator shacks and berthing compartments, as well as other large components (e.g., flaring booms, crane assemblies, etc.), may need to be cut/disconnected from the topsides and removed. The remaining topsides assembly is then cut from the piles/jacket, lifted, and secured on the load barge. When required, welders connect scaffolds and bracing around the open piles to allow for personnel and equipment access. If internal pile severing will be conducted, crews then install and operate jetting equipment down the pile to washout the existing mud plug (most often sequentially). Once all piles are jetted and gauged (i.e., internal clearance verification) to the proper cut depth, all unneeded equipment is removed from the structure and the severing operations can commence.

1.4.7. Severing Operations

A varied assortment of severing devices and methodologies has been designed to cut structural targets during the course of decommissioning activities. These devices are generally grouped and classified as either nonexplosive or explosive and they can be deployed and operated by divers, ROV's, or from the surface. Which severing tool the operators and contractors use takes into consideration the target size and type, water depth, economics, environmental concerns, tool availability, and weather conditions. A complete discussion of the economic considerations behind severance methodology can be found in *Modeling Structure Removal Processes in the Gulf of Mexico* (Kaiser et al., 2004).

A summary of the different severing tools available in the GOM is provided below (Sections 1.4.7.1 and 1.4.7.2). A complete description of the operational and socioeconomic impacts of nonexplosive severing methodologies can be found in *Operational and Socioeconomic Impact of Nonexplosive Removal of Offshore Structures* (TSB and CES, LSU, 2004). Detailed information on explosive severing tools and its related impacts is found in *Explosive Removal of Offshore Structures; Information Synthesis Report* (CSA, 2004). Both documents are available through the Public Affairs Office, MMS Gulf of Mexico Region, New Orleans, LA or at http:\\www.mms.gov.

1.4.7.1. Nonexplosive Tools

Nonexplosive severing tools are used on the OCS for a wide array of structure and well decommissioning targets in all water depths. Based on 10 years of historical data (1994-2003), nonexplosive severing is employed exclusively on about 58 (~37%) removals per year (Table 1-1). Since many decommissionings use both explosive and nonexplosive technologies (prearranged or as a backup method), the number of instances may be much greater. Over the next 5 years, MMS estimates that 55-94 structure removals could employ nonexplosive severance annually. Nonexplosive severing tools could also be used in other OCS-related activities that are not directly involved in decommissionings or abandonments, such as platform installation, facility modifications, and structure refurbishing.

With the exception of minor air and water quality concerns (i.e., exhaust from support equipment and toxicity of abrasive materials), nonexplosive severing tools generally cause little to no environmental impacts; therefore, there are very few regulations regarding their use. However, the use of nonexplosive cutters leads to greater human health and safety concerns, primary because (1) divers are often required in the methodology (e.g., torch/underwater arc cutting and external tool installation and monitoring), (2) more personnel are required to operate them (increasing their risks of injury in the offshore environment), (3) lower success rates require that additional cutting attempts be made, and (4) the cutters can only sever one target at a time; taking on average 30 min to several hours for a complete cut (Table 1-4). The last two items are often hard to quantify and assign risks to the cutters, but the main principle is that there is a linear relationship between the length of time any offshore operation is staged and on-site (exposure time) and the potential for an accident to occur (TSB and CES, LSU, 2004). Therefore, even if there are no direct injuries or incidents involving a diver or severing technicians, the increased “exposure time” needed to successfully sever all necessary targets could result in unrelated accidents involving other barge/vessel personnel.

1.4.7.1.1. Abrasive Cutters

Abrasive cutters sever decommissioning targets by using a system that infuses cutting material (i.e., sand, garnet, copper slag, etc.) into a jet of water to wear away the object at a focused point. There are currently two types of abrasive cutters in use today in the GOM; sand cutters and abrasive water jet cutters (AWJ). For most BML cuts, both AWJ’s and sand cutters can be deployed from inside the target, but a few companies offer external AWJ systems that use diver/ROV-mounted equipment. Sand cutters use a power swivel mounted on top of the pile/conductor to turn the cutting nozzle set at the proper cut depth. However, many internal AWJ systems have rotating nozzles and centralizing arms/rings built into the deployed cutting assembly itself, negating the need for a power swivel (Figure 1-5).

Sand cutters and AWJ’s have diverse equipment requirements, which primarily involve the different processes for creating the abrasive slurry. Sand cutters use equipment that mixes the cutting material with a high volume of water (80-100 gal/min) before being pumped through a low pressure (4,000-10,000 psi) cutting nozzle (NRC, 1996). Abrasive water jet equipment is most often designed for air delivery of its abrasive down to a high pressure (50,000-70,000 psi) diamond orifice, where it is mixed at low water volumes (50-80 gal/min) and focused on the target (TSB and CES, LSU, 2004).

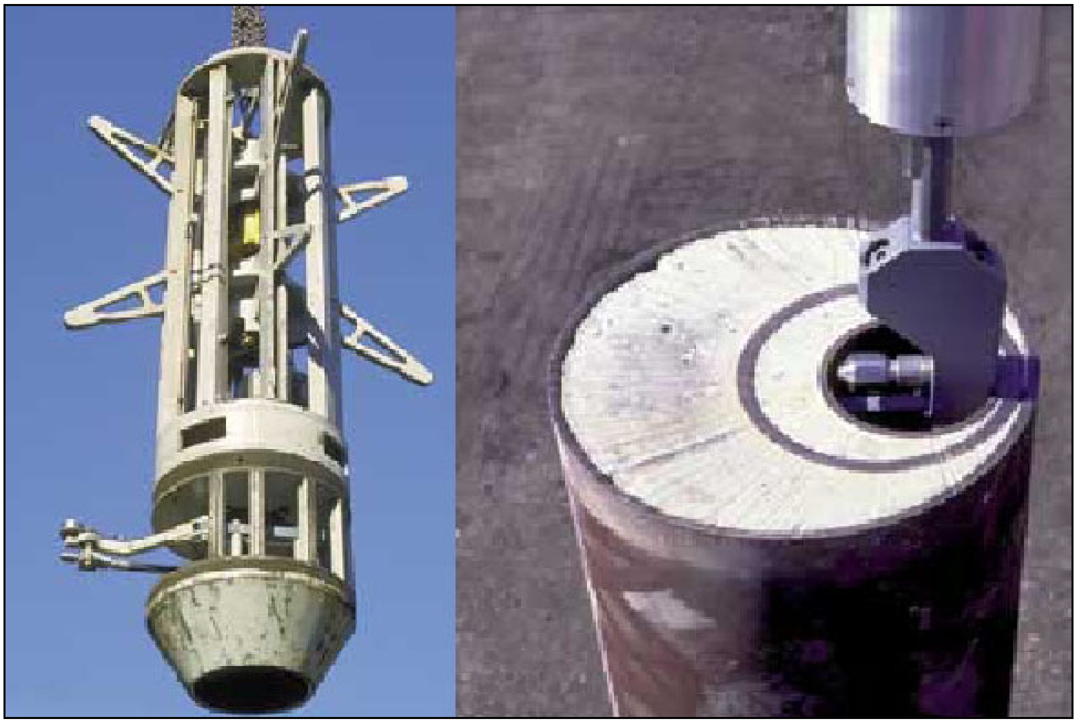


Figure 1-5. Abrasive Water Jet (AWJ) Manipulator Assembly (right) and a Sample Cut on an Eccentrically-Grouted Conductor (Courtesy of Oil States MCS, Inc.).

The distinctions between equipment, pressure, and delivery systems also define what target types and within what water depths sand cutters and AWJ's can be used. Since cutting efficiency decreases with distance to the nozzle, sand cutters are generally limited to uncemented conductors and shallow-water, single-thickness piles that are surface assessable (open-piled). Even though some sand cutting systems can cut up to two cemented casing strings, the power swivel and cutting assembly must be pulled from the conductor so that each cut set of internals can be removed from the well. Most AWJ systems work equally well on piles and grouted conductors (either eccentrically or concentrically set), but if the cutting jet encounters voids or water gaps between the strings, the energy of the jet is decreased and an incomplete cut may occur. The air delivery systems used in most AWJ's also limit its use to shallow-water targets. To contend with the limitations, some AWJ designs are now incorporating a fluid/water delivery system, which can extend the AWJ's cutting range beyond 600 ft with some ROV-deployed units working in 1,100 ft of water (Manago and Williamson, 1998).

With most BML targets, the extremely small cut left by sand cutters and AWJs make severance verification difficult. Since there are no visual indicators, cutter operators often rely on feedback from water pressure or acoustic signals to gauge whether the cut has been completed. At that point, the equipment is removed and the structure is pulled by the crane assembly on the assisting lift vessel. Because the small cut size also does little to decrease the friction or suction made on the target by 15 ft or greater of sediments, the crane often has to pull several times the actual target weight to get the structure to move. If at that point, no movement is recorded, many removal contractors consider the cut unsuccessful and redeploy the cutters or use an alternate severing method (TSB and CES, LSU, 2004).

1.4.7.1.2. Mechanical Cutters

One of the oldest and most widely-used severing technologies in the GOM is mechanical cutters. Also referred to as casing cutters, these devices generally consist of a carbide-blade cutting assembly connected to a string of drill pipe (Figure 1-6). The string is mounted below and rotated by either the power swivel on the drill/workover rig or a pile-mounted swivel. To allow for deployment, the cutter's blades are initially collapsed back against the drill string and lowered into an open pile or conductor. Once set at the proper cut depth, hydraulic pressure (drill water) forces the blades outward while the power swivel rotates the entire assembly (Manago and Williamson, 1998). The assembly continues to turn while the hydraulic pressure steadily forces the blades out, cutting through the pile or casing strings.

Once the pile is severed (platforms) or the outer conductor is penetrated, the cutter is pulled from the tubular. Much like abrasive cutters, it is very difficult to visibly confirm a mechanical cut's success because of the small cut size and the continued sediment friction/suction on the target. When the tool is still deployed, some cutter operators can determine penetration by monitoring the hydraulic/drill water pressure, and when the cutter assembly is withdrawn from the target, from the penetration marks on the blades (TSB and CES, LSU, 2004).

Since centralizers are often used to keep the cutter assembly centered in the tubular, mechanical cutters often produce incomplete cuts when used on eccentrically positioned casing strings. Even if perfectly concentric, grouted/cemented conductors are also problematic for mechanical cutters because the tool needs to be pulled from the target frequently to change dulled blades. Each trip "out of" and "into" the target becomes very time-consuming, and when combined with multiple conductors and/or piles, the on-location time required for mechanical cutters often makes it one of the most expensive methodologies available. In addition, because the cutting blades tend to severely deform outer conductor casings, it is often difficult to remove and recover conductors from platforms/jackets with close-tolerance conductor guides (Manago and Williamson, 1998). If a conductor cannot be pulled, the guides may need to be cut away from the jacket or it may be necessary to leave the conductors in place until the jacket is pulled with the lift vessel; both situations greatly increase operational and human safety concerns.

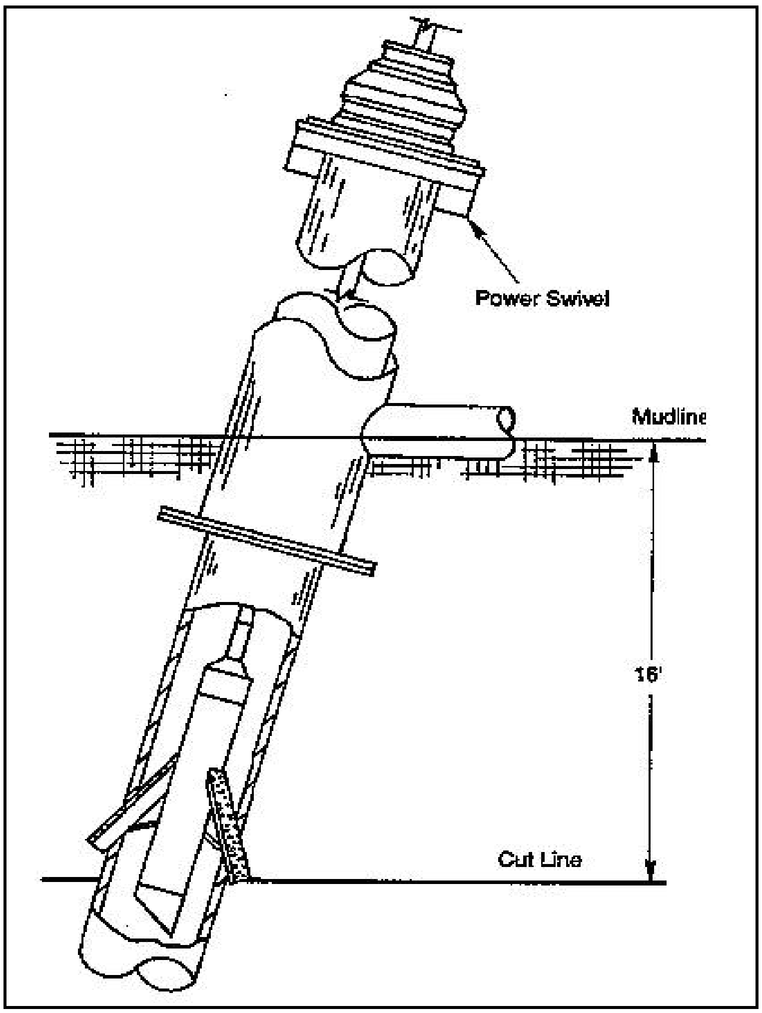


Figure 1-6. Mechanical Cutter Schematic (NRC, 1996).

1.4.7.1.3. Diver Cutters

Divers have been employed by removal contractors for several decades and have been used in almost every phase of decommissioning operations. A component of most barge crews, divers often conduct pre-severing surveys of the submerged sections of caissons, platform jackets, and conductors to determine the structural integrity of the target and in some cases, to search for marine protected species around the structure. Divers are also used to rig slings and other lift-related gear, as well as for installing, monitoring, and/or operating subsea severing equipment (e.g., AWJ's, external cutting equipment, explosive severing charges, etc.). However, the primary use of divers is associated with the use of torch cutting operations. There are two basic cutting torches that divers use: the underwater arc cutter and the oxyacetylene/oxy-hydrogen torch.

Underwater arc cutters use the extreme temperatures (~10,000°F) created by a high-voltage arc between an electrode and the target to melt the contacted metal. The developed flame is shielded and kept from extinguishing by a protective sheath of air, forced out a tube surrounding the torch tip. The compressed air also serves to evacuate the molten metal (plasma) away from the tip of the torch, creating a hole or cut (if drug across the target surface). Arc cutters are similar to standard (surface) arc welding systems in that a comparable power unit supplies the cutter with the necessary DC (direct current) voltage. However, since there are no filler or jointing metals added, the added compressed air system makes the unit function more like a typical plasma cutter (Broussard, personal communication, 2004). Much like the torches used by topside welders, the oxyacetylene/oxy-hydrogen torches used by divers depend on an ultra-high temperature flame created from a mixture of oxygen and acetylene or hydrogen to melt through metal targets. In water depths greater than 25 ft, divers often use torches set with a mixture of oxygen and hydrogen, since the hydrogen tends to be more stable under increased pressures (TSB and CES, LSU, 2004). As an average, a diver using an arc cutter or torch can burn one linear inch of steel per one-inch thickness in one minute, ultimately requiring several hours to conduct a complete cut on a pile or caisson (NRC, 1996).

Since the amount of bottom-time per diver is limited by the water depth and diving method, it is often necessary to use two or more dives or dive teams on a single target. In general, commercial diving methods are split into three categories: (1) compressed air, (2) mixed gas, and (3) saturation diving. Compressed air diving is the most common method used in cutting operations in water depths from the surface down to 200 ft. Mixed gas diving can be employed in water depths down to 300 ft since the diver breaths a mixture of oxygen combined with other gases (e.g., nitrogen [*nitrox*], helium [*heliox*], hydrogen [*hydrox*], or nitrogen/helium [*trimix*]) to control narcosis and limit the chances of decompression sickness (Wienke, 2000). The same mixed gas approach is used in saturation diving, but these operations are conducted from submerged, dive habitats near the work zone that make it possible for a dive team to remain at depth for extended periods (hours to several days). The controlled conditions within the dive habitat also allow the dive team to resurface under pressure and transfer to a shipboard decompression chamber. Saturation divers can be deployed in water depths between 140 and 1,200 ft (Oman, 1994); however, very few diver cutting operations have been conducted in GOM waters deeper than 750 ft (Kline, personal communication, 2004).

Diver cutting is generally limited to single wall, conductive targets such as caissons, pilings, braces, and structural components (NRC, 1996). Though rare, there are instances where diver cutters are used to sever wells, but problems concerning multi-string designs, grouted annular spaces, and trapped explosive gases often make the operations extremely complex and dangerous. In choosing to use divers on BML targets, operators must also consider additional excavation or jetting activities and equipment (Figure 1-7). Besides the standard pile/caisson jetting, external diver cutting on BML targets requires the excavation of a trench around the target to allow the diver access to the cutline. Depending on the sediment conditions and the risk of cave-in, the exterior jetting may need to extend down and out 20 ft from the mudline/target. Internal cutting (diver within the pile/caisson) also requires internal jetting (usually 5 ft below the cutline) to allow the diver access and mobility. In addition, some exterior sediment excavation is necessary to avoid the formation of gas pockets, which could explode when contacted by the torch or cutting arc (NRC, 1996).

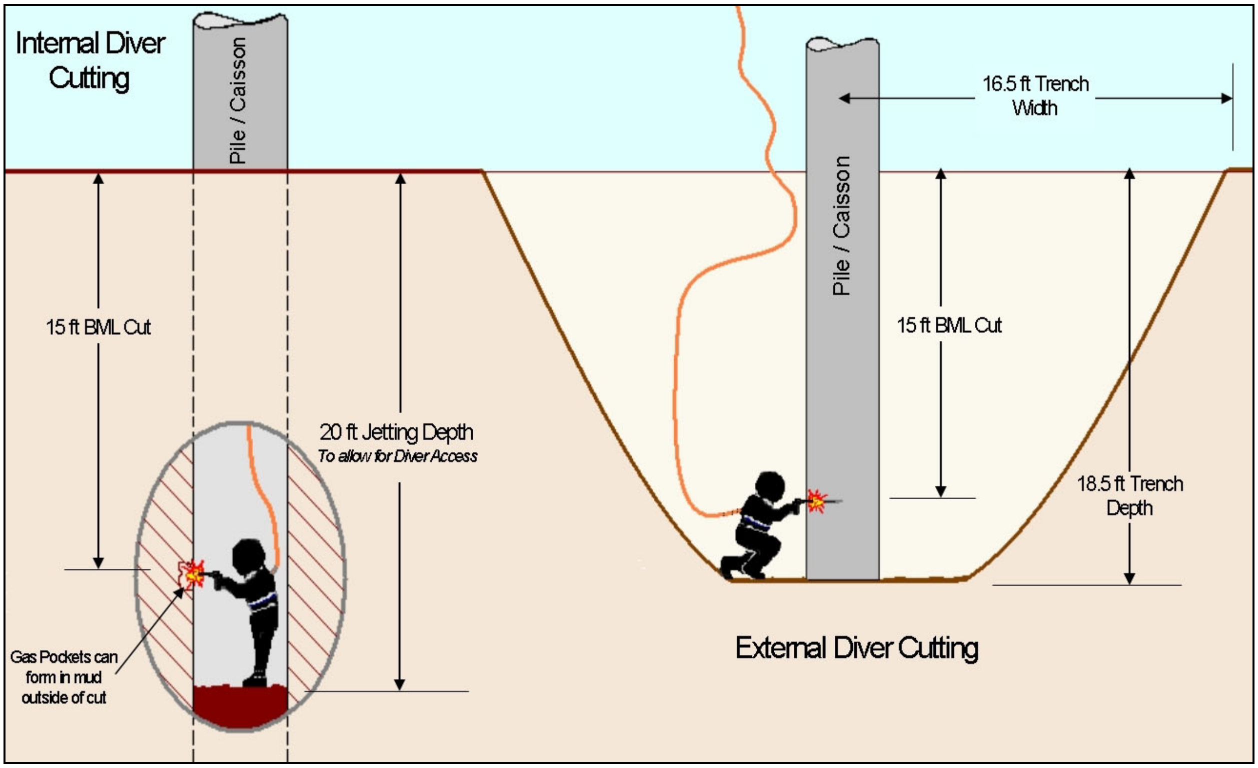


Figure 1-7. Internal and External Diver Cutting Techniques (adapted by MMS from [NRC, 1996]).

1.4.7.1.4. Diamond Wire Cutter

The diamond wire cutter (or diamond wire saw) is the most recent addition to nonexplosive cutting technology on the GOM OCS. Capable of severing most all structural materials with ease, industrial diamonds are embedded into nodules that are set within a steel wire at preset intervals. The wire is strung through the cutter on a group of framed pulleys in an arrangement that resembles a band saw. A set of electrically or hydraulically-driven motors are used to turn the pulleys and draw the wire into the target. Since the diamond wire is unaffected by grouting, internal voids, component composition, or the target's symmetric or concentric design (or lack thereof), the cutter can effectively sever any target upon which it can be configured and fastened. Diamond wire cutters (DWC) have been used to sever caissons, piles, structural braces, wells and conductors, pipelines, and moorings, as well as concrete and wooden objects such as creosote pilings and cement piles. Though not as commonly used as other nonexplosive tools, diamond wire services are being configured and deployed in an increasing number of operations; in both topside and subsea configurations.

For use in subsea operations, large-target DWC's can be deployed by either divers or ROV's, being fastened to their targets by manually or via self-actuating hydraulic/electric clamping systems (TSB and CES, LSU, 2004). Service providers have even designed smaller, ROV-housed and driven diamond wire units for small targets such as jacket members, fasteners, cables, and mooring lines (Figure 1-8). The primary limitation of most of the available diamond wire cutters is that the device can only be used for external installations and severings. Therefore, when a standard cutter is required for a BML cuts on piles, caissons, and wells, evacuation and jetting services must be employed for trenching around the targets (similar to diver cutting requirements) to allow for the mounting of the cutting assembly (Michel, personal communication, 2003). However, recent advancements in DWC technology has led to the creation of a modified cutting system that allows for BML severing without jetting or excavating. The "sub-bottom-cutter" is deployed to the seabed from a surface crane, and once in location, deploys a jetted tubing system to each side of the target (i.e., pile, conductor, well equipment, etc.) that tracks the diamond wire through the tubular and surrounding sediments (Hargrave, personal communication, 2004). Since the cutter's capabilities are impervious to the mud plug within and surrounding the target, no pile jetting is required.

Figure 1-8. Diamond Wire Cutter Mounted to a ROV's Manipulator Arm (Courtesy of CUT USA, Inc.).

1.4.7.1.5. Other Nonexplosive Cutters

Though not often used in BML severing, a tubular cutting tool called a guillotine saw is available and can be employed by divers or ROV's to cut horizontal, diagonal, and vertical structure members, conductors, and pipelines during decommissioning activities (Figure 1-8). Once secured to the tubular, the guillotine saw uses toothed, high-speed steel or carbide blades that are drawn back and forth across the target's surface in much the same manor as a hacksaw. Several different size guillotines are available to sever targets with a diameter of 2 to 32 in. The saws can be powered by pneumatic, electric, or hydraulic power, and once installed (~5 minutes), the guillotine saw can sever most tubulars and even grouted conductors in less than 60 min (E. H. Wachs Company, 2003). A series of hydraulic shears have also been developed to sever a number of targets during removal operations (Figure 1-9). Primarily deployed from ROV's, these shears can be used to cut steel mooring cables and wire (up to 6 in) and riser assemblies up to 12 in diameter (WEBTOOLS-SUBSEA, Inc., 2004). Several rotary cutting tools have also been deployed from ROV's to cut mooring lines and small tubulars; however, their limited capabilities often limit their use to non decommissioning severing jobs.

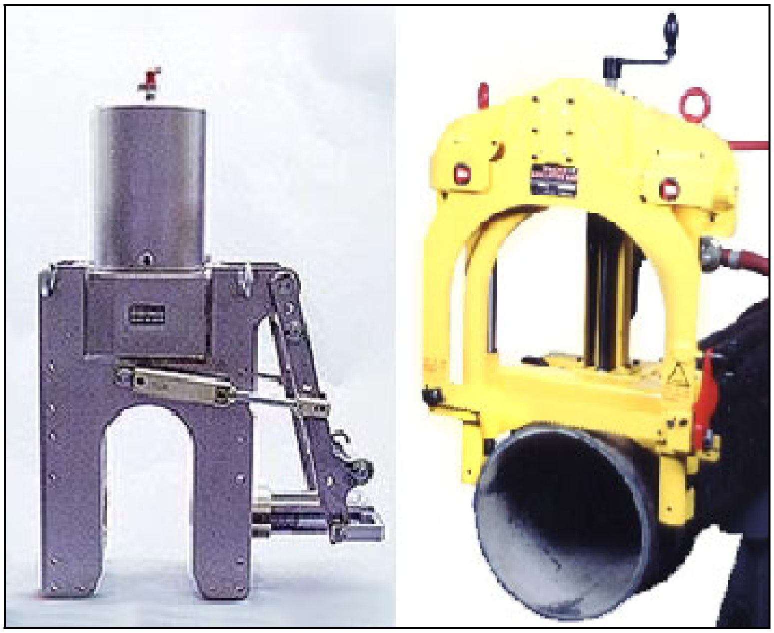


Figure 1-9. Hydraulic Shear (*right*—Courtesy of WEBTOOLS-SUBSEA, Inc.) and Guillotine Saw (Courtesy of E.H. Wachs Company).

1.4.7.2. Explosive Tools

A number of explosive severing tools have been designed for use in decommissioning operations on the GOM OCS. Depending on their configuration, explosive charges can be deployed on almost all structural and well targets in all water depths. Historically, explosive charges are used in about 98 (~63%) decommissioning operations annually (Table 1-1), often as a back-up cutter when other methodologies prove unsuccessful. Some explosive severing tools have been used in other OCS (but non decommissioning-related) activities, with some recent examples that include pipeline/hard-bottom trenching, emergency repair work, marine salvage (e.g., pipelines, vessels, etc.), and with explosive bolt sets and connectors used in quick-release mechanisms (e.g., moorings, riser assemblies, and installations).

Explosives work to sever their targets in three primary ways:

1. Mechanical distortion (ripping);
2. High-velocity jet cutting; and
3. Fracturing or "Spalling"

Mechanical distortion is best exhibited with the use of explosives such as standard and configured bulk charges. Bulk charges use the impulse (shock) wave and outwardly expanding gases created by their detonation to apply stress to the proximal target, with the ensuing strain resulting in mass distortion and rupturing (Cooper and Kurowski, 1996). If the situation calls for minimal distortion and an extremely clean severing, most contractors rely upon the jet-cutting capabilities of shaped charges. In order to 'cut' with these explosives, the specialized charges are designed to use the high-velocity forces released at detonation to transform a metal liner (often copper) into a thin jet that slices through its target at a single location or along a delineated line (CSA, 2004). The least used method of severing currently in use on the GOM OCS is fracturing. In fracturing, a specialized charge(s) is used to focus pressure waves into the target wall and use refraction forces to spall or fracture the steel on the opposing side (NRC, 1996). Even if the target is not completely severed using a fracture charge, the fracturing/heat stress often allows the lift vessel to "jerk" the spall line apart.

Like the previously-addressed nonexplosive severing options, explosive tools have the potential for both positive and negative impacts depending upon an operation's economic, environmental, and safety considerations (Table 1-4). Public concern tends to center on any offshore activities that have the potential to cause harm to marine protected species, most notably sea turtles and marine mammals, which could be harmed by the shock waves and acoustic energy released during an underwater detonation (USDOI, MMS, 2002). Details on the impacts of explosive charges can be found in Chapter 4, Environmental Consequences.

There is a wide range of explosive materials available for use in severing charges in GOM decommissioning activities. Severing contractors are responsible for assessing the type of material needed based upon its characteristics in relation to the target size and design, specific marine conditions, and potential methods of charge deployment. Several of the key characteristics of explosive materials are defined in Table 1-5, and Table 1-6 lists the specific properties of most of the commonly used explosive materials. A general discussion of commonly used cutting charges is included below.

Table 1-4

Concerns and Potential Impacts of Severing Methodologies

Method	Concern	Positive Impact	Negative Impact
Nonexplosive	Economic	No mitigative restrictions 24-hour severing No special permits required	Moderate to high cost per severing Slow, sequential cutting rates increase support costs (e.g., lift vessels, personnel, etc.) More personnel required for operation Entails extensive planning / engineering Low successful-cut ratios (except DWC) Costs increases with water depth Perimeter jetting/excavation often required (for BML diver/external cuts)
	Environmental	No damaging pressure or acoustic energy released No fish kills	Minor air / water quality concerns (i.e., equipment emissions, cutting slurry toxicity, excavated sediments, etc.)
	Safety	No special handling procedures Lift vessel can remain stationed during severing activities	Risks when divers used for cutter setting/deployment High risks when divers perform arc/torch cutting operations More personnel required for operation Increases "exposure time"
Explosive	Economic	Low to moderate cost per severing Potential for rapid, multiple severings decreases support costs Less personnel required Minimal planning/engineering Costs not affected by water depth	Costly mitigative measures required Daylight severing only Special permits required (USCG)
	Environmental	Decreased air emissions (i.e., no support equipment and decreased barge times)	Shock waves / acoustic energy released at detonation could harm or kill MPS Fish kills Minor water quality concerns
	Safety	Reduces "exposure time" Less personnel required on station No diver arc/torch cutting needed	Risks when divers used for charge setting/deployment Special handling procedures required Lift vessel required to 'back-off' at detonation

* Adapted by MMS from NRC (1996).

Table 1-5

Key Properties of Explosives Used in Severing Activities (DEMEX, 2003)

Name	Principal Uses*	Velocity (m/sec)	Density	Brisance	Water Resistance	Specific Energy (watts/g)	Weight Strength (%)
Initiating Explosives (Primary)							
Lead Azide	4	5,300	5.00	0.39	Fair	466	39
Diazodinitrophenol (DDNP)	4	6,600	1.63	0.92	Fair		76
Lead Styphnate	4	5,200	2.90	0.40	Fair	470	40
High Explosives (Secondary)							
Pentaerythritol tetranitrate (PETN)	2,3,5	8,400	1.70	1.73	Good	675	96
Cyclonite (RDX)	1,2,3,5	8,750	1.76	1.57	Good	675	93
Homocyclonite (HMX)	1,2,5	9,100	1.91	1.45	Good	664	93
Trinitrotoluene (TNT)	1,2,3,5	6,900	1.65	1.00	Good	488	74
Ammonium Picrate (Explosive D)	1,2,5	7,150	1.60	1.25	Poor	321	70
Nitroglycerin (NG)	1,5	7,600	1.81	1.81	Fair	720	96
Nitroglycol (NGC)	1,5	7,300	1.48	2.06	Fair	780	105
Nitromethane (NM)	1,2,5	6,290	1.14	1.33	Fair	533	86
Hexanitrohexaazaisowurzitan (HNIW)	1,2,5	10,300	2.10				
High Explosives (Tertiary)							
Composition B	1,2,5	7,840	1.68	1.30	Good		
Composition C-4	1,2,5	8,040	1.59	1.32	Good		
Cyclotol 70/30	1,2,5	8,060	1.73	1.31	Good		
Octol 75/25	1,2,5	8,643	1.81	1.16	Good	503	
Plastic Bonded (PBX9404)	1,2,5	8,800	1.86	1.37	Good		
Pentolite 50/50	1,2,5	7,465	1.66	1.22	Good	588	
Detasheet	1,2,5	7,300	1.62	1.12	Good	495	
Torpex (Aluminized Explosive)	1,2,5	7,500	1.81	1.64	Good	867	
Blasting Gelatin	1,2,5	7,300	1.50	1.91	Fair	740	100
HTA-3 Aluminized Explosive	1,2,5	7,870	1.90	1.19	Good	573	
Binary Explosives							
Binex 42P	1	4,000	1.50		Good		
Helex (Liquid, Solid)	1,2,5	7,100	1.14		Good		85
PLX (Liquid, Liquid)	1,2,5	6,200	1.14	1.27	Good	535	85
Kinepak (Solid, Liquid)	1,5	6,100	1.15		Good		80

*Principle Uses:
1—Demolition Charges; 2—Shaped Charges; 3—Detonating Cord; 4—Detonator Primer; 5—Metal Severance

Table 1-6

Key Characteristics of Explosive Materials

Characteristic	Definition as Applied to Explosive Material
Velocity of Detonation	The speed in which the explosive changes through a chemical reaction from a solid (or liquid) state to a gaseous state. *Low Velocity Explosives* change from a solid to a gaseous state over a sustained period up to 400 m/sec (1,300 ft/sec). *High Velocity Explosives* change to a gaseous state almost instantaneously at roughly 1,000 m/sec (3,821 ft/sec) to 10,300 m/sec (33,795 ft/sec), producing a very high pressure wave (up to 5,800,000 psi or 40 mPa).
Density	The amount of a substance contained within a specific area (the ratio of the mass of a substance to its volume). Density is an important characteristic of explosives, as the detonation rate relates directly to the square of the density (somewhat, but the higher the density in a given explosive, the higher the detonation rate).
Brisance *or* Shattering Effect	The rapidity with which an explosive develops its maximum pressure. *Brisance* is normally compared to Trinitrotoluene (TNT=1.00) and numbers >1.00 are desirable, and gives an estimate of the destructive power of the given explosive on steels. Brisance is more important in bursting charges than their strength.
Specific Energy *or* Enthalpy	The heat available from a fuel, or in the case of explosives, the working performance of explosive material per kilogram.
Strength *or* Weight Strength	The ability of a given amount of explosive to perform useful work (as in rock and earth blasting) and is compared to blasting gelatin, a composition of 92% nitroglycol and 8% guncotton, that has a strength of 100%.

1.4.7.2.1. Bulk Charges

Besides being the most common explosive cutters, bulk charges are the most often-used severing tools used on the GOM (CSA, 2004). As the name implies, the charge is made up of a bulk amount of explosive material (e.g., Composition B, C-4, HMX, etc.), designed to sever their targets using the mechanical distortion and subsequent ripping resulting from the shock wave and expanding gas bubble released during the charge's detonation. Bulk charges can be developed and engineered in several different configurations depending upon marine conditions, available support services, and target characteristics.

For internal cuts on surface accessible or "open-pile" targets, bulk charges can be deployed by hand or with the deck crane, lowering the charge to the required cut depth with ropes and harnesses. Divers and/or ROV's are required for the placement of externally-deployed bulk charges or in cases where internal bulk cutters are needed to sever subsea targets (e.g., skirt piles, casing stubs, and well heads). Depending on the charge configuration, divers may also be necessary to deploy some bulk cutters for the internal severing of surface-accessible, large-diameter caissons.

Standard Bulk Charge

Standard bulk charge cutters rely upon minimal designs that center on a simple container that holds the main charge and booster. Depending upon the explosive materials' pliability or viscosity, the charge container may consist of a section of polyvinylchloride (PVC) pipe, capped at both ends. A harness assembly consisting of nylon/polypropylene ropes or stainless wire line is generally fixed to the container or housing, allowing the explosive technicians (blasters) to lower the charge into the target or for guiding and positioning charges into subsea targets by ROV's or divers (Figure 1-10). The rope or line also gives the blaster a place to secure the fragile detonation cord and or signal wire so that it does not become chafed or damaged during the charge placement. Once the charge is at the proper cut depth, a brace or "t-bar" assembly is fastened to the rope/wire to maintain the charge's positioning and allow the blaster (and all other personnel, equipment, vessels, etc.) to be "backed-off" the target for detonation.

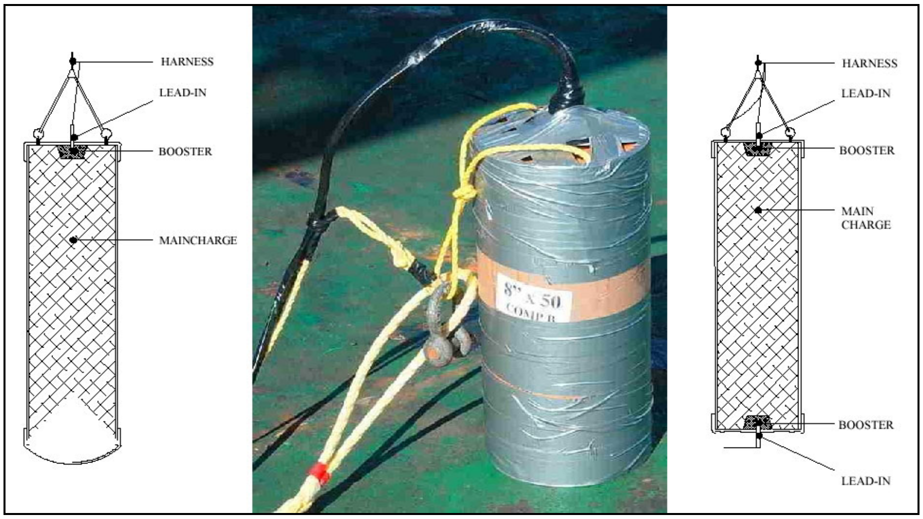


Figure 1-10. Simple Bulk Charge Design, Rigged 50lb Charge (center), and Double-Detonation Bulk Charge Design (Courtesy of DEMEX, Int.).

Double-Detonation Bulk Charge

Similar to a standard bulk charge cutter, the double-detonation bulk charge employs two or more boosters and detonation signals, often located at opposite ends of the cutter. When initiated, the forces of the dual detonations collide with one another at the midpoint of the charge, creating an outward focused force used to distort and mechanically sever its target (Manago and Williamson, 1998). Like a standard bulk charge, double-detonation cutters are assembled with simple components (i.e., PVC pipe, duct tape, rope/wire harnesses, etc.) making them fairly inexpensive and easy to develop.

Ring-Configured Bulk Charge

The ring-configured charge is a bulk charge design that employs a donut or ring-shaped charge housing that allows more of the explosive to be placed closer to the target wall (Figure 1-11, *left*). The increased efficiency often allows the overall charge weight to be reduced by 10-15%, over standard bulk charges for the same size target (NRC, 1996). Like standard bulk charge housings, the ring-configured charge form can be built from PVC tubing, making them easy to design and deploy. Borrowing from double-detonation charges, the ring charge can also be designed with multiple boosters and detonation signals, further enhancing its effectiveness. One alternation on the charge's housing design uses flexible tubing such as semi-rigid pipe or fire hoses to form a "flexible linear" bulk charge. Deployed only by divers, the flexible charge housing is situated around the inner periphery (internal cut) or outer diameter (external cut) of a target and braced into position with fill material or sandbags (DEMEX, 2003).

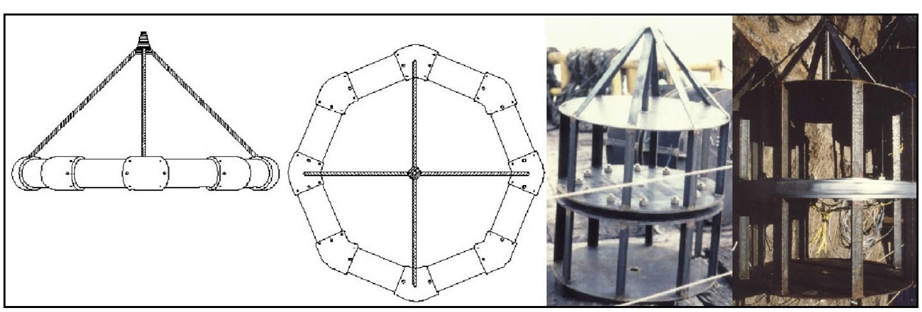


Figure 1-11. Ring (left) and Focusing-Configured Bulk Charge (DEMEX, 2003 and MMS Staff Photo).

Focusing-Configured Bulk Charge

Focusing-configured bulk charges use specifically-designed charge housings to direct their explosive power towards the target in a horizontal manner; ultimately increasing the efficiency of the cut and reducing the flaring that commonly occurs in standard bulk charges (Figure 1-11). These charges take advantage of the principle of "tamping" or "stemming;" an energy enhancement process that uses overlying layers of steel and or concrete in the charge housing to confine and focus the explosives (CSA, 2004). Much more complex than other bulk charges, the housings for focusing charges must be specially fabricated and sized for each particular target diameter prior to mobilizing offshore. The overall weight of the charge, housing, and tamping material often necessitates cable harnesses and handling duties are delegated to a deck crane; especially for large diameter targets.

1.4.7.2.2. Shaped Charges

Unlike the ripping affect achieved by bulk cutters, shaped charges are intended to sever targets by jet-cutting. Shaped charges utilize special housings that are designed to create a cavity or void between the explosive material and target wall. Employing a phenomenon known as the Monroe Effect, the shock wave produced at detonation accelerates and deforms the shaped housing into a high-velocity (24,000-27,000 fps) plasma jet within the void space (JRC, 2002). The formed jet is able to cut through steel targets of various thicknesses based upon the void shape and the "stand-off" distance to the target wall (Figure 1-12). Because the "cutting" efficiency of shaped charges is several times greater than that of bulk charges, they can often greatly reduce the net explosive weight needed to sever similar-sized targets. However, since shaped charges require an air gap within the void/stand-off space for proper jet formation, waterproof casings and casing deployment devices require prefabrication several weeks in advance; ultimately resulting in four to five times higher cutter costs (NRC, 1996).

Conical-shaped charges (CSC) have the cavity created in the shape of a cone designed to cut round holes and to penetrate deep into targets. Industry's primary use of CSC's is in the development of perforating guns; multiple CSC assemblies placed down boreholes and detonated to penetrate through the drill casing and into the surrounding geologic strata for the extraction of hydrocarbons. Linear-shaped charges (LSC) have a void shaped into a chevron or inverted "v" along its entire length, and they are designed to cut linearly through its target. Subcontractors use LSC's on a wide range of decommissioing targets in many different configurations depending on cutting requriements.

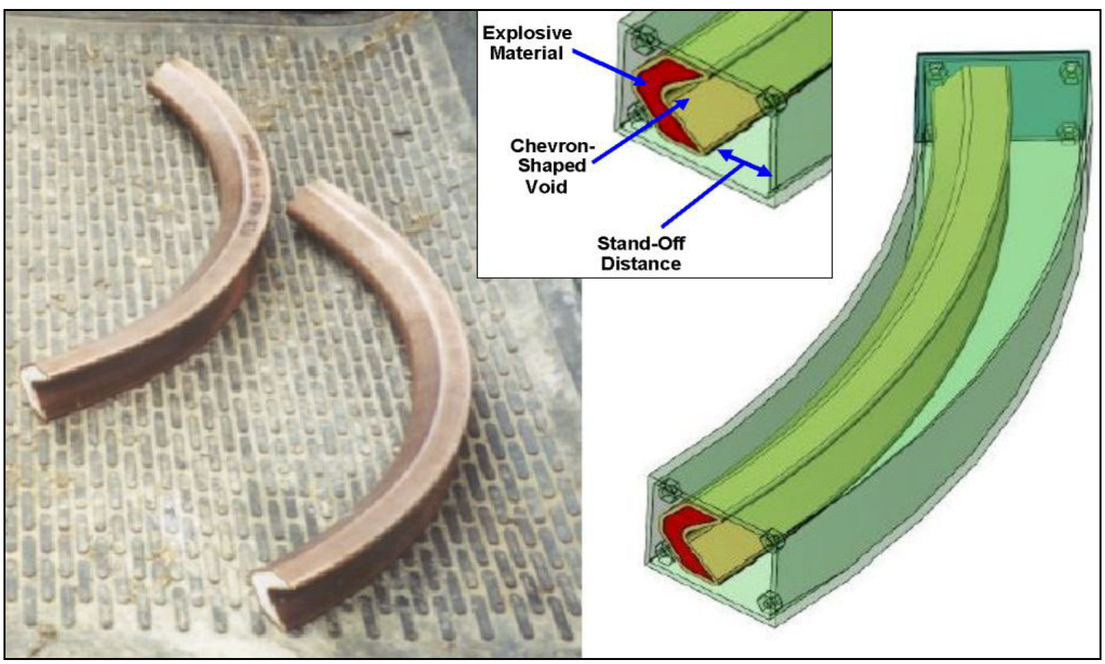


Figure 1-12. Internally-Deployed LSC's and Casing Diagram (Saint-Arnaud et al., 2004).

Internally-Deployed Shaped Charges

If LSC's are deployed to sever piles, the charge housings are required to be curved to a specific arc (depending upon the inner diameter (ID) of the target) with the void space on the convex surface. Likewise, the waterproof casing(s) require the same orientation to lie perfectly against the inner periphery of the target wall, holding fast to the charge housing inside while accounting for the proper stand-off distance (Saint-Arnaud et al., 2004). Since most severing targets are not entirely concentric and are often fabricated with "stabbing guides" (internal alignment braces within piles), the LSC housing and respective casing cannot be constructed or deployed as a single, 360º component. For this reason, some internal LSC's are designed to be deployed via a charge-delivery device that can be inserted into a target retracted, navigated past any obstructions to the required cut depth, and then mechanically actuated to position the casings (generally 2 or 4) tightly against the target wall (Figure 1-13). Another common practice relies upon divers to deploy each component (i.e., charge housing, det-cord, and bracing), especially when used to sever large diameter caissons. Once at the proper cut depth and oriented, the diver braces the charge housing snug to the target with simple turnbuckle rigging.

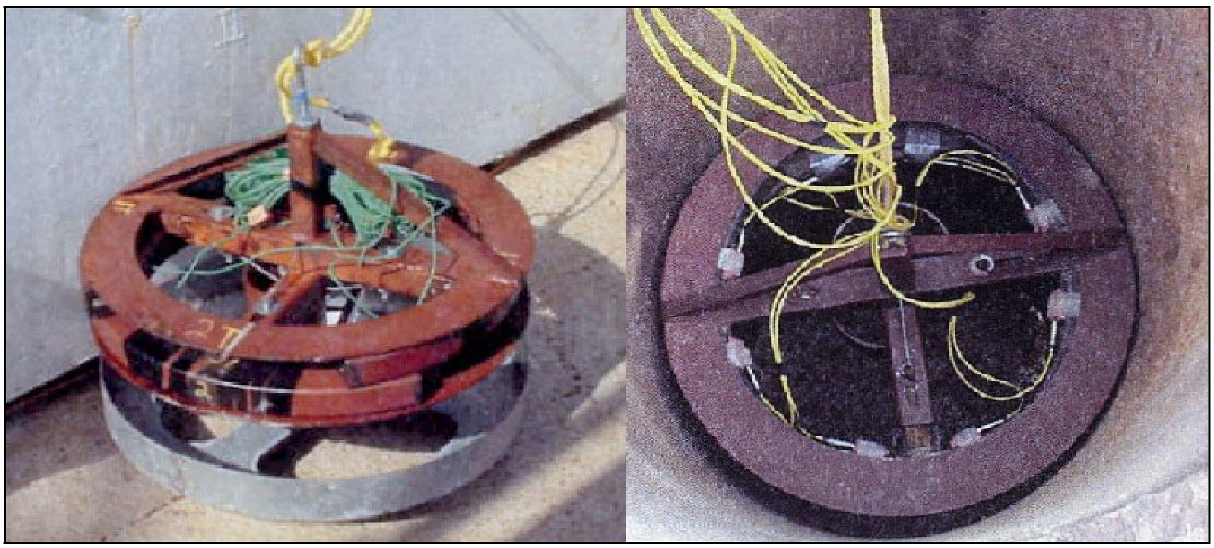


Figure 1-13. LSC Delivery System with Retracted Casings (*left*) and a Similar Design Being Lowered into a Pile (Courtesy of Explosive Services International; Saint-Arnaud et al., 2004).

When LSC's are used for internal severance of conductors, "casing cutter" devices have been designed and prefabricated with compensation/tolerances for the specific ID of most of the common casing sizes. Though used in some small-pile decommissioning work, the primary use of casing cutters in the GOM is for well-workover operations and P&A activities. As described in Chapter 1.4.4.1.1 (Wellheads and Conductors (Surface-Accessible), some well activities necessitate severing the smaller, internal casings that are pulled to allow larger casing cutters to sever the outer casings or conductor itself. Because of the small ID of most casings, most of the charges use less than 3-4 lb of explosives to achieve effective cuts.

Externally-Deployed Shaped Charges

Linear shaped charges can also be used to conduct external severings. As with internally-deployed LSC's, externally-deployed charge housings are required to be curved to a specific arc, but in this case, dependent upon the target's outer diameter (OD). The void space is also required to be formed on the concave surface so that its cutting jet is directed inward. Similarly, the casing(s) are oriented in the same manner with the proper stand-off distance figured into its design depending upon the wall thickness of the intended target. Since external LSC's generally encounter fewer obstructions, the housings and waterproof casings are often constructed in two piece designs, which can be deployed by either divers or via specialized ROV configurations (Figure 1-14). This feature is highly-beneficial for AML cutting, but as with other external BML severing methods, operators must first employ sediment jetting around the target to allow for diver/ROV access and charge deployment.

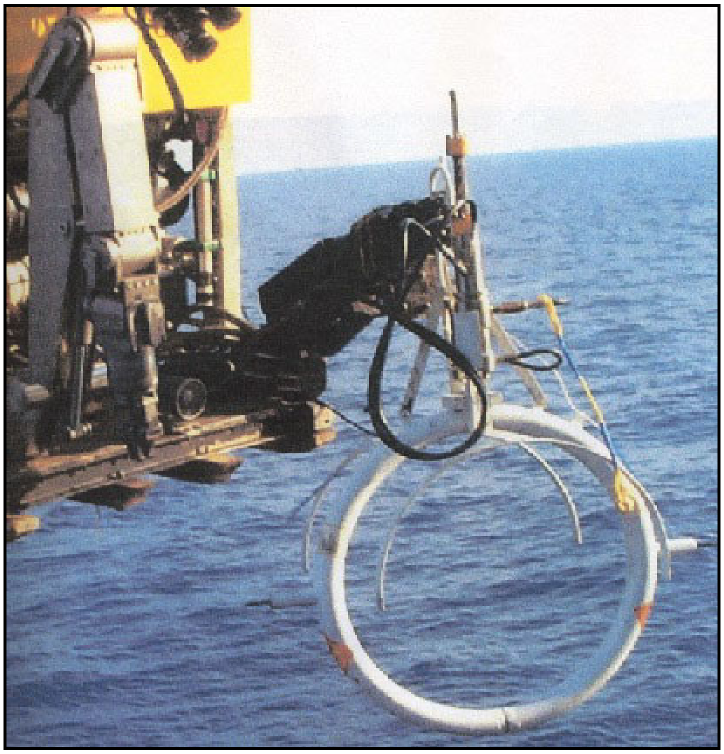


Figure 1-14. Externally-Deployed LSC Mounted to ROV (JRC, 2002).

1.4.7.2.3. Fracturing Charges

Fracturing charges are currently the least used explosives cutting tools on the GOM. Generally available as "plaster" or shock-refraction cutters, fracturing charges sever targets by taking advantage of the reflected shock wave resulting from the initial force developed during detonation (NRC, 1996). The wave propagation results in spalling or fracturing of the target wall opposite of the charge, with the ensuing gas bubble expanding and causing the completion of the cut. Not very effective on wells or grouted piles, fracturing charges are primarily available in the form of an adhesive-backed tape, which has always required divers for deployment (CSA, 2004). Severing contractors are currently working on improvements to the charges, including charge delivery systems that could negate the need for divers.

1.4.8. Post-Severing Operations

Once the operator completes their severing activities, the structures must be removed from the seabed and transported to its final destination (i.e., salvage yard, alternative location, reef site, etc.). Similar to its pre-severing duties, the on-station lift vessel is responsible for the post-severing hoisting of the cut material out of the water and onto a load barge or comparable transport vessel. If the lift vessel cannot pull the structure free from the sediments, on-station supervisors will decide whether or not to reattempt the severing method or to revert to a backup cutter. When preparing the initial decommissioning plan, the project management team works with engineers to establish minimum load requirements for the contracted lift vessel. The preplanning must take into consideration the target size and weight as well as the additional lift capacity needed to "break-suction" or overcome the friction placed on the cut structures by the surrounding sediments (TSB and CES, LSU, 2004).

1.4.8.1. Standard (Complete) Lift and Load

Depending on load arrangements, lift vessels generally begin by pulling any severed conductors first, slipping them from the jacket/caisson conductor guides. When removing jacketed or skirt-piled structures, the lift vessel then extracts the severed piles from the jacket legs or skirt bracings. If the cut method (i.e., bulk charges or a mechanical cutter) resulted in flaring or severe distortion of either the conductors or piles, the lift vessel will often pull all the components together. Any flaring will be cut by welders on the load barge or lift vessel once pulled from the water and secured along side or on deck.

As previously mentioned, preplanning takes into consideration the proposed severing methodology; therefore, if the potential exists for a complete lifting of the entire structure, an adequate lift vessel(s) is generally contracted. If necessary, large jackets can be "back loaded" onto a load barge, taking advantage of ballast and deballast assistance from the either the barge and/or the prepared jacket assembly itself. All of the lifted components are ultimately arranged on the load barge and sea-fastened (i.e., welded and braced) to the deck to facilitate transport (Figure 1-15) to its final destination (e.g., new location, salvage, recycling, or reefing).

Figure 1-15. Four-Pile Jacket, Topsides, and Components (TENNECO ST59 "A") Sea-Fastened to a Load Barge on Route to Morgan City, Louisiana, for Recycling and Scrapping (MMS Staff Photo).

1.4.8.2. Sectioned Lift and Load (Hopped)

Regardless of the preplanning, equipment availability sometimes conflicts and competing platform installation schedules necessitate the use of a lift vessel that does not possess the capabilities to successfully hoist a complete jacket assembly out of the water and onto a load barge or vessel deck. If divers or applicable severing methodologies are available, the company has the option of sectioning the jacket assembly underwater after all BML cuts are made and verified. Though rarely used in the GOM, a company may also need to employ a process called "progressive transport" or "hopping," which allows for the controlled, surface-accessible sectioning of oversized jacket assemblies by a limited-capacity lift vessels.

To conduct progressive transport of a jacket, following the BML severing and cut verification of all bottom-founded components, welders install closure plates atop of all exposed jacket legs or piles. Valve assemblies built into each of the closure plates allow compressed air to evacuate water from the tubulars, deballasting the jacket and making it buoyant (TSB, 2000). After being hoisted by and secured to the stern of the lift vessel, the jacket is then towed to a previously-surveyed location in shallower water (Figure 1-16). At the new site, the jacket is ballasted and set back onto the seafloor, exposing several additional feet of the structure above the water. From this position, welders can return to the jacket and set up scaffolding, which allows them to remove the closure plates and begin cutting all of the necessary legs, piles, and diagonal/vertical bracing. Once complete, the severed jacket section is rigged, lifted, and secured to a load barge. If the lift vessel is still not capable of lifting the remaining jacket assembly, welders reattach the closure plates, and the procedure is repeated until a complete lift and load can be accomplished (TSB and CES, LSU, 2004).

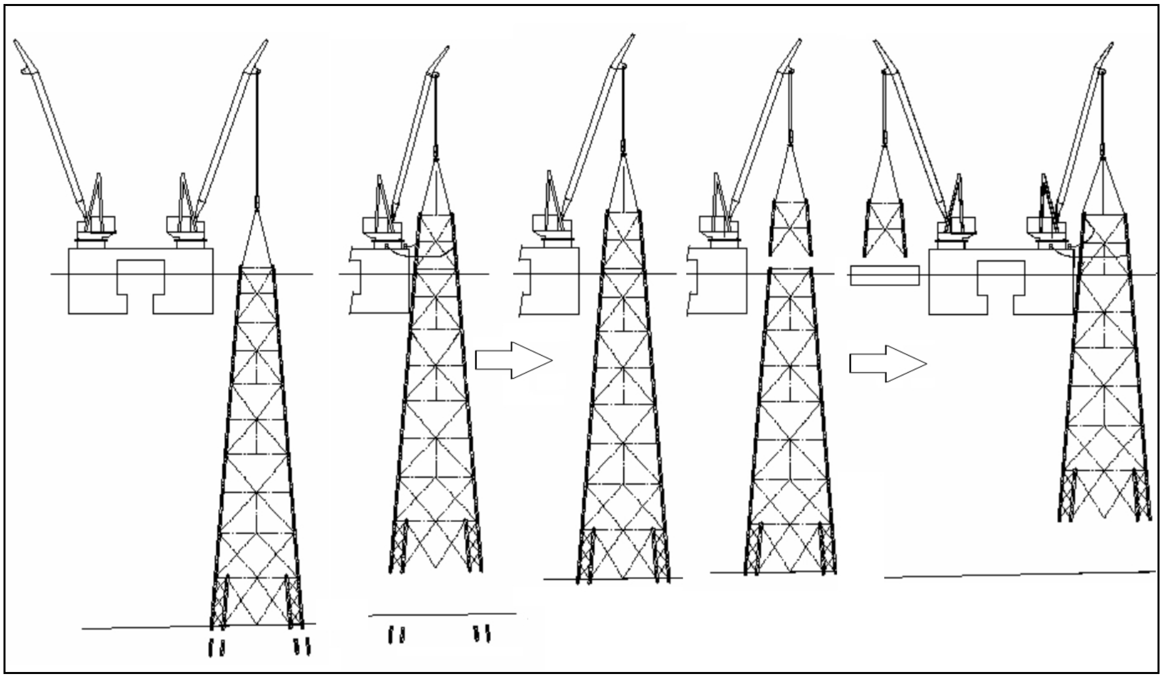


Figure 1-16. Progressive Transport or "Hopping" to Section a Large Jacket (TSB, 2000).

1.4.8.2.1. Component Recycling and Disposal

Even though some complete assemblies (i.e., jackets, topsides, and related equipment) have been transferred to other OCS locations for reinstallation, the final destinations for the majority of decommissioned structures are scrap and fabrication yards located along the coast of Texas, Louisiana, Mississippi, and Alabama. Components such as jackets and piles are brought to scrap yards and stripped of any non-steel elements (e.g., navigation aids, grouting, wooden/tire bumpers, etc.) to allow for their dissection into manageable portions for subsequent barging to steel-recycling plants. The removed drilling/production equipment, topsides assemblies, and subsea components are often returned to fabrication yards or refurbishing centers to be resold to other operators and reused at other facilities. Operators have also discussed the rare practice of deep ocean disposal (DOD) of abandoned structures and their components, which could be cost effective for the future decommissioning of several large, jacketed platforms in the deepwater fields of the GOM (Pulsipher and Daniel, 1999).

1.4.8.2.2. Artificial Reef Development

In addition to reusing or scrapping decommissioned structures and components, operators have the option to participate in the Rigs-to-Reef (RTR) Program. Working under direction of the National Fishing Enhancement Act (Chapter 1.5.7) and State agency guidance, MMS played a key role in establishing the RTR Program, which allows operators to take advantage of potential savings and to help improve the marine ecosystem by converting their decommissioned structures into artificial reefs. Since 1982, over 150 decommissioned platforms have been converted to artificial reefs for fisheries enhancement, allowing operators to save a portion of their decommissioning cost while simultaneously donating over $20 million to the respective State agencies (Dauterive, 2000). A summary of the primary methodologies currently used to convert decommissioned structures into artificial reefs is provided below.

Abandonment in Place

The simplest method of developing an artificial reef (i.e., reefing) is by abandoning the structure in place. From an ecological standpoint, allowing the structure to remain untouched in its upright orientation causes the least amount of disruption to the biological community and could lead to a greater degree of fisheries diversity throughout the entire water column (Reggio, 1987). Based upon economics, leaving the jacket and topsides completely intact would also result in minimal expenditures for drilling or production equipment flushing and removal, baring any additional liability for the structural and navigation aid maintenance. However, since authority and all future upkeep of the structure would have to be delegated to a responsible party (the State agency with an accompanying, "sizable" donation), this method of platform conversion is least likely choice and only in areas of strategic importance (Carr and Moore, 1989).

Partial Removal

The partial removal method of RTR conversion strikes a balance between the potential economic advantage for the operator and the overall ecological benefit for the resident biota. When an operator chooses to conduct partial removal operations for a structure, the operator first completes their preliminary equipment and component removal activities, which allow for the severing and removal of the topsides and upper portion of the jacket. The amount of jacket severed below the waterline depends on the water depth, navigational restrictions, and agency requirements (i.e., COE, USCG, etc.), with the standard cut depth generally allowing for 65-85 ft of clearance above the remaining jacket segment (TSB, 2000). In most cases, because the deck assemblies are left connected to the pile and jacket, external cutting devices are required to conduct the mid-water column severances of the jacket legs and bracings, piles, and any associated conductors or risers. These cutting methodologies may include diver torch/arc cutters, guillotine saws, diamond wire cutters, and externally-deployed AWJ's, configured bulk charges, and LSC's. With the upper jacket and deck portion severed, a lift vessel is used to lower it to the seafloor.

Because severing and support equipment and vessels are still required, the primary economic benefits for the operator result from not having to conduct BML cutting, contract a large lift vessel, or assume the liability for structure maintenance, navigation aids, or future removal requirements (Carr and Moore, 1989). Even though some temporary biological impacts could occur where the upper jacket segment is removed, the overall ecological benefits would be offset with the severed segment's expansion of the overall lateral, benthic area of the artificial reef (Reggio, 1987).

Toppling

The design, location, and marine environment surrounding some decommissioning targets make them good candidates for toppling operations. With these conversions, the topsides are secured and removed (or placed on the seafloor), and only enough piles and conductors are severed to allow the structure to "hinge" over when pulled with tugs. The biological community of the upper structure is temporarily impacted during the toppling, but the ecology of the reef site recovers quickly once new, horizontal extension is repopulated (Reggio, 1987). As with partial removal conversion, the economic incentives for the operator center on the reduced equipment requirements and elimination of maintenance and navigation liabilities.

Full Removal and Replacement

The most expensive method of reefing, a full removal and replacement, is essentially a complete decommissioning project where the severed and extracted components are barged or pulled to a new reef site for abandonment. Ecologically, the complete removal would totally destroy an established artificial reef (the platform in its original setting), only to develop a new reef system at an alternate location (Reggio, 1987). Economically, full removal conversions are the most expensive, with the cost rivaling or potentially surpassing standard salvage operations as the distance to the predetermined reef site is increased (Carr and Moore, 1989).

1.4.9. Site-Clearance Activities

After all decommissioning work is completed and the structure is salvaged, operators are required to perform site-clearance work to ensure that the seafloor of their lease(s) have been restored to prelease conditions. Based upon requirements found in Subpart Q of the OCSLA regulations (30 CFR 250.1740 to 250.1743), operators have the option of either trawling (with commercial nets) or conducting diver, high-resolution sonar, or ROV surveys over the following structure-based grid areas:

Surface-Accessible Wells:...................... 300 ft radius centered on well location
Subsea Wells: .... 600 ft radius centered on well location
Jacketed Platform: .... 1,320 ft radius centered on platform location
Single-Well Caisson/Well Protector: ..... 600 ft radius centered on structure location
Subsea Template or Manifold: .... 600 ft radius centered on structure location

The regulations contain specific trawling requirements that are designed to facilitate the removal of any small objects or obstructions (e.g., tools, containers, batteries, etc.) that may have been lost or discarded during the operational life of the structure. The guidelines also direct trawlers to conduct their operations in a manner that would avoid causing any impacts to pipelines in the structure area or known archaeological and sensitive biological resources. To avoid the occasion where an unknown obstruction (manmade or biological) could be damaged or cause damage to the trawling equipment, many operators choose to conduct diver, sonar, and/or ROV surveys of the grid area. A common practice with several decommissioning subcontractors uses a high-frequency sonar system (Figure 1-17) to determine geodetic positions for each seafloor obstruction and a dispatched diver(s) or ROV to aid in the recovery or investigation the object (Loggin, personal communication, 2003). Unlike trawling, survey-led recovery activities only disturb the seafloor in a limited area around the obstruction, reducing the potential for additional impacts to the benthic environment.

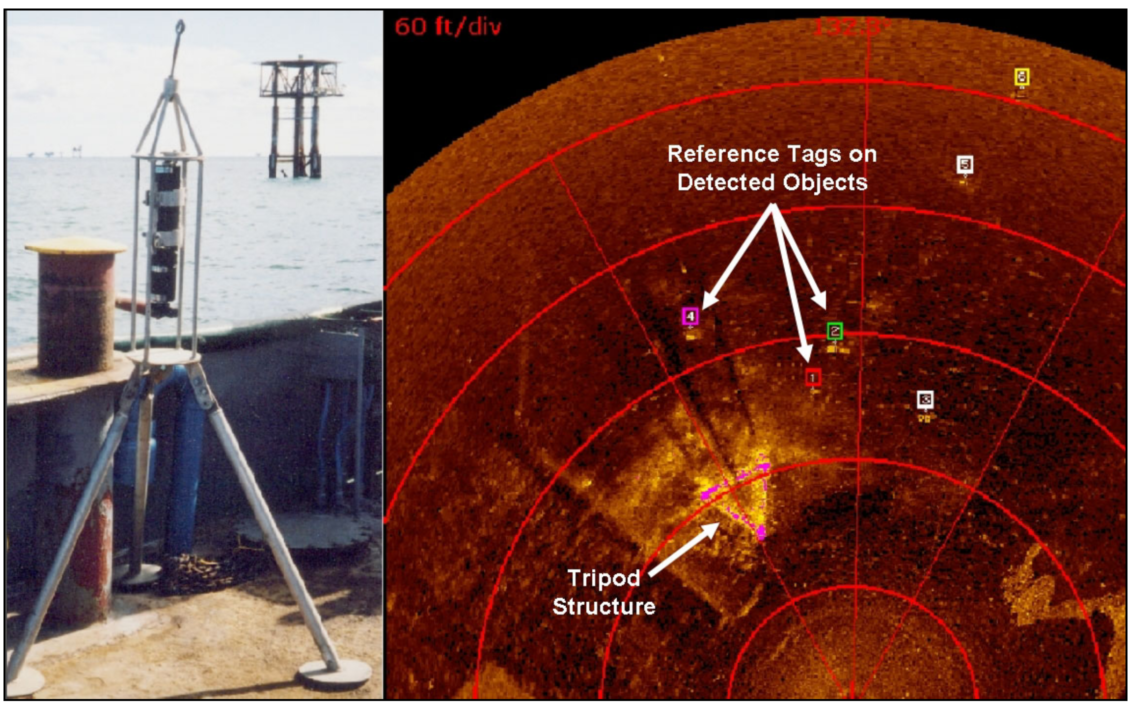


Figure 1-17. High-Resolution, Sector-Scanning Sonar Assembly and Respective Imaging of Decommissioning Site (Source: MMS Staff Photo and Image).

1.5. REGULATORY AND ADMINISTRATIVE FRAMEWORK

1.5.1. Regulatory Hierarchy Summary

The Secretary of the Interior has delegated the MMS responsibility for managing, regulating, and monitoring oil and natural gas exploration, development, and production operations on the OCS. Removal activities and operations on the OCS must comply with all applicable Federal, State, and local laws and regulations. Several Federal regulations establish specific consultation and coordination processes with Federal, State, and local agencies. The MMS regulatory framework is to ensure that removal operations are conducted in a technically prudent and environmentally sound manner and allows MMS to achieve its safety management and stewardship goals. The major laws and regulations applicable to decommissioning operations are summarized below.

1.5.2. National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 *et seq*.) requires that all Federal agencies use a systematic, interdisciplinary approach to protect the human environment; this approach will ensure the integrated use of the natural and social sciences in any planning and decisionmaking that may have an impact upon the environment. In 1979, the Council on Environmental Quality (CEQ) established uniform guidelines for implementing the procedural provisions of NEPA. These regulations (40 CFR 1500-1508) provide for the use of the NEPA process to identify and assess the reasonable alternatives to proposed actions that avoid or minimize adverse effects of these actions upon the quality of the human environment. The CEQ guidelines under 40 CFR 1501.3 allows Federal agencies to prepare an EA on certain Federal actions in order to assist in the planning and decisionmaking process. If the results of the EA conclude that significant adverse environmental effects may occur and cannot be avoided with either mitigation or alternatives to the proposed action, the Federal agency must then prepare a detailed EIS. The regulations also allow agencies to enter into cooperating agreements on NEPA documents (40 CFR 1508.5), as NOAA Fisheries has done with MMS for this PEA (see Chapter 5.4).

1.5.3. Outer Continental Shelf Lands Act

The OCSLA of 1953 (43 U.S.C. 1331 *et seq*.), as amended, established Federal jurisdiction over submerged lands on the OCS seaward of State boundaries. The Act, as amended, provides for implementing an OCS oil and gas exploration and development program. The goals of the Act include the following:

- to establish policies and procedures for managing the oil and natural gas resources of the OCS that are intended to result in expedited exploration and development of the OCS in order to achieve national economic and energy policy goals, assure national security, reduce dependence on foreign sources, and maintain a favorable balance of payments in world trade;
- to preserve, protect, and develop oil and natural gas resources of the OCS in a manner that is consistent with the need
  - — to make such resources available to meet the Nation's energy needs as rapidly as possible;
  - — to balance orderly resource development with protection of the human, marine, and coastal environments;
  - — to ensure the public a fair and equitable return on the resources of the OCS; and
  - — to preserve and maintain free enterprise competition; and
- to encourage development of new and improved technology for energy resource production, which will eliminate or minimize the risk of damage to the human, marine, and coastal environments.

Under the OCSLA, the Secretary of the Interior is responsible for the administration of mineral exploration and development of the OCS. Within the Department of the Interior (DOI), MMS is delegated with the responsibility of managing and regulating the development of OCS oil and gas resources in accordance with the provisions of the OCSLA. The MMS operating regulations are in 30 CFR 250, 30 CFR 251, and 30 CFR 254.

OCSLA Decommissioning Regulations; Subpart Q

Subpart Q of the MMS operating regulations (30 CFR 250.1700 *et seq.*) pertain to decommissioning activities for wells, structures/facilities, and pipelines. Under Subpart Q (30 CFR 250.1710—W*ellheads/Casings* and 30 CFR 250.1725—*Platforms and Other Facilities*), operators are required to remove seafloor obstructions from their leases within one year of lease termination or after a structure has been deemed obsolete or unusable. These regulations also require the operator to sever bottom-founded structures and their related components at least 5 m below the mudline (30 CFR 250.1716(a)—W*ellheads/Casings* and 30 CFR 250.1728(a)—P*latforms and Other Facilities*). The opportunity does exist for the abandonment-in-place of certain seafloor obstructions (30 CFR 250.1716(b)(3)—W*ellheads/Casings* and 30CFR 250.1728(b)(3)—P*latforms and Other Facilities*); however, the obstructions are limited to water depths greater than 800 m (2,625 ft) and need to be addressed on a case by case basis. Additional information establishes site-clearance verification procedures (30 CFR 250.1740 to 30 CFR 250.1743) that may include running trawls, remotely operated vehicles (ROV), or survey sonars over predetermined radii, depending upon water depth and structure type. In addition, guidelines for decommissioning OCS pipelines are found in 30 CFR 250.1750 through 30 CFR 250.1754. The Subpart Q regulations are further described in NTL No. 2001-G08, which provides lessees and contractors with additional information and application/reporting procedures.

Fishermen's Contingency Fund

Final regulations for the implementation of Title IV of the OCSLA, as amended (43 U.S.C. 1841-1846), were published in the *Federal Register* on January 24, 1980 (50 CFR 296). The OCSLA, as amended, established the Fishermen's Contingency Fund (not to exceed $2 million) to compensate commercial fishermen for actual and consequential damages, including loss of profit due to damage or loss of fishing gear by various materials and items associated with oil and gas exploration, development, or production on the OCS. This Fund, administered by the Financial Services Division of NOAA Fisheries, mitigates losses suffered by commercial fishermen because of OCS oil and gas activities. As required in the OCSLA, nine area accounts have been established—five in the GOM, one in the Pacific, one in Alaska, and two in the Atlantic. The five GOM accounts cover the same areas as the five MMS, GOM OCS Region Districts. Each area account is initially funded at $100,000 and cannot exceed this amount. The accounts are initiated and maintained by assessing holders of leases, pipeline rights-of-way and easements, and exploration permits. These assessments cannot exceed $5,000 per operator in any calendar year.

Damages are presumed to be caused by oil- and gas-related items provided the claimant establishes that (1) the commercial fishing vessel was being used for commercial fishing and was in an OCS oil and gas activity area, (2) a report was filed, (3) there is no record in recent nautical charts/weekly USCG *Notice to Mariners* of an obstruction in the vicinity, and (4) no marker or buoy marked the obstruction. Damages or losses occurring within a one-quarter-mile radius of obstructions recorded on charts, listed in the Notice to Mariners, or properly marked are presumed to involve the recorded obstruction.

1.5.4. Endangered Species Act

The ESA (16 U.S.C. 1631 *et seq.*) of 1973, as amended (43 U.S.C. 1331 *et seq.*), establishes a national policy designed to protect and conserve threatened and endangered species and the ecosystems upon which they depend. The ESA is administered by DOI's Fish and Wildlife Service (FWS) and NOAA Fisheries. Section 7 of the ESA governs interagency cooperation and consultation. Under Section 7, MMS consults with NOAA Fisheries and FWS to ensure that activities in the OCS under MMS jurisdiction do not jeopardize the continued existence of threatened or endangered species and/or result in adverse modification or destruction of their critical habitat. A formal consultation concludes with a BO and an ITS. The BO consists of a description of the proposed action, status of the species/critical habitat, the environmental baseline, effects of the action, cumulative effects, and the Services' conclusion of jeopardy/no jeopardy and/or adverse modification/no adverse modification, and reasonable and prudent alternatives, as appropriate. As a matter of policy, the Services require an ITS be included in all formal consultations, except those involving plants. The ITS includes a statement of anticipated incidental take with reasonable and prudent measures, as appropriate, to minimize such take. This statement provides an exemption from the prohibitions of section 9 of the ESA only when the agency and/or applicant demonstrate clear compliance with the implementing terms and conditions, which are binding on the action agency. The NOAA Fisheries issued a BO (July 1988) concerning the impacts of explosive-severing activities used during OCS structure decommissionings on endangered or threatened species, and the agency concluded that explosive severings may injure or kill sea turtles. At present, all sea turtle species occurring in the GOM are listed and protected under the ESA. As part of the ITS issued with the BO, NOAA Fisheries established mandatory mitigation measures that lessees and operators are required to perform whenever explosive severing operations are involved.

Emphasizing a continued need for an incentive to keep explosive weights low, the MMS formally requested that NOAA Fisheries amend the 1988 BO to establish a minimum charge size of 5 lb. NOAA Fisheries SERO subsequently addressed explosive charges ≤5 lb in a separate, informal BO. The October 2003, "de minimus" BO waives several mitigative measures of the 1988 BO (i.e., aerial observations, 48-hr pre-detonation observer coverage, on-site NOAA personnel, etc.), reduces the potential impact zone from 3,000 ft to 700 ft, and gives the operators/severing contractors the opportunity to conduct their own observation work.

According to ESA regulations and the previous BO's, a new consultation must be reinitiated if (1) new information reveals impacts of the proposed activities that may affect listed species in a manner or to an extent not considered thus far in the past BO's, (2) the identified activities are modified in a manner that causes an adverse effect to listed species not previously considered, (3) the amount or extent of incidental take is exceeded, or (4) a new species is listed or critical habitat is designated that may be affected by the operations. As NOAA Fisheries proceeds with rulemaking under the MMPA, they must consult on the proposed rule. When completed, this PEA will become the primary information document for formal consultation that will also consider both the 1988 and 2003 BO's. Pending the outcome of the PEA's impact analyses, the consultation is expected to address the possible impacts of explosive-severing and site-clearance activities on sea turtles and sperm whales in the GOM. It is likely MMS will join NOAA Fisheries in their consultation to allow NOAA Fisheries to also address our agency actions.

1.5.5. Marine Mammal Protection Act

The MMPA of 1972 (16 U.S.C. 1361 *et seq*.), made the Secretary of Commerce responsible for all cetaceans and pinnipeds, except walruses. Authority for implementing the Act within the Department of Commerce (DOC) is delegated to NOAA Fisheries. The Secretary of the Interior is responsible for walruses, polar bears, sea otters, manatees, and dugongs; authority is delegated to FWS. The Act established the Marine Mammal Commission (MMC) and its Committee of Scientific Advisors on Marine Mammals (CSAMM) to provide oversight and advice to the responsible regulatory agencies on all Federal actions bearing upon the conservation and protection of marine mammals. The MMPA also established a moratorium on the taking of marine mammals in waters under U.S. jurisdiction. The term "take" means to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal. Section 3(18)(A)Act defines harassment as:

> any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to migration, breathing, nursing, breeding, feeding, or sheltering.

The terms Level A and Level B harassment correspond to paragraphs (A)(i) and (A)(ii), respectively. Level B harassment is the most common form of taking associated with decommissioning activities. The moratorium may be waived when the affected species or population stock is within its optimum sustainable population range and will not be disadvantaged by an authorized taking (e.g., will not be reduced below its maximum net productivity level, which is the lower limit of the optimum sustainable population range). The Act directs that the Secretary, upon request, authorize the unintentional taking of small numbers of marine mammals incidental to activities other than commercial fishing when, after notice and opportunity for public comment, the Secretary finds that the total of such taking during the 5-year (or less) period will have, among other things, a negligible impact on the affected species. The MMPA also specifies that the Secretary shall withdraw, or suspend, permission to take marine mammals if, after notice and opportunity for public comment, the Secretary finds (1) that the applicable regulations regarding methods of taking, monitoring, or reporting are not being complied with or (2) the taking is, or may be, having more than a negligible impact on the affected species or stock.

In 1989, the American Petroleum Institute (API) petitioned NOAA Fisheries under Subpart A (§228) of the MMPA for the incidental take of spotted and bottlenose dolphins during structure-removal operations. The Incidental Take Authorization regulations were promulgated by NOAA Fisheries in October 1995 (60 FR 53139, October 12, 1995), and on April 10, 1996 (61 FR 15884), the regulations were moved to Subpart M (50 CFR 216.141 *et seq*.). Effective for five years, the take regulations detailed conditions, reporting requirements, and mitigative measures similar to those listed in the 1988 ESA BO requirements for sea turtles. After Subpart M expired in November 2000, NOAA Fisheries and MMS advised operators to continue following the guidelines and mitigative measures of the lapsed subpart pending a new petition and subsequent regulations. At the prompting of industry, NOAA Fisheries released Interim regulations (Subpart M) in August 2002, which expired on February 2, 2004 (67 FR 49869, August 1, 2002).

When complete, MMS will use this PEA as the primary component of its Subpart I petition package. NOAA Fisheries can tier from the PEA for their NEPA compliance with regard to the rulemaking process, expediting the development, review, and publication of new take regulations. Once MMPA regulations are implemented for the required marine mammals at all water depths, NOAA Fisheries will then be able to exempt MMS and operators from ESA section 9 take prohibitions of sperm whales.

1.5.6. Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson Fishery Conservation and Management Act (MFCMA) of 1976 (16 U.S.C. 1251 *et seq*.) established and delineated an area from the States' seaward boundary outward 200 nautical miles (nmi) as a fisheries conservation zone for the U.S. and its possessions. The Act established national standards for fishery conservation and management.

Congress amended and reauthorized the MFCMA through passage of the Sustainable Fisheries Act of 1996. The Act, as amended, established eight Regional Fishery Management Councils (FMC's) to exercise sound judgment in the stewardship of fishery resources through the preparation, monitoring, and revision of fishery management plans (FMP). An FMP is based upon the best available scientific and economic data. The reauthorization also promotes domestic commercial and recreational fishing under sound conservation and management principles, including the promotion and catch-and-release programs in recreational fishing and encouraging the development of currently underutilized fisheries. The reauthorization requires that the FMC's identify Essential Fish Habitat (EFH). To promote the protection of EFH, Federal agencies are required to consult on activities that may adversely affect EFH designated in the FMP's.

1.5.7. National Fishing Enhancement Act

The National Fishing Enhancement Act (NFEA) of 1984 (33 U.S.C. 2601 *et seq*.), also known as the Artificial Reef Act, establishes broad artificial-reef development standards and a National policy of the U.S. to encourage the development of artificial reefs that will enhance fishery resources and commercial and recreational fishing. The Secretary of Commerce provided leadership in developing a National Artificial Reef Plan (NARP) that identifies design, construction, siting, and maintenance criteria for artificial reefs and that provides a synopsis of existing information and future research needs. The Secretary of the Army issues permits to responsible applicants for reef development projects in accordance with the National Plan, as well as regional, State, and local criteria and plans. The law also limits the liability of reef developers complying with permit requirements and includes the availability of all surplus Federal ships for consideration as reef development materials. Although the Act mentions no specific materials other than ships for use in reef development projects, the Secretary cooperated with the Secretary of Commerce in developing the National Plan, which identifies oil and gas structures as acceptable materials of opportunity for artificial-reef development. The MMS adopted a Rigs-to-Reefs policy in 1985 to respond to the NFEA and to broaden interest in the use of petroleum platforms and other oil- and gas-related structures as artificial reefs.

1.5.8. Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) (16 U.S.C. 1451 *et seq*.) was enacted by Congress in 1972 to develop a national coastal management program that comprehensively manages and balances competing uses of and impacts to any coastal use or resource. The national coastal management program is implemented by individual State coastal management programs in partnership with the Federal Government. The CZMA Federal consistency regulations require that Federal activities (e.g., OCS lease sales) be consistent to the maximum extent practicable with the enforceable policies of a State's coastal zone management program (CZMP). The Federal consistency also requires that other federally approved activities (e.g., activities requiring Federal permits or approval) be consistent with a State's CZMP. The Federal consistency requirement is an important mechanism to address coastal effects, to ensure adequate Federal consideration of all CZMP's, and to avoid conflicts between States and Federal agencies. The Coastal Zone Act Reauthorization Amendments of 1990 (CZARA), enacted November 5, 1990, as well as the Coastal Zone Protection Act of 1996 (CZPA), amended and reauthorized the CZMA. The CZMA is administered by the Office of Ocean and Coastal Resource Management (OCRM) within NOAA's National Ocean Service.

Three subparts of the CZMA regulations (15 CFR 930) are directly related to OCS oil and gas activities. Subpart C (15 CFR 930.30 to 15 CFR 930.46) concerns consistency requirements for major Federal actions (e.g., lease sales) and Subpart E (15 CFR 930.70 to 15 CFR 930.85) deals with the consistency review process of plans outlining OCS exploration and production activities. Subpart D (15 CFR 930.50 to 15 CFR 930.66) outlines the requirements for ensuring consistency of any activities requiring a Federal permit or license (e.g., pipeline installation permits and geological and geophysical permits). In accordance with Subpart D guidance, each State CZMP lists which federally licensed or permitted activities could affect their coastal zone. At present, none of the Gulf States include structure-removal permits as listed activities in their CZMP's; however, Subpart D procedures (15 CFR 930.54) provide additional guidance for any "unlisted" activities. This, in turn, would offer each affected State the opportunity to receive and review each structure-removal application for consistency.

1.5.9. Clean Air Act

The 1970 Clean Air Act (CAA) (42 U.S.C. 7401 et seq.) established the National Ambient Air Quality Standards (NAAQS). The CAA required Federal promulgation of national primary and secondary standards. The primary NAAQS standards are to protect public health; the secondary standards are to protect public welfare. Under the Clean Air Act, the U.S. Environmental Protection Agency (USEPA) sets limits on how much of a pollutant can be in the air anywhere in the United States. Although the CAA is a Federal law covering the entire country, the states do much of the work to carry out the Act. The law allows individual states to have stronger pollution controls, but states are not allowed to have weaker pollution controls than those set for the whole country. The law recognizes that it makes sense for states to take the lead in carrying out the CAA because pollution control problems often require special understanding of local industries, geography, housing patterns, etc.

States may have to develop state implementation plans (SIP's) that explain how each state will come into or remain in compliance with the CAA, as amended. The states must involve the public, through hearings and opportunities to comment, in the development of the SIP. The USEPA must approve the SIP, and if the SIP is not acceptable, USEPA can take over enforcing the CAA, as amended, in that state. The U.S. Government, through USEPA, assists the states by providing scientific research, expert studies, engineering designs, and money to support clean air programs.

The CAA established the Prevention of Significant Deterioration (PSD) program to protect the quality of air in the regions of the United States where the air is cleaner than required by the NAAQS. Under the PSD program, air quality attainment areas in the United States were classified as Class I or Class II (a Class III designation was codified but no areas were classified as such). Class I areas receive the most protection. Any new major (250 tons per year or larger) permanent source of emissions is required to receive a review by the Federal permitting agency, and the Federal permitting agency must consult with the appropriate Federal land manager prior to granting approval. The FWS is the Federal land manager for Breton, St Marks, Okefenokee, and Chassahowitzka Class I areas. The National Park Service (NPS) is the Federal land manager for the Everglades Class I area.

The CAA, as amended, delineates jurisdiction of air quality between the USEPA and DOI. For OCS operations in the Gulf of Mexico, those operations east of 87.5ºW. longitude are subject to USEPA air quality regulations and those west of 87.5ºW. longitude are subject to MMS air quality regulations. In the OCS areas under MMS jurisdiction, the MMS regulations at 30 CFR 250 are in force.

The 1990 Clean Air Act Amendments (CAAA) (Public Law No. 101-549)) required that MMS conduct and complete a study to evaluate impacts from the development of OCS petroleum resources in the Gulf on air quality in the ozone nonattainment areas. (Florida was not included in the study area since, at that time, the counties in the Panhandle were in compliance with the Federal ozone standard.) That study was completed in late 1995. Based on the results of this study, the Secretary has consulted with the USEPA Administrator to determine if new requirements are needed for the OCS areas in the Gulf of Mexico that remain under MMS jurisdiction (the areas west of 87º30'W. longitude). Based on the consultation, it was determined that no new requirements are needed at this time.

The MMS air quality regulations are at 30 CFR 250 Subpart C. These regulations are based on potential impacts; as such, the farther away from shore, the larger the allowable emission rate before an air quality impact analysis is required. All OCS plans are required to include emission information and receive air quality review. The regulations allow MMS to select which OCS plans require emissions information for air quality review. In 1994, the Gulf of Mexico Region issued a Letter to Lessees requiring operators to submit standardized emissions information with all OCS plans. This requirement is more stringent than corresponding onshore requirements because MMS applies the same exemption levels and significance levels to temporary sources as it does to permanent sources. Under the onshore PSD regulations temporary sources are typically exempt from air quality permitting requirements. The MMS's impact-based regulations establish a three-tier process for identifying potentially significant emission sources. There are no screening models developed for offshore use. The only model approved by USEPA as a preferred model for modeling offshore emission sources' impacts upon onshore areas is the Offshore and Coastal Dispersal (OCD) model developed by MMS in 1989. The OCD model is based on steady-state Gaussian assumptions.

1.5.10. Clean Water Act

The Clean Water Act (CWA) is a 1977 amendment to the Federal Water Pollution Control Act of 1972. The CWA establishes the basic structure for regulating discharges of pollutants to waters of the United States. Under the CWA, it is unlawful for any person to discharge any pollutant from a point source into navigable waters without a National Pollution Discharge Elimination System (NPDES) permit. The USEPA may not issue a permit for a discharge into ocean waters unless the discharge complies with the guidelines established under Section 403(c). These guidelines are intended to prevent degradation of the marine environment and require an assessment of the effect of the proposed discharges on sensitive biological communities and aesthetic, recreation, and economic values, both directly and as a result of biological, physical, and chemical processes altering the discharges.

All waste streams generated from offshore oil and gas activities are regulated by the USEPA, primarily by general permits. Under Sections 301 and 304 of the CWA, USEPA issues technology-based effluent guidelines that establish discharge standards based on treatment technologies that are available and economically achievable. The most recent effluent guidelines for the oil and gas extraction point source category were published in 1993 (58 FR 12454). Within the Gulf of Mexico, USEPA Region 4 has jurisdiction over the eastern portion of the Gulf, including all of the OCS Eastern Planning Area and part of the CPA off the coasts of Alabama and Mississippi. The USEPA's Region 6 has jurisdiction over the majority of the CPA and all of the WPA. Each region has promulgated general permits for discharges that incorporate the 1993 effluent guidelines as a minimum. In some instances, a site-specific permit is required. The USEPA also published new guidelines for the discharge of synthetic-based drilling fluids (SBF) on January 22, 2001 (66 FR 6850).

Other sections of the CWA also apply to offshore oil and gas activities. Section 404 of the CWA requires a Corps of Engineers' (COE) permit for the discharge or deposition of dredged or fill material in all the waters of the United States. Approval by the COE, with consultation from other Federal and State agencies, is also required for installing and maintaining pipelines in coastal areas of the Gulf of Mexico. Section 303 of the CWA provides for the establishment of water quality standards that identify a designated use for waters (e.g., fishing/swimming). States have adopted water quality standards for ocean waters within their jurisdiction (waters of the territorial sea that extend out to 3 mi off Louisiana, Mississippi, and Alabama, and 3 leagues off Texas and Florida). Section 402(b) of the CWA authorizes USEPA approval of State permit programs for discharges from point sources.

1.5.11. Occupational Safety and Health Act

The Occupational Safety and Health Act (OSHA) of 1970 (29 U.S.C. 651-678) was enacted to assure, to the extent possible, safe and healthful working conditions and to preserve our human resources. The Act encourages employers and employees to reduce occupational safety and health hazards in their places of employment and stimulates the institution of new programs and the perfection of existing programs for providing safe and healthful working conditions. The Act establishes a National Institute for Occupational Safety and Health, which is authorized to develop and establish occupational safety and health standards. The Act also establishes a National Advisory Committee on Occupational Safety and Health.

The Act empowers the Secretary of Labor or his representative to enter any factory, plant, establishment, workplace, or environment where work is performed by employees and to inspect and investigate during regular working hours and at other reasonable times any such place of employment and all pertinent conditions and equipment therein. If, upon inspection, the Secretary of Labor or authorized representative believes that an employer has violated provisions of the Act, the employer shall be issued a citation and given 15 days to contest the citation or proposed assessment of penalty.

1.5.12. Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act (RHA) of 1899 (33 U.S.C. 401 *et seq*.) prohibits the unauthorized obstruction or alteration of any navigable water of the U.S. The construction of any structure in or over any navigable water of the U.S., the excavating from or depositing of dredged material or refuse in such waters, or the accomplishment of any other work affecting the course, location, condition, or capacity of such waters is unlawful without prior approval from the U.S. Army Corps of Engineers (COE). The legislative authority to prevent inappropriate obstructions to navigation was extended to installations and devices located on the seabed to the seaward limit of the OCS by Section 4(e) of the OCSLA of 1953, as amended.

1.5.13. Ports and Waterways Safety Act

The Ports and Waterways Safety Act (PWSA—33 U.S.C. 1223) authorizes the USCG to designate safety fairways, fairway anchorages, and traffic separation schemes (TSS's) to provide unobstructed approaches through oil fields for vessels using GOM ports. The USCG provides listings of designated fairways, anchorages, and TSS's in 33 CFR 166 and 167, along with special conditions related to oil and gas production in the GOM. In general, no fixed structures, such as platforms, are allowed in fairways. Temporary underwater obstacles such as anchors and attendant cables or chains attached to floating or semisubmersible drilling rigs may be placed in a fairway under certain conditions. Fixed structures may be placed in anchorages, but the number of structures is limited.

A TSS is a designated routing measure that is aimed at the separation of opposing streams of traffic by appropriate means and by the establishment of traffic lanes (33 CFR 167.5). The Galveston Bay approach TSS and precautionary areas is the only TSS established in the GOM.

2. ALTERNATIVES

2.1. IDENTIFICATION OF ALTERNATIVES

As a programmatic document, the alternatives analyzed in this PEA are required to address a broad range of activities that could occur during GOM decommissioning operations. The general scope of this PEA will aid in its role as a reference document for future, tiered SEA's; allowing their analyses to focus on site-specific issues and the potential impacts related to individual removal activities. Additional factors that had to be adopted into the alternatives concerned the PEA's subsequent role a supporting document for a MMPA take-regulation rulemaking petition. Rulemaking application guidelines (50 CFR 216.104(a)(1)) require that the petition package and reference information include detailed descriptions of all activities that could result in the incidental take of marine mammals for a complete rulemaking cycle. The alternatives presented in this PEA incorporate necessary information from industry and severing subcontractors, which summarizes and projects their decommissioning needs for the next several years. Under guidance given by NOAA Fisheries, and using the industry information and additional data from several funded studies, MMS developed and evaluated the following alternatives as possible methods of meeting the purpose and need of the proposed action previously described in Chapter 1.2.

2.1.1. Alternatives Analyzed

The three alternatives analyzed in this PEA provide oil and gas operators and their decommissioning contractors with the means necessary to conduct structure-removal operations safely and effectively while successfully adhering to all applicable OCS laws and regulations. Each of the alternatives encompass activities that include: (1) equipment and vessel mobilization and target preparation (Chapter 1.4.6); (2) underwater structural-member severance (Chapter 1.4.7); (3) post-severance salvage (Chapter 1.4.8); and (4) final site-clearance verification (Chapters 1.4.9). All of these activities, including the potential target structures (Chapter 1.4.5), are identical for Alternatives A, B, and C with the exception of underwater severance options. The severance options proposed in each alternative differ based upon the type of cutting tools used, which are classified in this PEA as either nonexplosive (Chapter 1.4.7.1) or explosive (Chapter 1.4.7.2). Additionally, where all of the alternatives propose identical nonexplosive-severance methods, the use of explosive-severance is extensive in Alternative A, limited in Alternative B, and prohibited in Alternative C. Consequently, the alternative summaries (below) and discussions (Chapter 2.2) will focus primarily on the differences between each proposal's explosive-severance options.

Alternative A—Structure-Removal Operations with "Dynamic" Severance Options

Activities addressed under Alternative A (the proposed action) would allow for the severance and removal of all of the structures described in Chapter 1.4.5 in all water depths of the area of the proposed action (Chapter 1.4.2). Severances conducted under this alternative permit the use of all nonexplosive (Chapter 1.4.7.1) and explosive (Chapter 1.4.7.2) severing tools in both internal/external and AML/BML configurations. Because of their minimal impact on MPS, no criteria, restrictions, or mitigation will be established for nonexplosive severance methodologies. However, primarily because of the potentially-harmful pressures and acoustic energy released by underwater detonations, individual explosive-severance charges will be limited to 500 lb and grouped into the following categories:

Very-Small Blasting	0-10 lb BML 0-5 lb AML
Small Blasting	>10-20 lb BML >5-20 lb AML
Standard Blasting	>20-80 lb BML/AML
Large Blasting	>80-200 lb BML/AML
Specialty Blasting	>200-500 lb BML/AML

The blasting categories were developed by MMS in direct coordination with industry representatives from the Offshore Operators Committee (OOC) and the three primary GOM explosive-severance contractors (e.g., DEMEX International, Inc. (DEMEX), Explosive Service International, Ltd. (ESI), and Jet Research Center (JRC)). Industry input on current and future severance needs was provided to MMS in the Explosive Technology Report for Structure Removals in the Gulf of Mexico (ETR; DEMEX, 2003). In addition to recommended blasting categories (minimum and maximum charge sizes), the ETR also provided MMS with descriptions of methodologies, target structures, explosive-charge designs, and general safety concerns.

In addition, all of the explosive-severance activities conducted under Alternative A would be performed in accordance with the mitigation proposed for use in Appendix F. To afford added protection of sea turtles and archaeological, benthic, and infrastructure resources, Appendix F also details vessel mobilization/demobilization, progressive-transport, and site-clearance trawling mitigation measures. Depending upon the future NEPA review of removal applications filed subsequent to this PEA, additional operational and environmental mitigation/guidance could be issued via MMS's SEA and permit approval process. Because of possible MPS impacts, the explosive tools proposed under this alternative would also require formal ESA Section 7 consultation and MMPA incidental-take authorization.

Alternative B—Structure-Removal Operations with "Generic" Severance Options

Alternative B represents the "no action" alternative and continuation of the status quo. Severance activities conducted under this alternative would permit the use of all nonexplosive cutters (Chapter 1.4.7.1) in both internal/external and AML/BML configurations. No criteria, restrictions, or mitigation would be established for nonexplosive methodologies; however, explosive-severance charges would be restricted to the following, status quo categories:

"De Minimus" Blasting	0-5 lb BML
"Generic" Blasting	>5-50 lb BML

Explosive-severance activities conducted under Alternative B would also be limited to the terms and conditions of the "generic" (USDOC, NMFS, 1988) and "de minimus" (USDOC, NOAA, 2003) BO's that are currently applicable to "status quo" operations. For this reason, all explosive activities are limited to targets within the CPA and WPA, with "generic" blasting charges (>5-50 lb) restricted to use in water depths <200 m. As with the proposed action, Alternative B is subject to the mobilization/demobilization, progressive-transport, and site-clearance trawling mitigation measures outlined in Appendix F, and additional operational and environmental mitigation/guidance could be dispensed via MMS's SEA and permit approval process. Even though explosive severance would be limited to status quo levels under this alternative, the continued potential for impacts to MPS would also require formal ESA; Section 7 consultation and MMPA incidental-take authorization.

Alternative C—Structure-Removal Operations with Nonexplosive Severance Options

Activities addressed under Alternative C would allow for the severance and removal of all of the structures described in Chapter 1.4.5 within all water depths of the area of the proposed action (Chapter 1.4.2). Severance activities conducted under this alternative would only permit the use of the nonexplosive cutting tools described in Chapter 1.4.7.1. The nonexplosive cutters could be deployed in both internal/external and AML/BML configurations, with no applied criteria, restrictions, or mitigation. However, the applicable vessel mobilization/demobilization, progressive-transport, and site-clearance trawling mitigation outlined in Appendix F would apply to non-severance activities to afford protection of sea turtles and archaeological, benthic, and infrastructure resources. As with Alternatives A and B, site-specific removal activities may be subject to additional mitigation pending MMS's SEA and permit approval process. Since explosive-severance is prohibited under Alternative C, MMPA incidental-take authorization would not be necessary. However, MMS would still consult formally under the ESA because of the potential for sea turtle impacts that could result from site-clearance trawling activities.

2.1.2. Alternatives Considered but Not Analyzed in Detail

Several other alternatives were considered and reviewed during the early stages of this PEA's development. Ultimately, a viable alternative had to present a programmatic approach, ensure that the purpose and need of this assessment could be met, and be feasible under the regulatory directives of the OCSLA, MMPA, ESA, and other applicable guidance. Table 2-1 lists alternatives that were considered, but dismissed and not analyzed further along with the rationale.

Table 2-1

Alternatives Considered But Not Analyzed

Dismissed Alternative	Reason Not Analyzed
"In-Situ" Abandonment Only (No Decommissionings Permitted)	Not a true "no action" alternative since implementation would require major modifications to OCSLA and RHA regulations to allow for expired-lease obstructions and increased navigation hazards. The abandoned structures would also require continual maintenance and present space-use conflicts with future leaseholders and other potential users of the GOM OCS.
Structure Removals with "Unlimited" Severance Options (No Limit on Explosive Charges)	This alternative prevents proper mitigative planning at the programmatic level and would be problematic for subsequent MMPA rulemaking and ESA consultation efforts since the explosive charge size is used within a model to determine the potential impact zone for marine protected species.
Structure Removals with "Seasonal" Severance Options (Seasonal Removal Restrictions)	Based primarily upon observed "seasonal" movements or behavioral patterns of MPS, this alternative would restrict certain mobilization and severing activities for several weeks or months each year. However, this option would rely upon incomplete seasonal data and fail to account for intermittent decommissioning needs (i.e., emergency removals, lease expirations, etc.).
Structure Removals without Existing or Additional Mitigation (No Mitigation Scenarios)	This alternative was not analyzed in detail based upon the reported effectiveness of the current level of mitigation placed on "status quo" severing activities, which additionally limits explosive charge sizes to 50 lb or less (the Proposed Action increases the level to 500 lb).

It was determined that Alternative A (the proposed action) would best present permittees with all the options available to meet the objectives of the purpose and need (Chapter 1.2) while allowing MMS and NOAA Fisheries to engage in the proper mitigative planning that would benefit effective rulemaking and consultation endeavors to comply with MMPA, ESA, and the OCSLA.

2.2. DESCRIPTION OF ALTERNATIVES

2.2.1. Alternative A—Structure-Removal Operations with "Dynamic" Severance Options (the Proposed Action)

As detailed in Chapter 1.4, Description of the Proposed Action, the measures addressed under this alternative would allow for a complete suite of activities that could be conducted during structure, well, and pipeline decommissioning operations. The first set of these activities to occur on the GOM OCS involve the onsite mobilization of lift and support vessels, specialized equipment, and load barges necessary to receive the salvaged structure. Distinguished as "pre-severance" operations (Chapter 1.4.6), these intensive, though temporary (generally <2 weeks), activities also include the procedures necessary to prepare decommissioning targets for severance (e.g., equipment shutdown, topside cutting/bracing, and sediment jetting).

Once the target is readied, specialized contractors are allowed to deploy either nonexplosive (Chapter 1.4.7.1) and explosive (Chapter 1.4.7.2) cutting tools to conduct required seabed (BML) and or water column (AML) severances. Nonexplosive-severance methods include the use of mechanical, abrasive, and diamond wire cutters or commercial divers outfitted with cutting torches (i.e., arc or gas). The use of these nonexplosive-severance tools under this alternative is expected to result in minimal MPS and marine impacts; therefore, there are no related criteria, restrictions, or mitigation on their use. However, the underwater detonation of explosive-severance tools releases shock wave (pressure) and acoustic energy at levels that may be harmful or fatal to proximal MPS. For this reason, AML/BML explosive cutting tools (e.g., bulk, shaped, and refraction charges) are categorized into 5 separate blasting ranges, and depending upon their use in either a shelf (<200 m) or slope (>200 m) species-delineation zone, would result in 20 separate severance scenarios (Table 2-2).

Table 2-2

Blasting Category Parameters and Associated Severance Scenario Numbers

Blasting Category	Charge Range	Configuration	Species-Delineation Zone	Scenario Number
Very-Small Blasting	0-10 lb	BML	Shelf (<200 m)	A1
			Slope (>200 m)	A2
	0-5 lb	AML	Shelf (<200 m)	A3
			Slope (>200 m)	A4
Small Blasting	>10-20 lb	BML	Shelf (<200 m)	B1
			Slope (>200 m)	B2
	>5-20 lb	AML	Shelf (<200 m)	B3
			Slope (>200 m)	B4
Standard Blasting	>20-80 lb	BML	Shelf (<200 m)	C1
			Slope (>200 m)	C2
	>20-80 lb	AML	Shelf (<200 m)	C3
			Slope (>200 m)	C4
Large Blasting	>80-200 lb	BML	Shelf (<200 m)	D1
			Slope (>200 m)	D2
	>80-200 lb	AML	Shelf (<200 m)	D3
			Slope (>200 m)	D4
Specialty Blasting	>200-500 lb	BML	Shelf (<200 m)	E1
			Slope (>200 m)	E2
	>200-500 lb	AML	Shelf (<200 m)	E3
			Slope (>200 m)	E4

Annual activity projections for each of the explosive-severance scenarios are addressed in Appendix A of this PEA. The approach and steps taken by MMS to model detonation pressure/energy propagation, establish impact-zone ranges, and calculate potential take-estimates related to each scenario are detailed in Appendix E. In addition, Appendix F, Programmatic Mitigation for the Proposed Action, details the parameters of the pre- and post-detonation monitoring and reporting of each scenario necessary to ensure MPS protection.

Alternative A includes all of the post-severance activities related to the lifting, loading, transporting, and salvaging (i.e., artificial reef development, reuse, scraping, etc.) of the decommissioning target (Chapter 1.4.8). The trawling and/or sonar work conducted in the final, site-clearance and verification activities is also afforded under the proposed action (Chapters 1.4.9). Since these and most of the pre-severance activities proposed under this alternative could result in bottom-disturbing impacts on archaeological sites/artifacts and sensitive benthic features, Appendix F includes vessel mobilization and demobilization, progressive-transport, and site-clearance trawling mitigation measures. Depending upon future NEPA review of individual decommissioning applications, additional operational and environmental mitigation/guidance could be issued conditional to permit approval.

Because of possible MPS impacts, the use of explosive tools and/or site-clearance trawling techniques proposed under this alternative would require ESA Section 7 consultation (for sea turtles and sperm whales) and MMPA incidental-take authorization (for all applicable marine mammals).

2.2.2. Alternative B—Structure-Removal Operations with "Generic" Severance Options (the "Status Quo" Action)

Alternative B represents the "no action" alternative and continuation of the status quo. This alternative would include the same suite of pre-severance, nonexplosive cutting, post-severance, and site-clearance/verification activities included in the proposed action (Alternative A). However, explosive-severance methodologies would continue to be permitted under the conditions described in the 1987 PEA (USDOI, MMS, 1987) and the terms, conditions, and mitigation measures of the "generic" (USDOC, NMFS, 1988) and "de minimus" (USDOC, NOAA, 2003) BO's for explosive-severing activities. The scope of status quo limitations on explosive-severances restricts charges to internally-configured, BML cutters that can be used only in the CPA and WPA of the GOM. In addition, explosive charges used in water depths <200 m are restricted to 50 lb, and charges designed for use in water depths >200 m are limited to 5 lb.

As with the proposed action, pre- and post-severance activities included in Alternative B are subject to the mobilization/demobilization, progressive-transport, and site-clearance trawling mitigation measures outlined in Appendix F, and additional operational and environmental mitigation/guidance could be dispensed via MMS's SEA and permit approval process. Even though explosive severance limits would be identical to status quo conditions under this alternative, the continued potential for impacts to MPS would require ESA Section 7 consultation; primarily to address potential impacts to sea turtles captured in site-clearance trawls. Incidental-take authorization under would still be required. Ultimately, despite being the "no action" alternative, the activities proscribed under Alternative B would ensure that the purpose and need of this assessment could be met, and it is feasible under all regulatory directives.

2.2.3. Alternative C—Structure-Removal Operations with Nonexplosive Severance Options

Alternative C would include the same suite of pre-severance, nonexplosive cutting, post-severance, and site-clearance/verification activities included in the proposed action (Alternative A) and no-action alternative (Alternative B); however, all explosive-severance activities would be prohibited. As with Alternatives A and B, pre- and post-severance activities included in Alternative B are subject to the mobilization/demobilization, progressive-transport, and site-clearance trawling mitigation measures outlined in Appendix F, and additional operational and environmental mitigation/guidance could be dispensed via MMS's SEA and permit approval process.

Since severing activities conducted under this alternative would only permit the use of the nonexplosive cutting tools outlined in Chapter 1.4.7.1, MMS determined that no marine mammal impacts would result and an application for MMPA incidental-take authorization regulation will not be necessary. However, since potential sea turtle impacts could result from site-clearance trawling activities, MMS would still consult under the ESA Section 7. Despite the prohibition of explosive severance, the activities proscribed under Alternative C would ensure that the purpose and need of this assessment could be met, and it is feasible under all regulatory directives.

2.3. Comparison of Alternatives

As noted in the previous discussions, the suite of activities included in Alternatives A, B, and C would provide oil and gas operators and their decommissioning contractors with the means necessary to conduct structure-removal operations safely and effectively while successfully adhering to all applicable OCS laws and regulations. The only difference between each alternative relates to the extensive, limited, or prohibited use of explosive-severing tools; of which, MMS identified the primary advantages and disadvantages listed in Table 2-3.

Table 2-3

Comparison of Alternatives — Advantages and Limitations/Additional Requirements Identified by MMS

Alternative	Advantages	Limitations/Additional Requirements
A. Structure-Removal Ops with "Dynamic" Severance Options (Proposed Action)	▪ Multiple charge ranges allow for flexibility and the removal of larger/more-difficult targets. ▪ Larger Standard charge (80 lb) decreases odds of incomplete cuts and high net-weight reshoots. ▪ AML severances expand removal options (i.e., reefing, sectioning, pipeline and mooring cuts, etc.). ▪ Will increase research and development of smaller/more-efficient severance charges. ▪ If used; nonexplosive severance options would result in nominal environmental impacts.	▪ Requires ESA consultation / MMPA authorization because of possible MPS impacts. ▪ Fish kills (some perhaps large) ▪ Extensive monitoring/mitigation requirements. ▪ Standard-, Large-, and Specialty-charge ranges are above those currently observed/monitored. ▪ Little-to-no increase in research and development of nonexplosive cutting methodologies. ▪ The Platform Removal Observer Program (PROP) would require some changes/modifications.
B. Structure-Removal Ops with "Generic" Severance Options ("Status Quo" Action)	▪ "Status Quo" criteria/mitigation is established and demonstrated as effective for MPS protection. ▪ Little-to-no change in PROP coordination and processes. ▪ If used; nonexplosive severance options would result in nominal environmental impacts.	▪ Requires ESA consultation / MMPA authorization because of possible MPS impacts. ▪ Fish kills. ▪ Most explosive-severance activities limited to the shelf (<200 m) of the CPA/WPA only. ▪ Little-to-no increase in research/ development of smaller charges or nonexplosive methodologies. ▪ Potential to limit the removal of upcoming, problematic targets.
C. Structure-Removal Ops with Nonexplosive Severance Options	▪ Nominal environmental impacts. ▪ No fish kills. ▪ No daytime restrictions or severance-related mitigation. ▪ Minimal-to-no MPS impacts. ▪ MMPA take authorization not required. ▪ Will increase research and development of nonexplosive cutting methodologies. ▪ Economic benefit to nonexplosive-severance contactors.	▪ Requires ESA consultation due to potential sea turtle impacts from site-clearance trawling. ▪ Will increase the "exposure time" and subsequent safety risks and costs for all removal operations. ▪ Limits severance options and capabilities; chiefly in deepwater. ▪ Economic detriment for explosive-severance contractors.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

The description of, and impacts to, the potentially affected environment and associated resources discussed in Chapters 3 and 4 of the PEA are based on the potential impact-producing factors (IPF's) identified by MMS's internal scoping. The IPF's and related resources/activities are listed below:

Issue	Impact-Producing Factors	Affected Resource/Activity (Chapter)
Air Emissions	From support vessels/equipment during mobilization, severing, and demobilization stages	Air Quality (3.2.1)
Water Degradation	From vessel discharges, products released during severing (i.e., abrasives, explosive products, etc.), and sediment redistribution	Water Quality (3.2.2)
Acoustic Energy and Shock Waves	Released into the underwater environment during operations and the detonation of explosive severing charges	Marine Mammals (3.3.1) Sea Turtles (3.3.2) Fish Resources (3.3.3) Commercial Fishing (3.4.1)
Bottom Disturbances	Occurring during anchor handling, progressive transport of the jacket assembly, and site-clearance trawling	Benthic Resources (3.3.4) Archaeological Resources (3.4.2) Pipeline and Cables (3.4.3)
Structure Lifting and "Removal"	Severed obstructions/platforms hoisted from the seafloor and transported off-site	Military Use and Warning Areas (3.4.4) Navigation and Shipping (3.4.5)

The affected resources and activities listed above are grouped and discussed under the **physical environment** (air and water quality), **marine resources** (marine mammals, sea turtles, and fish and benthic resources), and **other resources/activities** (archaeological resources, pipelines and cables, navigation and shipping, and military use and warning areas).

3.1. PHYSICAL ENVIRONMENT

3.1.1. Air Quality

The CAA established the NAAQS; the primary standards are to protect public health and the secondary standards are to protect public welfare. New NAAQS for ozone and particulate matter took effect on September 16, 1997. The current NAAQS (40 CFR 50.12 and 62 FR 138, July 18, 1997) are shown in Table 3-1. The CAA Amendments of 1990 established classification designations based on regional monitored levels of ambient air quality. These designations impose mandated timetables and other requirements necessary for attaining and maintaining healthful air quality in the U.S. based on the seriousness of the regional air quality problem. When measured concentrations of regulated pollutants exceed standards established by the NAAQS, an area may be designated as a nonattainment area for a regulated pollutant. The number of exceedances and the concentrations determine the nonattainment classification of an area. There are five classifications of nonattainment status: marginal, moderate, serious, severe, and extreme (CAA Amendments, 1990).

The Federal OCS waters attainment status is unclassified. The OCS areas are not classified because there is no provision for any classification in the Clean Air Act for waters outside of the boundaries of State waters. Only areas within State boundaries are to be classified either attainment, nonattainment, or unclassifiable. Operations west of 87.5^{o} W. longitude fall under MMS jurisdiction for enforcement of the Clean Air Act. The OCS waters east of 87.5^{o} W. longitude are under the jurisdiction of USEPA. Figure 3-1 presents the air quality status along the Gulf Coast as of August 2001. All air-quality nonattainment areas reported in Figure 3-1 are for ozone nonattainment. It is expected that the number of areas of violation will increase under the new 8-hr ozone NAAQS as compared to the number of areas under the old 1-hr standard. As of August 2001, the new 8-hr ozone standard had not yet been fully implemented because of pending court action.

Table 3-1

National Ambient Air Quality Standards (NAAQS)

Pollutant	Averaging Period	Primary Standards[a]	Secondary Standards[b]
Ozone	1-hour [c]	0.12 ppm (235 µg/m^3)	(same as primary)
	8-hour [d e]	0.08 ppm (157 µg/m^3)	(same as primary)
Sulphur Dioxide	Annual	0.03 ppm (80 µg/m^3)	NA
	24-hour	0.14 ppm (365 µg/m^3)	NA
	3-hour [c]	NA	1,300 µg/m^3
Carbon Monoxide	8-hour [c]	9.0 ppm (10 mg/m^3)	NA
	1-hour c	35 ppm (40 mg/m$^{3)}$	NA
Nitrogen Dioxide	Annual	0.053 ppm (100 µg/m$^{3)}$	(same as primary)
Suspended Particulate Matter (PM_{10})	Annual	50 µg/m^3	(same as primary)
	24-hour	150 µg/m^3 [f]	(same as primary)
$PM_{2.5}$[d]	Annual	15 µg/m3 [g]	(same as primary)
	24-hour	65 µg/m^3 [h]	(same as primary)
Lead	Calendar Quarter	1.5 µg/m^3	(same as primary)

[a] The levels of air quality necessary, with an adequate margin of safety to protect the public health.
[b] The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.
[c] Not to be exceeded more than once a year.
[d] New standard effective 9/16/97, but as of 8/01 has not yet been fully implemented because of pending court action.
[e] Three-year average of the annual fourth-highest daily maximum 8-hour average for each monitor.
[f] Based on the 99th percentile of 24-hour PM_{10} concentration at each monitor.
[g] Based on 3-year average of annual arithmetic mean concentrations.
[h] Based on 3-year average of 98th percentile of 24-hour concentrations.

Notes: mg/m^3 = milligrams per cubic meter = 1,000 µg/m$^{-3.}$
µg/m^3 = micrograms per cubic meter.

Source: 40 CFR 50 (*Federal Register*, 1997).

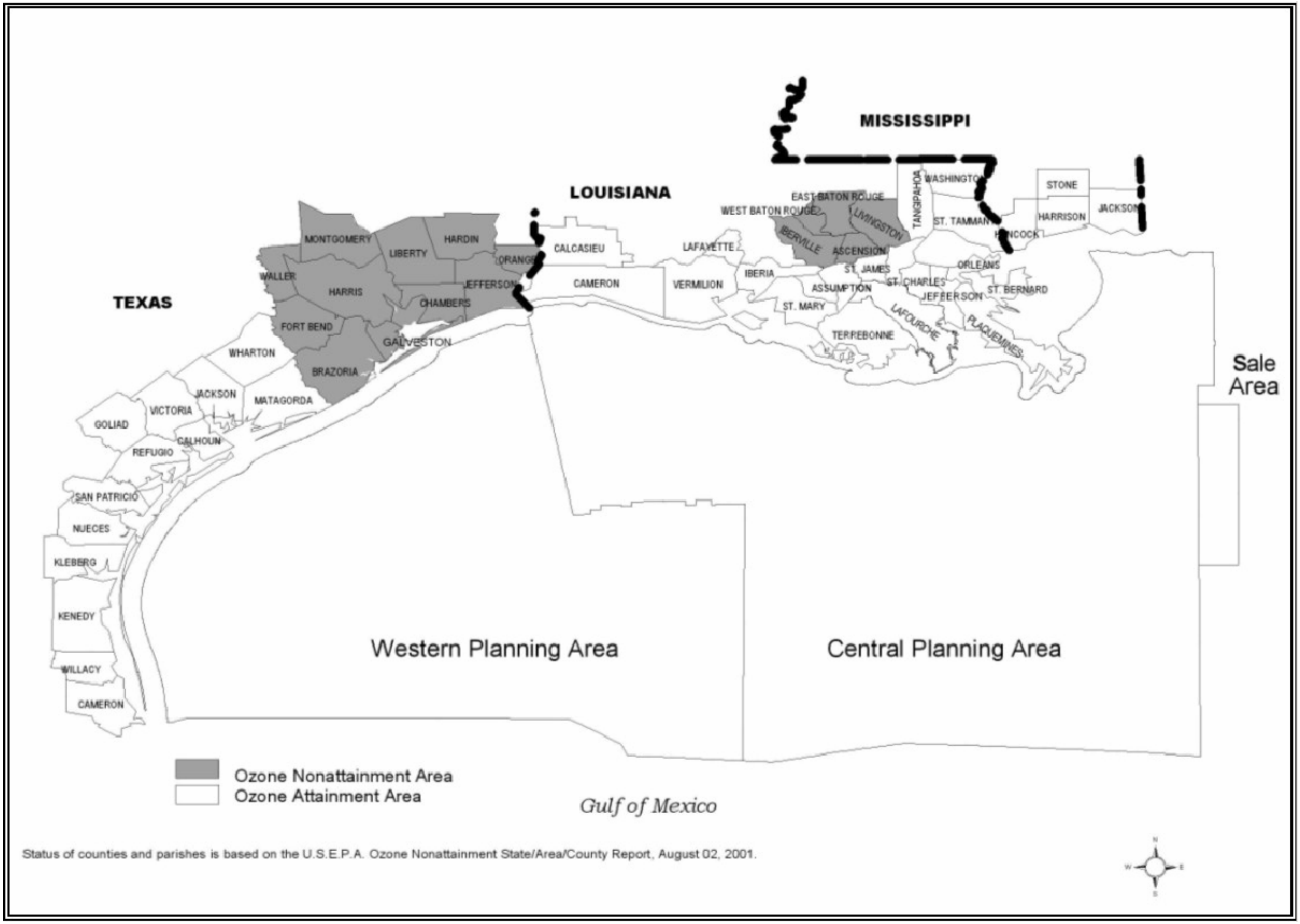


Figure 3-1. Status of Ozone Attainment in the Coastal Counties and Parishes Near the Area of the Proposed Action.

Pollutant levels in coastal areas of Texas reported in the *Air Monitoring Report, 1991* (Texas Air Control Board, 1994) were nitrogen dioxide (NO_2), carbon monoxide (CO), sulphur dioxide (SO_2), particulate matter (PM_{10}), and ozone (O_3). The State of Texas is considered to be in attainment for the pollutants SO_2 and NO_2. Exceedances of the national standards for CO and PM_{10} have only been measured in the interior of the state. Thus, there have been no exceedances of the NAAQS for SO_2, NO_2, CO, and PM_{10} in Texas coastal areas (also see USEPA, 2001). The following Texas coastal counties are classified as nonattainment for ozone: Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Jefferson, Hardin, and Orange (USEPA, 2001).

Measurements of pollutant concentrations in Louisiana are presented in *the Air Quality Data Annual Report, 1996* (LADEQ, 1996). Louisiana is considered to be in attainment of the NAAQS for CO, SO_2, NO_2, and PM_{10} (also see USEPA, 2001). As of August 2001, six Louisiana coastal zone parishes have been tentatively designated nonattainment for ozone: Iberville, Ascension, East Baton Rouge, West Baton Rouge, and Livingston (USEPA, 2001). Ozone measurements (LADEQ, written communication, 1997) between 1989 and 1997 show that the number of days exceeding the national standards are declining.

Air quality data for 1993 were obtained from the Alabama Department of Environmental Management (ALDEM) for PM_{10}, NO_2, and O_3. The data show that Mobile County is in attainment of the NAAQS for all criteria pollutants. There have been no exceedances of the NAAQS for SO_2, NO_x, CO, and PM_{10} in the State of Alabama (USEPA, 2001).

The State of Florida has no nonattainment areas in its coastal counties (USEPA, 2001). Relative to onshore air quality in Escambia County, USEPA's Aerometric Information Retrieval System was accessed for ambient air monitoring data of SO_2, O_3, and PM_{10} for the years 1995 through 1997. During this period, the following exceedances of applicable standards were recorded: no measurements of SO_2; three measurements of O_3 (one in 1995 and two in 1996); and no measurements of PM_{10}. If the proposed, new, 8-hr ozone standard is imposed using the 1996-1998 data, Escambia County would be in violation. Indeed, during the 1998 summer season, there were a number of ozone alerts.

Prevention of Significant Deterioration (PSD) Class I air quality areas, designated under the Clean Air Act, are afforded the greatest degree of air quality protection and are protected by stringent air quality standards that allow for very little deterioration of their air quality. The PSD maximum allowable pollutant increase for Class I areas are as follows: 2.5 $\mu g/m^3$ annual increment for NO_2; 25 $\mu g/m^3$ 3-hr increment, 5 $\mu g/m^3$ 24-hr increment, and 2 $\mu g/m^3$ annual increment for SO_2; and 8 $\mu g/m^3$ 24-hr increment and 5 $\mu g/m^3$ annual increment for PM_{10}. The CPA includes the Breton National Wildlife Refuge and National Wilderness Area south of Mississippi, which is designated as a PSD Class I area (Figure 3-2). The FWS has responsibility for protecting wildlife, vegetation, visibility, and other sensitive resources called air-quality-related values in this area. The FWS has expressed concern that the NO2 and SO2 increments for the Breton National Wilderness Area have been consumed. There is no PSD Class I air quality area in the WPA. The EPA includes several wilderness areas designated by the Clean Air Act as PSD Class I air quality areas: the Breton National Wildlife Refuge and National Wilderness Area off Mississippi, and the Saint Marks, Bradwell Bay, and Chassahowitzka Class I air quality areas in Florida.

Ambient air quality is a function of the size, distribution, and activities related to population in association with the resulting economic development, transportation, and energy policies of the region. Meteorological conditions and topography may confine, disperse, or distribute air pollutants. Assessments of air quality depend on multiple variables such as the quantity of emissions, dispersion rates, distances from receptors, and local meteorology. Because of the variable nature of these independent factors, ambient air quality is an ever-changing dynamic process.

3.1.2. Water Quality

For the purposes of this PEA, water quality is the ability of a waterbody to maintain the ecosystems it supports or influences. In the case of coastal and marine environments, the quality of the water is influenced by the rivers that drain into the area, the quantity and composition of wet and dry atmospheric deposition, and the influx of constituents from sediments. Besides the naturally-occurring inputs, human activity can contribute to water quality through discharges, run-off, burning, dumping, air emissions, and

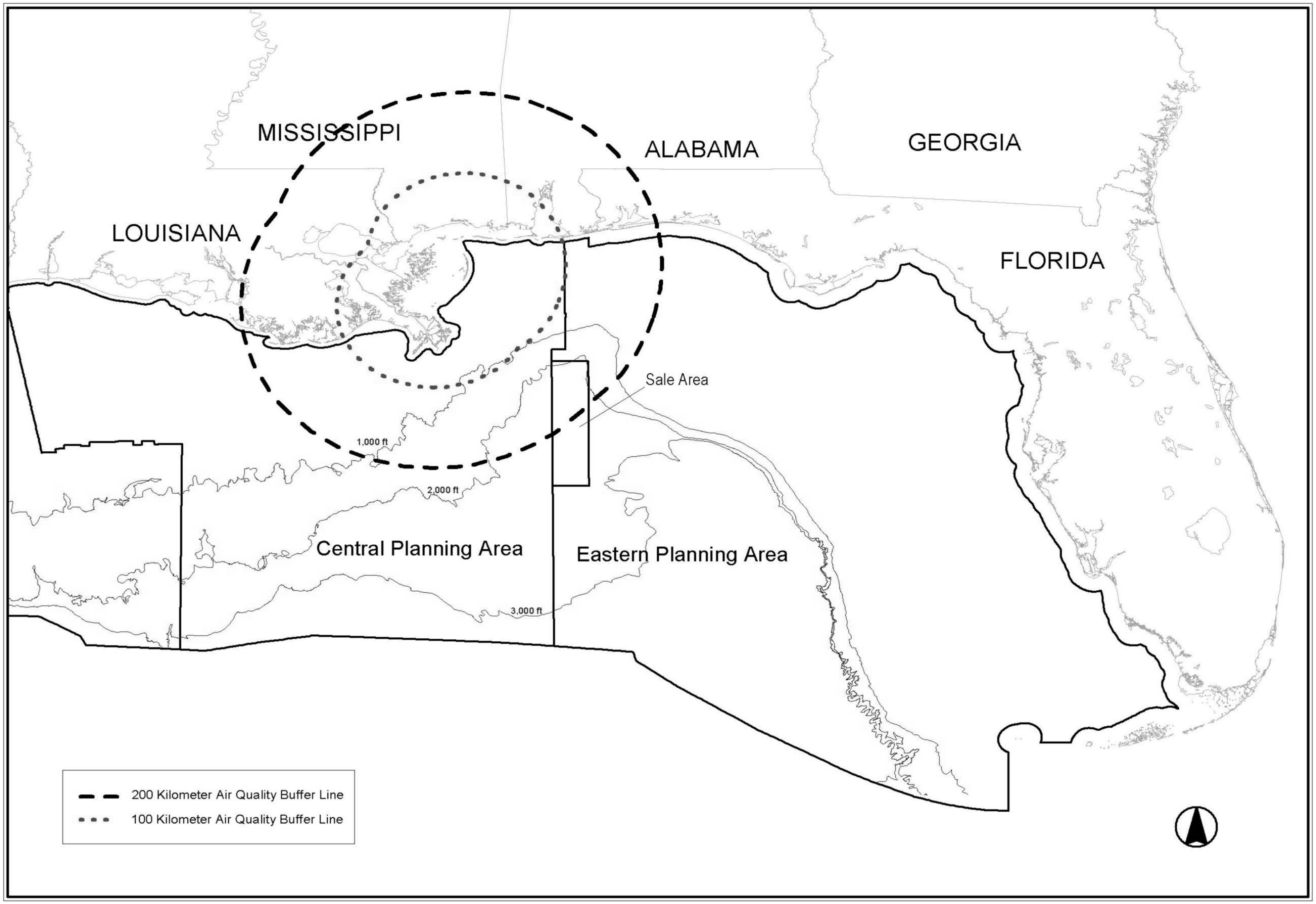


Figure 3-2. Breton National Wilderness Area and its Proximity to the Area of the Proposed Action.

spills. Also, mixing or circulation of the water can either improve or diminish the water quality through flushing or through the introduction of factors that contribute to the decline of water quality, respectively.

Evaluation of water quality is done by measuring the factors that indicate the health of an ecosystem. The primary factors that influence coastal and marine environments are temperature, salinity, dissolved oxygen, nutrients, potential of hydrogen (pH), oxidation reduction potential (Eh), pathogens, and turbidity or suspended load. The presence of trace constituents such as metals and organic compounds can also affect water quality. The water quality and sediment quality may be closely linked. Contaminants, which are associated with the suspended load, may ultimately deposit in the sediments and contaminants that have been sequestered in sediments may be resuspended in the water column following a storm or other disturbance.

The region under consideration is divided into coastal and marine waters for the following discussion. Coastal waters, as defined by MMS, include all the bays and estuaries from the Rio Grande River to Florida Bay. Marine water as defined in this document includes both State offshore water and Federal OCS waters, which includes the waters outside of any barrier islands to the Exclusive Economic Zone (EEZ). The inland extent is defined by the CZMA.

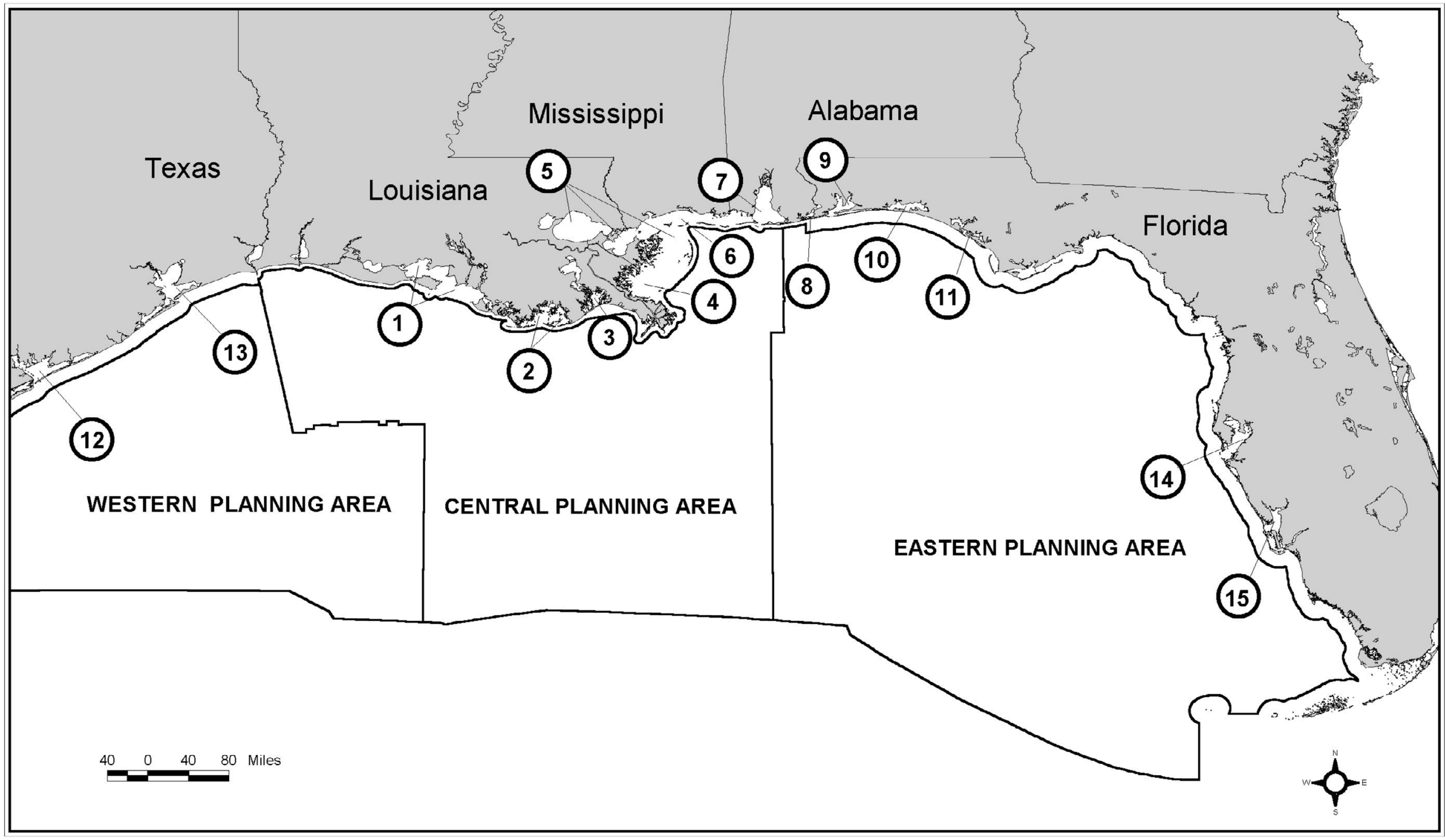
3.1.2.1. Coastal Waters

Along the Gulf Coast lies one of the most extensive estuary systems in the world, which extends from the Rio Grande River to Florida Bay (Figure 3-3). Estuaries represent a transition zone between the freshwater of rivers and the higher salinity waters offshore. These bodies of water are influenced by freshwater and sediment influx from rivers and the tidal actions of the oceans. The primary variables that influence coastal water quality are water temperature, total dissolved solids (salinity), suspended solids (turbidity), and nutrients. An estuary's salinity and temperature structure are determined by hydrodynamic mechanisms including tides, nearshore circulation, freshwater discharges from rivers, and local precipitation. Gulf Coast estuaries exhibit a general east to west trend in selected attributes of water quality associated with changes in regional geology, sediment loading, and freshwater inflow.

Estuaries provide habitat for plants, animals, and humans. Marshes, mangroves, and seagrasses surround the Gulf Coast estuaries, providing food and shelter for shorebirds, migratory waterfowl, fish, invertebrates (e.g., shrimp, crabs, and oysters), reptiles, and mammals. Estuarine-dependent species constitute more than 95 percent of the commercial fishery harvests from the GOM. Several major cities are located along the coast, including Houston, New Orleans, Mobile, and Tampa. Tourism supplies an estimated $20 billion to the economy each year (USEPA, 1999). Shipping and marine transport is an important industry, with 7 of the top 10 busiest ports in the U.S., in terms of total tonnage, located in GOM estuaries.

Estuarine ecosystems are impacted by human activities, primarily upstream water withdrawals for agricultural, industrial, and domestic purposes, contamination by industrial, municipal, and agricultural discharges, and habitat alterations (e.g., construction and dredge and fill operations). Drainage from more than 55 percent of the contiguous U.S. enters the GOM, primarily from the Mississippi River. Texas, Louisiana, and Alabama ranked first, second, and fourth, respectively, in the nation in 1995 in terms of discharging the greatest amount of toxic chemicals (USEPA, 1999). The GOM region ranks highest of all coastal regions in the U.S. in the number of wastewater treatment plants (1,300), number of industrial point sources (2,000), percent of land use devoted to agriculture (31%), and application of fertilizer to agricultural lands (62,000 tons of phosphorus and 758,000 tons of nitrogen) (USDOC, NOAA, 1990).

A recent assessment of the ecological condition of GOM estuaries was published by the USEPA (1999). The assessment describes the general ecology and summarizes the "health" of all the GOM estuarine systems. Sources of the data include the USEPA's Environmental Monitoring and Assessment Program for Estuaries (EMAP-E), the NOAA Estuarine Eutrophication Survey (USDOC, NOAA, 1997), and 305(b) reports from each state. A classification scheme based on 11 indicators was developed. The indicators included measurements of water and sediment quality, habitat change, biological integrity, and public health (pathogens in shellfish and contaminants, mainly mercury, in fish). Of the 78 percent of GOM estuaries surveyed in 1994-1995, 35 percent of the estuaries were impaired and 65 percent supported their designated use. Pathogen indicators and eutrophication indicators were the main sources of impairment.



1. Atchafalaya/Vermilion Bays
2. Terrebonne/Timbalier Bays
3. Barataria Bay
4. Breton Sound
5. Lakes Pontchartrain/Borgne and Chandeleur Sound
6. Mississippi Sound
7. Mobile Bay
8. Perdido Bay
9. Pensacola Bay
10. Choctawhatchee Bay
11. St. Andrew Bay
12. Corpus Christi Bay
13. Galveston Bay
14. Tampa Bay
15. Florida Bay

Figure 3-3. Estuarine Systems of the Gulf of Mexico.

Many Gulf Coast States now sample the edible tissue of estuarine and marine fish for total mercury. Atmospheric deposition is considered to be the main source of mercury. A Gulfwide fish consumption advisory exists for king mackerel (Ache et al., 2000). The National Science and Technology Council (NSTC) Interagency Working Group on Methylmercury, formed in May 2002, has prioritized the collection of additional data on GOM fish tissue mercury levels. Additional sampling of recreationally caught fish species is underway.

3.1.2.2. Marine Waters

The marine water, within the area of interest, can be divided into three regions: the continental shelf west of the Mississippi River, the continental shelf east of the Mississippi River, and deep water (> 400 m). For this discussion, the continental shelf includes the upper slope to a water depth of 400 m. While the various parameters measured to evaluate water quality do vary in marine waters, one parameter, pH, does not. The buffering capacity of the marine system is controlled by carbonate and bicarbonate, which maintain the pH at 8.2.

Continental Shelf West of the Mississippi River

The Mississippi and Atchafalaya Rivers are the primary sources of freshwater, sediment, and pollutants to the continental shelf west of the Mississippi (Murray, 1997). The drainage basin that feeds the rivers covers 55 percent of the contiguous U.S. While the average river discharge from the Mississippi River exceeds the input of all other rivers along the Texas-Louisiana coast by a factor of 10, during low-flow periods, the Mississippi River can have a flow less than all the other rivers combined (Nowlin et al., 1998). This area is highly influenced by the input of sediment and nutrients from the Mississippi and Atchafalaya Rivers.

A turbid surface layer of suspended particles is associated with the freshwater plume from these rivers. A bottom nepheloid layer composed of suspended clay material from the underlying sediment is always present on the shelf. This layer can reach a thickness of 30 m and ranges in location from within 1 m of the bottom to 42 m above the bottom (Boehm, 1987). Lower levels of suspended particulate matter in the bottom nepheloid layer occurred at the same time as low surface particulate matter levels (Nowlin et al., 1998). Higher water-column suspended matter could be the result of enhanced bottom currents. A temporary resuspension of fine-grained sediments in the water column may also be caused by storms.

During summer months, the less dense, low-salinity water from the Mississippi and Atchafalaya Rivers spread out over the shelf, resulting in a stratified water column. While surface oxygen concentrations are at or near saturation, hypoxia, defined as oxygen (O_2) concentrations less than 2 milligrams (mg) per liter (l) O_2, is observed in bottom waters during the summer months. The zone of hypoxia on the Louisiana-Texas shelf is one of the largest areas of low oxygen in the world's coastal waters (Murray, 1997). The area of hypoxia stretched over 17,000 km^2 at its peak and was observed as far away as Freeport, Texas.

Nutrients supplied by the river water stimulate phytoplankton production. This, in turn, increases the carbon flux to the bottom, which, under stratified conditions, results in oxygen depletion. The hypoxic conditions last until local wind-driven circulation mixes the water again.

Increased nutrient loading since the turn of the 19th century correlates with the increased extent of hypoxic events (Eadie et al., 1992), and supports the theory that hypoxia is related to the nutrient input from the Mississippi and Atchafalaya River systems. From 1980 to 1996, the annual average flux of nitrogen and phosphorus from the Mississippi—Atchafalaya River Basin to the Gulf was 1.6 million metric tons per year and 136,500 metric tons per year, respectively (Goolsby et al., 1999). The USEPA Gulf of Mexico Program works with Federal, State, and local agencies; industry; and nongovernmental organizations (NGO's) to collect information and improve the environmental quality of the GOM.

Coastal sediments contain trace quantities of organic pollutants including chlorinated pesticides, polychlorinated biphenyls (PCB's), polynuclear aromatic hydrocarbons (PAH's), and trace inorganic (metals) pollutants. Many of these contaminants originate inland and are transported via the rivers to the coast. The concentrations of chlorinated pesticides and PCB's, which are associated with suspended particulates and sediment, continue to decline since their use has been discontinued.

River water is also a source of petroleum hydrocarbons in sediments. Oil released from land-based activities is the main source of oil to coastal waters across the GOM. Urban run-off is the largest contributor of the land-based sources of oil to coastal waters and includes the transport of oil that has been spilled on streets and parking lots and the improper disposal of used oil. Additional land-based sources of oil include industrial and municipal wastewaters (NRC, 2003). Low levels of oil are chronically discharged to waterways where they are removed through biodegradation and other weathering processes.

Oil exploration and production activities introduce drilling muds, cuttings, produced water, and other miscellaneous discharges into coastal waters. All discharges are periodically tested and must meet the NPDES limits set by the USEPA. When a well is drilled, muds containing barite and cuttings are discharged into the water where they settle to the bottom. Sediments within several hundred meters of a well contain elevated barium concentrations and show differences in grain size from distant sediments. Concentrations of some trace metals are present in barite and are found in the sediments around wells.

Trace metals found in the barite discharges, including mercury and cadmium, were localized to within 150 m of the structure (Kennicutt, 1995). A comparison of total mercury and methylmercury to barium concentrations in shelf and slope sediments showed more total mercury in sediment samples near the drilling site and drill cuttings (Trefrey et al., 2002). However, methylmercury was not elevated in sediment samples near or far from the drill site. Thus, the study indicated that mercury in barite used in drilling muds offshore is not contributing to elevated methylmercury.

The discharge of produced water contributes to the loading of oil in coastal waters and sediments (NRC, 2003). The USEPA requires that produced water be treated to achieve a monthly average oil and grease concentration of less than 29 mg/l prior to discharge.

Continental Shelf East of the Mississippi River

Water quality on the continental shelf from the Mississippi River Delta to Tampa Bay is influenced by river discharge, run-off from the coast, and eddies from the Loop Current. The Mississippi River accounts for 72 percent of the total discharge onto the shelf (SUSIO, 1975). The outflow of the Mississippi River generally extends only 75 kilometers (km) (45 mi) to the east of the river mouth (Vittor and Associates, Inc., 1985) except under extreme flow conditions. The Loop Current intrudes in irregular intervals onto the shelf, and the water column can change very rapidly from well mixed to highly stratified. Discharges from the Mississippi River can be easily entrained in the Loop Current. The flood of 1993 provided an infusion of fresh water to the entire northeastern GOM shelf with some Mississippi River water transported to the Atlantic Ocean through the Florida Straits (Dowgiallo, 1994). Hypoxia is rarely observed on the Mississippi-Alabama shelf, although low dissolved oxygen values of 2.93-2.99 mg/l were observed during the MAMES cruises (Brooks and Giammona, 1991).

The Mississippi-Alabama shelf sediments are strongly influenced by fine sediments discharged from the Mississippi River. The shelf area is characterized by a bottom nepheloid layer and surface lenses of suspended particulates that originate from river outflow. The West Florida Shelf has very little sediment input with primarily high-carbonate sands offshore and quartz sands nearshore. The water clarity is higher towards Florida, where the influence of the Mississippi River outflow is rarely observed.

A three-year, large-scale marine environmental baseline study conducted from 1974 to 1977 in the Eastern GOM resulted in an overview of the Mississippi, Alabama, and Florida (MAFLA) OCS environment to 200 m (SUSIO, 1977; Dames and Moore, 1979). Analysis of water, sediments, and biota for hydrocarbons indicated that the MAFLA area is pristine, with some influence of anthropogenic and petrogenic hydrocarbons from rivers. Analysis of trace metal contamination for the nine trace metals analyzed (barium, cadmium, chromium, copper, iron, lead, nickel, vanadium, and zinc) also indicated no contamination. A decade later, the continental shelf off Mississippi and Alabama was revisited (Brooks, 1991). Bottom sediments were analyzed for high-molecular-weight hydrocarbons and heavy metals. High-molecular-weight hydrocarbons can come from natural petroleum seeps at the seafloor or recent biological production as well as input from anthropogenic sources. In the case of the Mississippi-Alabama shelf, the source of petroleum hydrocarbons and terrestrial plant material is the Mississippi River. Higher levels of hydrocarbons were observed in the late spring, coinciding with increased river influx. The sediments, however, are washed away later in the year, as evidenced by low hydrocarbon values in winter months. Contamination from trace metals was not observed (Brooks, 1991).

The Science Applications International Corporation (SAIC, 1997) summarized information about water quality on the shelf from DeSoto Canyon to Tarpon Springs and from the coast to 200-m water depth. Several small rivers and the Loop Current are the primary influences on water quality in this region. Because there is very little onshore development in this area, the waters and surface sediments are uncontaminated. The Loop Current flushes the area with clear, low-nutrient water.

More recent investigations of the continental shelf east of the Mississippi River confirm previous observations that the area is highly influenced by river input of sediment and nutrients (Jochens et al., 2002). Hypoxia was not observed on the shelf during the three years of the study.

Deepwater

Limited information is available on the deepwater environment. Water at depths greater than 1,400 m is relatively homogeneous with respect to temperature, salinity, and oxygen (Nowlin, 1972; Pequegnat, 1983; Gallaway et al., 1988). Of importance, as pointed out by Pequegnat (1983), is the flushing time of the GOM. Oxygen in deep water must originate from the surface and be mixed into the deep water by some mechanism. If the replenishment of the water occurs over a long period of time, the addition of nonnaturally occurring hydrocarbons through the discharge from oil and gas activities could lead to low oxygen and potentially hypoxic conditions in the deep water of the GOM. The time scales and mechanism for maintaining the high oxygen levels in the deep GOM are unknown.

Limited analyses of trace metals and hydrocarbons for the water column and sediments exist (Trefrey, 1981; Gallaway et al., 1988; Rowe and Kennicutt, 2002). Metals concentrations in deepwater sediments reflect abundance in the earth's crust and Mississippi River discharges (Rowe and Kennicutt, 2002).

Hydrocarbon seeps are extensive throughout the continental slope and contribute hydrocarbons to the surface sediments and water column, especially in the Central GOM (Sassen et al., 1993a and b). Natural seeps are the dominant source of hydrocarbons and contribute 85 percent of the oil that is present in offshore water (NRC, 2003). MacDonald et al. (1993) observed 63 individual seeps using remote sensing and submarine observations. Estimates of the total volume of seeping oil vary widely from 29,000 bbl/yr (MacDonald, 1998) to 520,000 bbl/yr (Mitchell et al., 1999). These estimates used satellite data and an assumed slick thickness. At some seep locations, gas hydrates have formed and are present as outcrops on the seafloor. Gases, mainly methane, are trapped inside of the ice-like structure of the hydrate. The zone where hydrates are stable intersects the seafloor at about 500 m (Boatman and Peterson, 2000). Hydrates dissociate in conditions outside of a narrow range of temperatures and pressures. Large sections of gas hydrate outcrops have disappeared between annual visits by submersibles (MacDonald et al., 1994; Roberts et al., 1999).

In addition to hydrocarbon seeps, other fluids have the potential to leak from the underlying sediments into the bottom water along the slope. These fluids have been identified to have three origins: (1) seawater trapped during the settling of sediments; (2) dissolution of underlying salt diapirs; and (3) deep-seated formation waters (Fu and Aharon, 1998; Aharon et al., 2001). The first two fluids are the source of authigenic carbonate deposits while the third is rich in barium and is the source of barite deposits such as chimneys.

3.2. MARINE RESOURCES

3.2.1. Marine Mammals

Twenty-nine species of marine mammals occur in the GOM (Davis et al., 2000) (Table 3-2). The GOM's marine mammals are represented by members of the taxonomic order Cetacea, which is divided into the suborders Mysticeti (i.e., baleen whales) and Odontoceti (i.e., toothed whales), as well as the order Sirenia, which includes the manatee and dugong. In the GOM, there are 28 species of cetaceans (7 mysticete and 21 odontocete species) and 1 sirenian species, the manatee (Jefferson et al., 1992).

Table 3-2

Population Estimates for Marine Mammal Species

Species	Population Estimate
Killer Whale (*Orcinus orca*)	180
False Killer Whale (*Pseudorca crassidens*)	1,515
Pygmy Killer Whale (*Feresa attentuata*)	443
Dwarf Sperm Whale (*Kogia sima*)	809[a]
Pygmy Sperm Whale (*Kogia breviceps*)	809[a]
Melon-headed Whale (*Peponocephala electra*)	3,320
Risso's Dolphin (*Grampus griseus*)	1,777
Short-finned Pilot Whale (*Globicephala macrorhynchus*)	3,252
Sperm Whale (*Physeter macrocephalus*)	1,315
Bryde's Whale (*Balaenoptera edeni*)	42
Cuvier's Beaked Whale (*Ziphius cavirostris*)	88
Blainville's Beaked Whale (*Mesoplodon densirostris*)	98[b]
Gervais' Beaked Whale (*Mesoplodon europaeus*)	98[b]
Bottlenose Dolphin (*Turisops truncatus*)	26,852
Atlantic Spotted Dolphin (*Stenella frontalis*)	39,545[c]
Pantropical Spotted Dolphin (*Stenella attenuatus*)	93,174[c]
Striped Dolphin (*Stenella coeruleoalba*)	6,258[c]
Spinner Dolphin (*Stenella longirostris*)	11,550[c]
Rough-toothed Dolphin (*Steno bredanensis*)	2,469[c]
Clymene's Dolphin (*Stenella clymene*)	16,439
Fraser's Dolphin (*Lagenodelphis hosei*)	698[c]
Absent from Stock Assessment:	
Northern Right Whale (*Eubalaena glacialis*)	Extralimital
Minke Whale (*Balaenoptera acutorostrata*)	Rare
Sei Whale (*Balaenoptera edeni*)	Rare
Blue Whale (*Balaenoptera musculus*)	Extralimital
Fin Whale (*Balaenoptera physalus*)	Rare
Humpback Whale (*Megaptera novaeangliae*)	Rare
Sowerby's Beaked Whale (*Mesoplodon bidens*)	Extralimital

[a] Estimate of abundance is for pygmy and dwarf sperm whales combined.
[b] Estimate is based on the undifferentiated complex of beaked whales (*Ziphius* and *Mesoplodon* spp.).
[c] This estimate is for oceanic waters, which is the best available for the GOM.

EXTRALIMITAL: known on the basis of only a few records that probably resulted from unusual wanderings of animals into the region (Würsig et al., 2000).
RARE: present in such small numbers throughout the region that it is seldom seen (Würsig et al., 2000).

Source: USDOC, NOAA, 2004.

3.2.1.1. Nonendangered and Nonthreatened Species

Cetaceans—Mysticetes

Bryde's Whale (Balaenoptera edeni)

The Bryde's whale (*Balaenoptera edeni*) is found in tropical and subtropical waters throughout the world. The Bryde's whale feeds on small pelagic fishes and invertebrates (Leatherwood and Reeves, 1983; Cummings, 1985; Jefferson et al., 1993). Bryde's whale in the northern GOM, with few exceptions, has been sighted along a narrow corridor near the 100-m (328-ft) isobath (Davis and Fargion, 1996; Davis et al., 2000). Most sightings have been made in the DeSoto Canyon region and off western Florida, though there have been some in the west-central portion of the northeastern GOM. The best estimate of abundance for the northern GOM is 42 individuals (USDOC, NOAA, 2004).

Minke Whale (Balaenoptera acutorostrata)

The minke whale *(Balaenoptera acutorostrata*) is the second smallest baleen whale and is found in all the world's oceans. They feed on a variety of marine invertebrates (copepods and squid) and fishes (Jefferson et al., 1993). At least three geographically isolated populations are recognized: North Pacific, North Atlantic, and Southern Hemisphere. The North Atlantic population migrates southward during winter months to the Florida Keys and the Caribbean Sea. Minke whales are considered rare in the GOM, with the only confirmed records coming from stranding information (Würsig et al., 2000). Most records from the GOM have come from the Florida Keys, although strandings in western and northern Florida, Louisiana, and Texas have been reported (Jefferson and Schiro, 1997). There are no abundance estimates for the GOM.

Cetaceans—Odontocetes

Pygmy and Dwarf Sperm Whales (Family Kogiidae)

Pygmy Sperm Whales (Kogia breviceps)

The pygmy sperm whale *(Kogia brevicep*s) has a worldwide distribution in temperate to tropical waters (Caldwell and Caldwell 1989). They feed mainly on squid, but they will also eat crab, shrimp, and smaller fishes (Würsig et al., 2000). In the GOM, they occur primarily along the continental shelf edge and in deeper waters off the continental shelf (Mullin et al., 1991). At sea, it is difficult to differentiate pygmy from dwarf sperm whales (*Kogia sima*) and sightings are often grouped together as "*Kogia* spp." The best estimate of abundance for pygmy and dwarf sperm whales combined, in the northern GOM, is 809 individuals (USDOC, NOAA, 2004).

Dwarf Sperm Whales (Kogia sima)

The dwarf sperm whale *(Kogia sima*) has a worldwide distribution in temperate to tropical waters (Caldwell and Caldwell, 1989). It is believed that they feed on squid, fishes, and crustaceans (Würsig et al., 2000). In the GOM, they are found primarily along the continental shelf edge and over deeper waters off the continental shelf (Mullin et al., 1991). At sea, it is difficult to differentiate dwarf from pygmy sperm whales (*Kogia breviceps*) and sightings are often grouped together as "*Kogia* spp." The best estimate of abundance for dwarf and pygmy sperm whales combined, in the northern GOM, is 809 individuals (USDOC, NOAA, 2004).

Beaked Whales (Family Ziphiidae)

Sowerby's Beaked Whale (Mesoplodon bidens)

Sowerby's beaked whale (*Mesoplodon bidens*) occurs in cold temperate to subarctic waters of the North Atlantic and feeds on squid and small fishes (Würsig et al., 2000). It is represented in the GOM by only a single record, a stranding in Florida; this record is considered extralimital since this species normally occurs much farther north in the North Atlantic (Jefferson and Schiro, 1997). There are no abundance estimates for the GOM.

Gervais' Beaked Whale (Mesoplodon europaeus)

Gervais' beaked whale (*Mesoplodon europaeus*) appears to be widely but sparsely distributed worldwide in temperate to tropical waters (Leatherwood and Reeves, 1983). Little is known about their life history, but it is believed that they feed on squid (Würsig et al., 2000). Beaked whales in the GOM are grouped into an undifferentiated complex (*Mesoplodon* spp. and *Ziphius* sp.) because of the difficulty of at sea identification. In the northern GOM, they are broadly distributed in waters >1,000 m over lower slope and abyssal landscapes (Davis et al., 1998 and 2000). Stranding records suggest that this is probably the most common mesoplodont in the northern GOM (Jefferson and Schiro, 1997). Abundance estimates for the undifferentiated beaked whale complex in the northern GOM is 98 individuals (USDOC, NOAA, 2004).

Blainville's Beaked Whale (Mesoplodon densirostris)

Blainville's beaked whale (*Mesoplodon densirostris*) is distributed throughout temperate and tropical waters worldwide, but it is not considered common (Würsig et al., 2000). Little life history is known about this secretive whale, but it is known to feed on squid and fish. Beaked whales in the GOM are grouped into an undifferentiated complex (*Mesoplodon* spp. and *Ziphius* sp.) because of the difficulty of at sea identification. In the northern GOM, they are broadly distributed in waters >1,000 m over lower slope and abyssal landscapes (Davis et al., 1998 and 2000). Abundance estimates for the undifferentiated beaked whale complex in the northern GOM is 98 individuals (USDOC, NOAA, 2004).

Cuvier's Beaked Whale (Ziphius cavirorostris)

Cuvier's beaked whale (*Ziphius cavirorostris*) is widely (but sparsely) distributed throughout temperate and tropical waters worldwide (Würsig et al., 2000). Their diet consists of squid, fishes, crabs, and starfish. Beaked whales in the GOM are grouped into an undifferentiated complex (*Mesoplodon* spp. and *Ziphius* sp.) because of the difficulty of at sea identification. In the northern GOM, they are broadly distributed in waters >1,000 m over lower slope and abyssal landscapes (Davis et al., 1998 and 2000). Sightings data indicate that Cuvier's beaked whale is probably the most common beaked whale in the GOM (Jefferson and Schiro, 1997; Davis et al., 1998 and 2000). Abundance estimates for the undifferentiated beaked whale complex in the northern GOM is 98 individuals (USDOC, NOAA, 2004).

Dolphins (Family *Delphinidae*)

Atlantic Spotted Dolphin (Stenella frontalis)

The Atlantic spotted dolphin (*Stenella frontalis*) is endemic to the Atlantic Ocean in tropical to temperate waters (Perrin et al., 1994a). They are known to feed on a wide variety of fishes, cephalopods, and benthic invertebrates (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Perrin et al., 1994a). In the GOM, they are commonly found in continental shelf waters <200 m in depth, primarily from 10 m on the shelf to up to 500 m on the slope. Abundance estimates are 1,827 and 1,096 individuals from ship and aerial surveys, respectively, of the shelf of the Eastern GOM (Davis et al., 2000). Estimated abundance of individuals for both the OCS and oceanic waters is 39,545 individuals (USDOC, NOAA, 2004).

Bottlenose Dolphin (Tursiops truncatus)

The bottlenose dolphin *(Tursiops truncatu*s) is a common inhabitant of the continental shelf and upper slope waters of the northern GOM. Bottlenose dolphins are opportunistic feeders, taking a wide variety of fishes, cephalopods, and shrimp (Davis and Fargion, 1996; Jefferson and Schiro, 1997; Wells and Scott, 1999). There appears to be two ecotypes of bottlenose dolphins: a coastal form and an offshore form (Hersh and Duffield, 1990; Mead and Potter, 1990). The coastal or inshore stock(s) is genetically isolated from the offshore stock (Curry and Smith, 1997). In the northern GOM, bottlenose dolphins appear to have an almost bimodal distribution: a shallow water (16-67 m) and a shelf break (about 250 m) region. These regions may represent the individual depth preferences of the coastal and offshore forms (Baumgartner, 1995). The best estimate of abundance for bottlenose dolphins in the GOM is 26,852 individuals (USDOC, NOAA, 2004).

Clymene Dolphin (Stenella clymene)

The Clymene dolphin *(Stenella clymene*) is endemic to tropical and subtropical waters of the Atlantic Ocean (Perrin and Mead, 1994). This species is thought to feed on fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Mullin et al., 1994a). Data suggest that Clymene dolphins are widespread within deeper GOM waters (i.e., shelf edge and slope) (Davis et al., 2000; Würsig et al., 2000). The abundance estimate for the northern GOM is 16,439 individuals (USDOC, NOAA, 2004).

False Killer Whale (Pseudorca crassidens)

The false killer whale (*Pseudorca crassidens*) occurs worldwide in tropical and temperate oceanic waters (Odell and McClune, 1999). False killer whales primarily eat fish and cephalopods, but they have been known to attack other toothed whales (Leatherwood and Reeves, 1983; Jefferson et al., 1993). In the GOM, most sightings occur in deeper waters off the continental shelf (Davis and Fargion, 1996). The abundance estimate for the northern GOM is 1,515 individuals (USDOC, NOAA, 2004).

Fraser's Dolphin (Lagenodelphis hosei)

The Fraser's dolphin (*Lagenodelphis hosei*) has a worldwide distribution in tropical waters (Perrin et al., 1994b). Fraser's dolphins feed on fishes, cephalopods, and crustaceans (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Jefferson and Schiro, 1997). In the GOM, they occur in deeper waters off the continental shelf. The estimated abundance for this species in the northern GOM is 698 individuals (USDOC, NOAA, 2004).

Killer Whale (Orcinus orca)

The killer whale (*Orcinus orca*) has a worldwide distribution from tropical to polar waters. (Dahlheim and Heyning, 1999). They feed on marine mammals, marine birds, sea turtles, cartilaginous and bony fishes, and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). In the GOM, they occur primarily in the deeper waters off the continental shelf (Davis and Fargion, 1996). The estimated abundance for the northern GOM is 180 individuals (USDOC, NOAA, 2004).

Melon-headed Whale (Peponocephala electra)

The melon-headed whale *(Peponocephala electra*) has a worldwide distribution in subtropical to tropical waters (Jefferson et al., 1992), feeding on cephalopods and fishes (Mullin et al., 1994b; Jefferson and Schiro, 1997). In the GOM, they occur in the deeper waters off the continental shelf (Mullin et al., 1994b). The estimated abundance for the northern GOM is 3,320 individuals (USDOC, NOAA, 2004).

Pantropical Spotted Dolphin (Stenella attenuata)

The pantropical spotted dolphin *(Stenella attenuat*a) is distributed in tropical and subtropical waters worldwide (Perrin and Hohn, 1994). It feeds on epipelagic fishes and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). It is the most common cetacean in the oceanic northern GOM (Mullin et al., 1994b) and is found in the deeper waters off the continental shelf (Mullin et al., 1994a; Davis et al., 1998 and 2000). Estimated abundance for the northern GOM is 93,174 individuals (USDOC, NOAA, 2004).

Pygmy Killer Whale (Feresa attenuata)

The pygmy killer whale (*Feresa attenuata*) occurs worldwide in tropical and subtropical waters (Ross and Leatherwood, 1994). Its diet includes cephalopods and fishes, though reports of attacks on other dolphins have been reported (Leatherwood and Reeves, 1983; Jefferson et al., 1993). In the GOM, they occur primarily in deeper waters off the continental shelf (Mullin and Fulling, 2004). The estimated abundance for the northern GOM is 443 individuals (USDOC, NOAA, 2004).

Risso's Dolphin (Grampus griseus)

The Risso's dolphin (*Grampus griseus*) is distributed worldwide in tropical to warm temperate waters (Leatherwood and Reeves, 1983). They feed primarily on squid, and secondarily on fishes and crustaceans (Leatherwood and Reeves, 1983; Jefferson et al., 1993). In the GOM, they occur primarily along the continental shelf and continental slope (Mullin and Fulling, 2004). The estimated abundance for the northern GOM is 1,777 individuals (USDOC, NOAA, 2004).

Rough-toothed Dolphin (Steno bredanensis)

The rough-toothed dolphin (*Steno bredanensis*) occurs in tropical to warm temperate waters worldwide (Miyazaki and Perrin, 1994). This species feeds on cephalopods and fishes (Leatherwood and Reeves, 1983; Jefferson et al., 1993). In the GOM, they occur primarily over the deeper waters off the continental shelf (Mullin and Fulling, 2004). The estimated abundance for the northern GOM (both oceanic waters and the OCS) is 2,469 individuals (USDOC, NOAA, 2004).

Short-finned Pilot Whale (Globicephala macrorhynchus)

The short-finned pilot whale (*Globicephala macrorhynchus*) is distributed worldwide in tropical to temperate waters (Leatherwood and Reeves, 1983). They feed predominately on squid, with fishes being consumed occasionally (Würsig et al., 2000). In the GOM, they are most frequently sighted along the continental shelf and continental slope. The estimated abundance for the northern GOM is 3,252 individuals (USDOC, NOAA, 2004).

Spinner Dolphin (Stenella longirostris)

The spinner dolphin *(Stenella longirostris*) occurs worldwide in tropical and warm temperate waters (Perrin and Gilpatrick, 1994; Jefferson and Schiro, 1997), primarily in offshore, deepwater environments. They feed on mesopelagic fishes and squid (Würsig et al., 2000). In the northern GOM, they occur in deeper waters off the continental shelf (Mullin and Fulling, 2004). The estimated abundance for the northern GOM is 11,550 individuals (USDOC, NOAA, 2004).

Striped Dolphin (Stenella coeruleoalba)

The striped dolphin *(Stenella coeruleoalba*) occurs in tropical to temperate oceanic waters (Perrin et al., 1994c). They feed primarily on small, mid-water squid and fishes, especially lanternfish (myctophid). In the GOM, they occur in the deeper waters off the continental shelf (Mullin and Fulling, 2004). The estimated abundance for the northern GOM is 6,258 individuals (USDOC, NOAA, 2004).

3.2.1.2. Endangered and Threatened Species

Five baleen whales (the northern right, blue, fin, sei, and humpback), one toothed whale (the sperm whale), and one sirenian (the West Indian manatee) occur in the GOM and are listed as endangered. The sperm whale is common in oceanic waters of the northern GOM and is a resident species, while the baleen whales are considered rare or extralimital in the GOM (Würsig et al., 2000). The West Indian manatee *(Trichechus manatus*) inhabits only coastal marine, brackish, and freshwater areas.

Cetaceans—Mysticetes

Blue Whale (Balaenoptera musculus)

The blue whale (*Balaenoptera musculus*) is the largest of all marine mammals. The blue whale occurs in all major oceans of the world; some blue whales are resident, some are migratory (Jefferson et al., 1993; USDOC, NMFS, 1998). Those that migrate move to feeding grounds in polar waters during spring and summer, after wintering in subtropical and tropical waters (Yochem and Leatherwood, 1985). They feed almost exclusively on concentrations of zooplankton (Yochem and Leatherwood, 1985; Jefferson et al., 1993). They are considered extralimital in the GOM (Würsig et al., 2000), with the only records consisting of two strandings on the Texas coast (Lowery, 1974). There are no abundance estimates for the GOM.

Fin Whale (Balaenoptera physalus)

The fin whale (*Balaenoptera physalus*) is an oceanic species that occurs worldwide in marine waters and is most commonly sighted where deep water approaches the coast (Jefferson et al., 1993). Fin whales feed on concentrations of zooplankton, fishes, and cephalopods (Leatherwood and Reeves, 1983; Jefferson et al., 1993). The fin whale makes seasonal migrations between temperate waters, where it mates and calves, and polar feeding grounds that are occupied during summer months. Their presence in the northern GOM is considered rare (Würsig et al., 2000). There are seven reliable reports of fin whales in the northern GOM, indicating that fin whales are not abundant in the GOM (Jefferson and Schiro, 1997). There are no abundance estimates for the GOM.

Humpback Whale (Megaptera novaeangliae)

The humpback whale (*Megaptera novaeangliae*) occurs in all oceans, feeding in higher latitudes during spring, summer, and autumn, and migrating to a winter range over shallow tropical banks, where they calve and presumably conceive (Jefferson et al., 1993). Humpback whales feed on concentrations of zooplankton and fishes using a variety of techniques that concentrate prey for easier feeding (Winn and Reichley, 1985; Jefferson et al., 1993). Humpback whales are considered rare in the GOM (Würsig et al., 2000) based on a few confirmed sightings and one stranding event. There are no abundance estimates for the GOM.

Northern Right Whale (Eubalaena glacialis)

The northern right whale (*Eubalaena glacialis*) inhabits primarily temperate and subpolar waters. Right whales forage primarily on subsurface concentrations of zooplankton (Watkins and Schevill, 1976; Leatherwood and Reeves, 1983; Jefferson et al., 1993). Northern right whales range from wintering and calving grounds in coastal waters of the southeastern United States (U.S.) to summer feeding, nursery, and mating grounds in New England waters and northward to the Bay of Fundy and the Scotian Shelf. Five major congregation areas have been identified for the western North Atlantic right whale (southeastern U.S.'s coastal waters, Great South Channel, Cape Cod Bay, Bay of Fundy, and Scotian Shelf). They are considered extralimital in the GOM (Würsig et al., 2000), and confirmed records in the GOM consist of a single stranding event in Texas (Schmidly et al., 1972) and a sighting off Sarasota County, Florida (Moore and Clark, 1963; Schmidly, 1981). There are no abundance estimates for the GOM.

Sei Whale (Balaenoptera borealis)

The sei whale (*Balaenoptera borealis*) is an oceanic species that is not often seen close to shore (Jefferson et al., 1993). They occur in marine waters from the tropic to Polar Regions, but they are more common in mid-latitude temperate zones (Jefferson et al., 1993). Sei whales feed on concentrations of zooplankton, small fishes, and cephalopods (Gambell, 1985; Jefferson et al., 1993). They are considered rare in the GOM (Würsig et al., 2000), based on records of a stranding in the Florida Panhandle and three in eastern Louisiana (Jefferson and Schiro, 1997). There are no abundance estimates for sei whales in the GOM.

Cetaceans—Odontocetes

Sperm Whale (Physeter macrocephalus)

The sperm whale (*Physeter macrocephalus*) is found worldwide in deep waters between approximately 60°N. and 60°S. latitudes (Whitehead, 2002), although generally only large males venture to the extreme northern and southern portions of their range (Jefferson et al., 1993). As deep divers, sperm whales generally inhabit oceanic waters, but they do come close to shore where submarine canyons or other geophysical features bring deep water near the coastline (Jefferson et al., 1993). Sperm whales regularly prey on cephalopods, demersal fishes, and benthic invertebrates (Rice, 1989; Jefferson et al., 1993).

The sperm whale is the only great whale that is considered common in the northern GOM (Fritts et al., 1983; Mullin et al., 1991; Davis and Fargion, 1996; Jefferson and Schiro, 1997). Aggregations of sperm whales are commonly found in waters over the shelf edge in the vicinity of the Mississippi River delta in waters that are 500-2,000 m (1,641-6,562 ft) in depth (Mullin et al., 1994b; Davis and Fargion, 1996; Davis et al., 2000). Sperm whales are often concentrated along the continental slope in or near cyclones (Davis et al., 2000). Consistent sightings in the region indicate that sperm whales most likely occupy the northern GOM throughout all seasons (Mullin et al., 1994b; Davis and Fargion, 1996; Sparks et al., 1996; Jefferson and Schiro, 1997; Davis et al., 2000), although it has yet to be demonstrated that a resident sperm whale population exists. For management purposes, sperm whales in the GOM are provisionally considered a separate stock from those in the Atlantic Ocean and Caribbean Sea (Waring et al., 1997). Estimated abundance for the northern GOM sperm whales is 1,315 individuals (USDOC, NOAA, 2004).

Sirenians

West Indian Manatee (Trichechus manatus)

The West Indian manatee (*Trichechus manatus*) is the only sirenian occurring in tropical and subtropical coastal waters of the southeastern U.S., GOM, and Caribbean Sea (Reeves et al., 1992; Jefferson et al., 1993; O’Shea et al., 1995). There are two subspecies of the West Indian manatee: the Florida manatee *(T. m. latirostri*s), which ranges from the northern GOM to Virginia; and the Antillean manatee *(T. m. manatu*s), which ranges from northern Mexico to eastern Brazil, including the islands of the Caribbean Sea.

Manatees are herbivores that feed opportunistically on a wide variety of submerged, floating, and emergent vegetation (USDOC, FWS, 2001a). Manatees primarily use open coastal (shallow nearshore) areas and estuaries; manatees are also frequently found far up freshwater tributaries. Shallow grass beds with access to deep channels are preferred feeding areas in coastal and riverine habitats (USDOI, FWS, 2001a). Manatees often use secluded canals, bayous, creeks, embayments, ponds, and lagoons, particularly near the mouths of coastal rivers and sloughs, for feeding, resting, mating, and calving (USDOI, FWS, 2001a).

During warmer months, manatees are common along the Gulf Coast of Florida from Everglades National Park northward to the Suwannee River in northwestern Florida and less common farther westward. In winter, the GOM subpopulations move southward to warmer waters. The winter range is restricted to waters at the southern tip of Florida and to waters near localized warm-water sources, such as power plant outfalls and natural springs in west-central Florida. Crystal River in Citrus County is typically the northern limit of the manatee’s winter range on the Gulf Coast. Manatees are uncommon west of the Suwannee River in Florida and are infrequently found as far west as Texas (Powell and Rathbun, 1984; Rathbun et al., 1990; Schiro et al., 1998).

3.2.2. Sea Turtles

Of the seven or eight extant species of sea turtles, five are known to inhabit the waters of the GOM and the area of the proposed action (Pritchard, 1997): the green turtle, the loggerhead, the hawksbill, the Kemp’s ridley, and the leatherback (Table 3-3). Various geographic locations referenced in this section are shown in Figure 3-4.

As a group, sea turtles possess elongated, paddle-like forelimbs that are modified for swimming and shells that are streamlined (Márquez-M., 1990; Ernst et al., 1994; Pritchard, 1997). Sea turtles spend nearly all of their lives in the water and only depend on land (specifically sandy beaches) as nesting habitat. They mature slowly and are long-lived. Generally, their distributions are primarily circumtropical, although various species differ widely in their seasonal movements, geographical ranges, and behavior. There are also considerable differences in behavior among populations of the same species (Márquez-M., 1990).

Table 3-3

Sea Turtle Taxa (Order Testudines) of the Northern Gulf of Mexico

	Relative Occurrence	ESA Status
Family Cheloniidae (hardshell sea turtles)		
Loggerhead sea turtle (*Caretta caretta*)	C	T/E*
Green sea turtle (*Chelonia mydas*)	C	E
Hawksbill sea turtle (*Eretmochelys imbricata*)	R	E
Kemp's Ridley sea turtle (*Lepidochelys kempi*)	C	E
Family Dermochelyidae		
Leatherback sea turtle (*Dermochelys coriacia*)	U	E

Population status in the northern Gulf is summarized according to the following categories:
COMMON (C): A common species is one that is abundant wherever it occurs in the region (i.e., the northern Gulf). Most common species are widely distributed over the area.
UNCOMMON (U): An uncommon species may or may not be widely distributed but does not occur in large numbers. Uncommon species are not necessarily rare or endangered.
RARE (R): A rare species is one that is present in such small numbers throughout the region that it is seldom seen. Although not threatened with extinction, a rare species may become endangered if conditions in its environment change.
Endangered Species Act (ESA) status is summarized according to listing status under the following categories:
ENDANGERED (E): Species determined to be in imminent danger of extinction throughout all of a significant portion of their range.
THREATENED (T): Species determined likely to become endangered in the foreseeable future.
ENDANGERED POPULATION (E*): Breeding populations occurring off Florida are listed as endangered; however, elsewhere in the GOM, the species is listed as threatened.

Most sea turtles exhibit differential distributions among their various life stages; hatchling, juvenile, and adult (Márquez-M., 1990; Musick and Limpus, 1997; Hirth, 1997). After evacuating a nest and reaching the sea, hatchling turtles swim away from the nesting beach until they encounter zones of watermass convergence and/or sargassum rafts that are rich in prey and provide refuge (USDOC, NMFS and USDOI, FWS, 1991a and b; USDOC, NMFS and USDOI, FWS, 1992; Hirth, 1997). Most then undergo a passive migration, drifting with prevailing current systems such as oceanic gyres.

After a period of years (the duration varies among species), juveniles actively move to juvenile habitats, which vary by species of sea turtle and are typically located in neritic waters. The term "habitat" is frequently used to communicate two very different perspectives of the concept of "home." When properly used, the term "habitat" actually refers to the "home area" used by a single species, population, or even individuals, and should convey both functionality and geographic area. The term is often misused to convey a biotic community that a species sometimes associates with (e.g., coral reef); the correct term for this is "biotope."

Examples of biotopes that sea turtles might inhabit as older juveniles include estuaries, bays, and nearshore waters. When approaching maturity, subadult juvenile turtles move into adult foraging areas, which vary among species or populations, and are geographically distinct from their juvenile habitats (Musick and Limpus, 1997). Biotopes that adult sea turtles might forage in include coral reefs, bays, estuaries, nearshore waters, infralittoral, circalittoral, and oceanic waters.

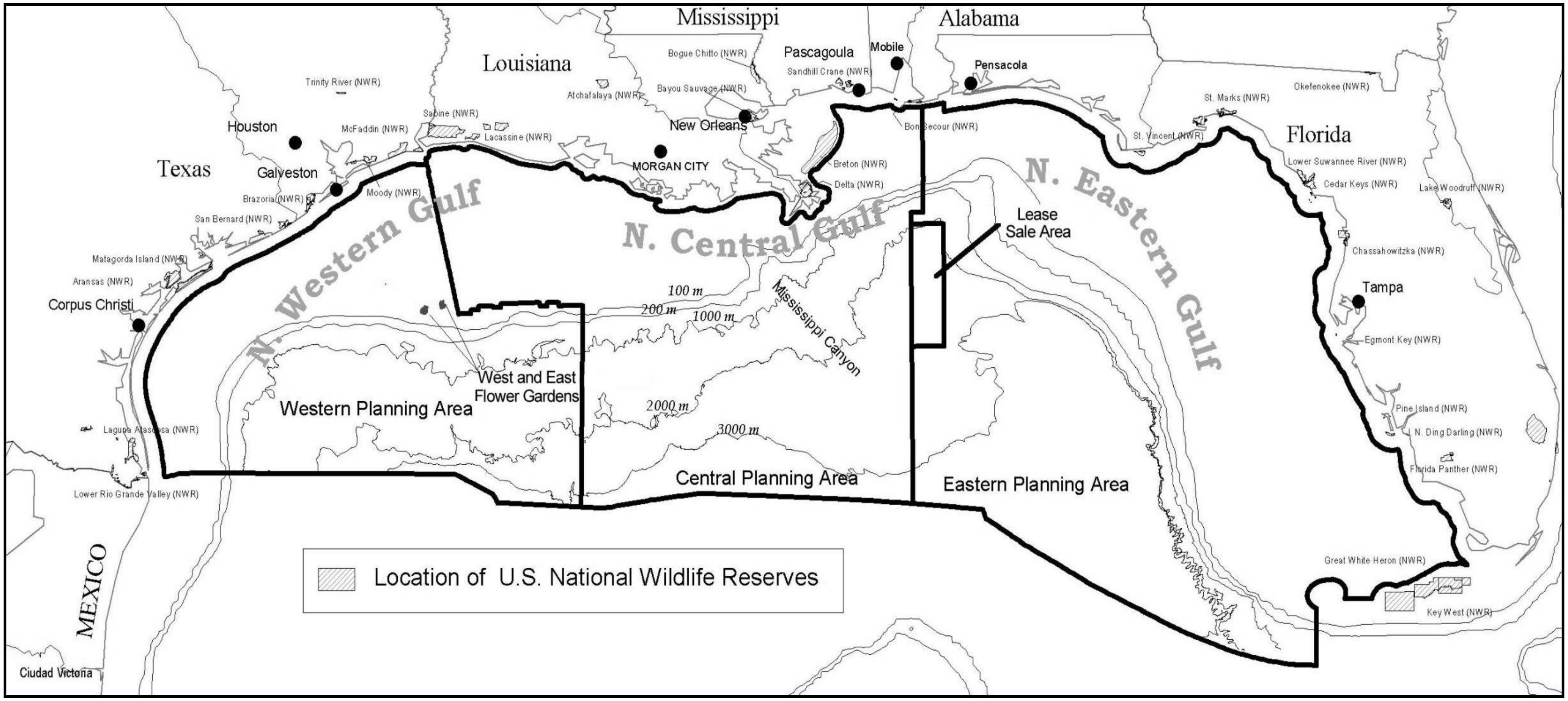


Figure 3-4. Referenced Locations throughout the Gulf of Mexico.

All sea turtle species inhabiting the GOM are listed as either endangered or threatened under the Endangered Species Act of 1973 (Pritchard, 1997). Green, Kemp's ridley, leatherback, and hawksbill sea turtles are currently listed as endangered; the loggerhead sea turtle is currently listed as threatened.

Hard-shell Sea Turtles (Family *Cheloniidae*)

Green Sea Turtle (Chelonia mydas)

The green sea turtle (*Chelonia mydas*) is the largest hard-shelled sea turtle; adults commonly reach 100 cm in carapace length and 150 kg in weight (USDOC, NMFS, 1990). The green sea turtle inhabits tropical and subtropical marine waters with extralimital occurrences generally between latitude 40° N. and latitude 40° S. (USDOC, NMFS and USDOI, FWS, 1991a; Hirth, 1997). In U.S. Atlantic waters, green sea turtles are found around the U.S. Virgin Islands, Puerto Rico, and Atlantic and Gulf Coasts of the U.S. from Texas to Massachusetts. Areas in Texas and Florida were heavily fished for green sea turtles at the end of the last century (Hildebrand, 1982).

Green sea turtles primarily occur in coastal and littoral waters, where they forage on seagrasses, algae, and associated organisms (Carr and Caldwell, 1956; Hendrickson, 1980). Some green sea turtles may move through a series of juvenile habitats as they grow (Hirth, 1997). Small juvenile green sea turtles are omnivorous. Adult green sea turtles in the Caribbean and GOM are herbivores, feeding primarily on seagrasses and, to a lesser extent, on algae and sponges. The adult feeding areas typically include beds of seagrasses and algae in relatively shallow, protected waters; juveniles may forage in areas such as coral reefs, emergent rocky bottom, sargassum mats, and in lagoons and bays. Areas known as important feeding areas for green sea turtles in Florida include the Indian River, Florida Bay, Homosassa River, Crystal River, and Cedar Key (USDOC, NMFS, 1990). Green sea turtles in the Western GOM are primarily restricted to the Texas coast where seagrass meadows and algae-laden jetties provide them juvenile habitat, especially during warmer months (Landry and Costa, 1999). Movements between principal foraging areas and nesting beaches can be extensive, with some populations regularly conducting transoceanic migrations (USDOC, NMFS and USDOI, FWS, 1991a; Ernst et al., 1994; Hirth, 1997).

Statewide in Florida, nesting has been reported for greens as early as April 28 and as late as October 3 (Meylan et al., 1995). Nesting activity in Florida is increasing; however, this trend is not uniform for the entire state (FFWCC, 2002). Green turtle nesting activity is increasing in southwestern Florida counties (Monroe through Pinellas), as well as in all coastal Florida counties west of Franklin County (FFWCC, 2002).

Hawksbill Sea Turtle (Eretmochelys imbricata)

The hawksbill (*Eretmochelys imbricata*) is a small- to medium-sized sea turtle that inhabits tropical to subtropical waters of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean. In the continental United States, the hawksbill has been recorded in coastal waters of each Gulf State and along the Atlantic Coast from Florida to Massachusetts (USDOC, NMFS, 1993), although sightings north of Florida are rare (Hildebrand, 1982). They are considered more tropical than other sea turtle species and are the least commonly reported sea turtle species occurring in the northern GOM (Márquez-M., 1990; Hildebrand, 1995).

Older juveniles, subadults, and adults generally use coral reefs as foraging habitat. Adult hawksbills feed primarily on sponges (Carr and Stancyk, 1975; Meylan, 1988) and demonstrate a high degree of selectivity, feeding on a relatively limited number of sponge species, primarily demosponges (Ernst et al., 1994).

Texas and Florida are the only states in the U.S. where hawksbills are sighted with any regularity (USDOC, NMFS, 1993). Stranded hawksbills have been reported in Texas (Hildebrand, 1982; Amos, 1989) and in Louisiana (Koike, 1996); these tend to be either hatchlings or yearlings. A hawksbill was captured accidentally in a purse seine net just offshore Louisiana (Rester and Condrey, 1996). Hawksbills found stranded in Texas are believed to originate from nesting beaches in Mexico (Landry and Costa, 1999). Northerly currents may direct juvenile hawksbills away from their natal beaches in Mexico northward into Texas (Amos, 1989; Collard and Ogren, 1990). Offshore at the Flower Garden Banks National Marine Sanctuary, seven sightings of the hawksbill were made between 1994 and 2000

(Hickerson, 2000). Hickerson (2000) determined that Stetson Bank, a midshelf bank that is part of the Flower Garden Banks National Marine Sanctuary, is more suitable habitat to the hawksbill sea turtle than either the East or West Flower Garden Bank. More recently, scientific divers at Stetson Bank observed an adult hawksbill sea turtle during the warmer months of 2001 (Hickerson, personal communication, 2001).

The hawksbill turtle is a solitary nester. Nesting within the continental U.S. is limited to southeastern Florida and the Florida Keys. Nesting by hawksbills in Florida is considered rare. Statewide, nesting has been reported as early as June 6 and as late as October 31 (Meylan et al., 1995). Juvenile hawksbills show evidence of residency on specific foraging grounds, although hawksbill migrations are possible (USDOC, NMFS, 1993). Some populations of adult hawksbills undertake reproductive migrations between foraging grounds and nesting beaches (Márquez-M., 1990; Ernst et al., 1994). The hawksbill is presently listed as an endangered species.

Kemp's Ridley Sea Turtle (Lepidochelys kempi)

The Kemp's ridley (*Lepidochelys kempi*) is the smallest sea turtle species and occurs chiefly in the GOM. It may also be found along the northwestern Atlantic Coast of North America as far north as Newfoundland. It is the most imperiled of the world's sea turtle species. The GOM's population of nesting females has dwindled from an estimated 47,000 in 1947 to a current nesting population of approximately 4,200 females (Shaver, personal communication, 2001). A population crash that occurred between 1947 and the early 1970's may have resulted from both intensive annual harvest of the eggs and mortality of turtles in trawl fisheries (NRC, 1990). Recovery of the Kemp's ridley from the threat of extinction has been forestalled primarily by mortality attributed to the commercial shrimp fishery (USDOI, FWS and USDOC, NMFS, 1992).

In the northern GOM, Kemp's ridleys are most abundant in coastal waters from Texas to west Florida (Ogren, 1989; Márquez-M., 1990 and 1994; Rudloe et al., 1991). Kemp's ridleys display strong seasonal fidelity to tidal passes and adjacent beachfront environs of the northern GOM (Landry and Costa, 1999). There is little prolonged utilization of waters seaward of the 50-m isobath by this species (Renaud, 2001). Adult Kemp's ridley turtles usually occur only in the GOM, but juvenile and immature individuals sometimes occur in tropical and temperate coastal areas of the northwestern Atlantic and GOM (Márquez-M., 1990). Juveniles are more common than adults along the East Coast of the U.S., from Florida to New England and especially off eastern Florida and Georgia. Within the GOM, juvenile and immature Kemp's ridleys have been documented along the Texas and Louisiana coasts, at the mouth of the Mississippi River, and along the west coast of Florida, as quoted in stranding reports (Ogren, 1989; Márquez-M., 1990).

The primary nesting area used by the Kemp's ridley sea turtle is near Rancho Nuevo along the northeastern coast of Mexico in the State of Tamaulipas (USDOI, FWS and USDOC, NMFS, 1992, Márquez-M. et al., 2001), although secondary nest areas have also been reported in other areas of Mexico, Texas (specifically south Texas), Florida, and South Carolina (USDOI, FWS and USDOC, NMFS, 1992; Ernst et al., 1994; Márquez-M. et al., 2001). Eggs are laid annually, and following the nesting season, the adults disperse towards two feeding grounds: one northwest toward Florida and the other southeast to the Campeche Bank off the Yucatan Peninsula of Mexico. Some adult female Kemp's ridley sea turtles tagged at Rancho Nuevo have been recorded off Louisiana and Mississippi (Márquez-M., 1994). Two adult females bearing flipper tags applied at the Rancho Nuevo nesting beach were recaptured at Calcasieu and Sabine Passes, Louisiana. These post-nesting females may have been in transit to shallow GOM foraging areas to begin conditioning for their next reproductive cycle (Landry and Costa, 1999). Post-nesting females have also been tagged in Texas, and 17 of the 18 animals tagged with satellite transmitters between 1997 and 2001 were discovered to occupy waters along at least one of the Gulf Coast States (Shaver, personal communication, 2001). Only one post-nesting female that was tagged with a satellite transmitter in Texas moved south to Mexican waters (Shaver, personal communication, 2001). Juveniles, subadults, and adults are common off Big Gulley, an offshore area east of Mobile Bay, Alabama, where they have been sometimes captured in trawls since the mid-1970's (Carr, 1980; Ogren, 1989; Márquez-M., 1994). Some of the smallest Kemp's ridley sea turtles have been found off Wakulla and Franklin Counties, Florida (Ogren, 1989). Two sightings of Kemp's ridley turtles were reported over the continental shelf in the Eastern GOM during GulfCet II surveys (Davis et al., 2000).

Nesting in the U.S. occurs annually on Padre and Mustang Islands in south Texas from May to August (Thompson, 1988). A multiagency program initiated in 1978 to establish a secondary nesting colony in south Texas supplemented natural nesting. From 1948 through 1998, 45 Kemp's ridley nests on the Texas coast were documented (Shaver and Caillouet, 1998). Only 11 Kemp's ridley nests were found in Texas from 1979 to 1995 (Shaver, 1995). The first documented nesting of living-tagged Kemp's ridley in 1996 is the first documentation of any sea turtle nesting at an experimental imprinting site and outside of captivity after being released from a head-starting program (Shaver, 1996a and b). During the 1998 nesting season, 13 confirmed Kemp's ridley nests were found on the Texas coast (Shaver and Caillouet, 1998). A record 16 Kemp's ridley nests were found on Texas beaches during 1999. Twelve nests were documented in Texas during 2000; however, only eight Kemp's ridley nests were located in Texas during the 2001 nesting season (Shaver, personal communication, 2001).

The first confirmed nesting in the U.S. of a Kemp's ridley turtle that had previously nested in Mexico occurred in 1998 (Shaver and Caillouet, 1998). Kemp's ridleys that nest in south Texas today are likely a mixture of returnees from the experimental imprinting and head-starting project and others from the wild stock. Kemp's ridley sea turtles have been also documented nesting in Alabama and Florida, although less frequently than on Texas beaches. In 1998, one nest was confirmed in Alabama on Bon Secour National Wildlife Refuge (Baldwin County) (MacPherson, personal communication, 2000). In the same year, another nesting site was confirmed on Gulf Islands National Seashore (GINS) (Perdido Key Area, Escambia County, Alabama) (Nicholas, personal communication, 2000). Another nest that yielded approximately 26 hatchlings was documented during 2001 (USDOI, FWS, 2001b). Kemp's ridley turtles have occasionally nested in Florida. There are two reports for Pinellas County, Florida: one on Madeira Beach in 1989 (Meylan et al., 1990) and the second on Clearwater Beach in 1994 (Anonymous, 1994). There were two nests for Volusia County on the southeast coast of Florida (May 14 and June 1, 1996) (Johnson et al., 2000). The Kemp's ridley sea turtle nesting and hatching season for northwest Florida beaches extends from May 1 through October 31. For the one confirmed nest on GINS, the nest was laid on May 31 and eggs hatched on August 3, for an incubation period of 64 days (Nicholas, personal communication, 2000). Two adult female Kemp's ridleys found at Padre Island were satellite tagged to document post-nesting movements (Shaver, personal communication, 1998). Both females moved northward, spending most of their time in Louisiana waters; one female moved as far as western Florida, the other stayed in the vicinity of Louisiana.

Hatchlings appear to disperse offshore and are sometimes found in sargassum mats (Collard and Ogren, 1990). Two juvenile Kemp's ridleys released through the NOAA Fisheries' headstart program were found drifting in sargassum: one was found 46.3 km south of Mobile, Alabama; the other 4.6 km off Horseshoe and Pepperfish Keys on the north-central Gulf Coast of Florida (Manzella et al., 1991). During the pelagic life history stage, the Kemp's ridley sea turtle is dependent on currents, fronts, and gyres to determine its distribution. Hatchling and small juvenile habitats are hardly known. Some young turtles stay within the GOM, whereas others are carried by currents out of the GOM into the Gulf Stream current and up to the northeastern U.S. The latter migrate south and enter the GOM as they approach maturity. With growth, the turtles actively move to shallow coastal waters, especially off western Louisiana and eastern Texas or off northwestern Florida, where feeding on benthos occurs. Portions of the north and northeastern GOM are used as foraging habitat by juveniles, subadults, and post-nesting females (Ogren, 1989; Rudloe et al., 1991). Kemp's ridleys inhabiting coastal waters of Texas and Louisiana use sandy and muddy bottoms, feeding on portunids and other crabs (Ogren, 1989; Shaver, 1991), and possibly on bycatch generated by the shrimp fishery (Landry and Costa, 1999). Other Kemp's ridleys move to Cedar Key, Florida, an area where they also prey on portunid crabs. This is an area where seagrass communities are common, and Kemp's ridleys are known to penetrate bays and estuaries there (Carr and Caldwell, 1956; Lutcavage and Musick, 1985; Landry, personal communication, 2000). Strandings of Kemp's ridleys on Texas beaches indicate that they are mostly from Mexico (Shaver, personal communication, 1998).

Loggerhead Sea Turtle (Caretta caretta)

The loggerhead (*Caretta caretta*) is a large sea turtle that inhabits temperate and tropical waters of the Atlantic, Pacific, and Indian Oceans. This species is wide-ranging and is capable of living in a variety of biotopes (Márquez-M., 1990; USDOC, NMFS and USDOI, FWS, 1991b; Ernst et al., 1994). The loggerhead is the most abundant species of sea turtle occurring in U.S. waters of the Atlantic, from

Florida to Cape Cod, Massachusetts. The loggerhead is probably the most common sea turtle species in the northern GOM (e.g., Fritts et al., 1983; Fuller and Tappan, 1986; Rosman et al., 1987; Lohoefener et al., 1990) and is currently listed as a threatened species.

In the western North Atlantic, there are at least four loggerhead nesting subpopulations: the Northern Nesting Subpopulation (North Carolina to northeast Florida, about 29° N. latitude); the South Florida Nesting Subpopulation (29° N. latitude to Naples); the Florida Panhandle Nesting Subpopulation (Eglin Air Force Base and the beaches near Panama City); and the Yucatán Nesting Subpopulation (northern and eastern Yucatán Peninsula, Mexico) (Byles et al., 1996). Based upon the returns of tags applied at nesting beaches, non-nesting adult females from the South Florida Subpopulation are distributed throughout the Bahamas, Greater Antilles, Yucatán, Eastern GOM, and southern Florida (Meylan, 1982). Non-nesting adult females from the Northern Subpopulation occur occasionally in the northeastern GOM (Meylan, 1982). Limited tagging data suggest that adult females nesting in the GOM remain in the GOM (Meylan, 1982). Five transmitters were placed on loggerheads nesting at the Archie Carr National Wildlife Refuge on the eastern coast of Florida during August 2000. Each of these nesting females subsequently traveled south along the Florida coast and turned northward into the GOM after passing the Florida Keys. One female was tracked moving northward into the Big Bend area off Florida, where it then turned southward and was last detected offshore of the Ten Thousand Islands area of Florida. Female loggerheads have also been outfitted with satellite transmitters upon nesting at beaches of the Gulf Islands National Seashore and Pensacola Beach. Upon departing these beaches, females moved eastward to offshore waters of the Big Bend area or southward to the Florida Keys, remained in waters adjacent to the nesting beaches where tagged, or traveled westward past the mouth of the Mississippi River to waters offshore of Galveston, Texas. In 1999, satellite tags were also placed on three female adult loggerhead turtles after they finished nesting on Cape San Blas, St. Joseph Peninsula, in Gulf County, Florida. Before the tags expired, two of the three turtles were recorded off the Yucatan in Mexico and the third was located offshore the Ten Thousand Islands area of Florida. Information regarding these migrations can be found at the following website: www.cccturtle.org. However, little information is available regarding activity of adult males, although they have been observed year-round in south Florida (Byles et al., 1996).

The largest nesting concentration in the U.S. is on the southeast Florida coast from Volusia to Broward Counties. Statewide in Florida, nesting has been reported for loggerheads as early as March 16 and as late as October 16 (Meylan et al., 1995). Loggerheads are the most common nesting sea turtle in northwest Florida and account for over 99 percent of the nests. The loggerhead sea turtle nesting and hatching season for northwest Florida beaches generally extends from about May 1 through October 31. The earliest nest was documented on April 27 and the latest nest on November 1. Nest incubation ranges from about 49 to 95 days. On the Gulf Coast of Florida, nesting by loggerheads occurs from Monroe through Pinellas Counties (southwest Florida) and from Franklin through Escambia Counties (northwest Florida) (Brost, personal communication, 2001). The greatest density of loggerhead nests known per region occur in Sarasota and Charlotte Counties (southwest Florida), and Bay, Gulf, and Franklin Counties (northwest Florida).

On the Central Gulf Coast, limited monitoring of nesting activity has been conducted. A total of 107 loggerhead nests were documented during the 1999 and 2000 nesting seasons on the Bon Secour National Wildlife Refuge to Mobile Bay (Swilling, personal communication, 2001). The FWS's Sea Turtle Volunteer Program documented 48 loggerhead nests in Alabama during 2001 (USDOI, FWS, 2001c). Loggerhead nesting was reported at Biloxi, Mississippi, in 1991 (South and Tucker, personal communication, 1991). It is unknown whether the nesting sea turtles in Alabama, Mississippi, and Louisiana are genetically similar to the Florida Panhandle Subpopulation (Bowen et al., 1993). Nesting in Texas occurs primarily on North and South Padre Islands, although occurrences are recorded throughout coastal Texas (Hildebrand, 1982).

Based on aerial surveys conducted in the western North Atlantic, loggerheads are distributed about 54 percent in the southeast U.S. Atlantic, 29 percent in the northeast U.S. Atlantic, 12 percent in the eastern GOM, and 5 percent in the western GOM (Byles et al., 1996). Aerial surveys indicate that loggerheads are abundant in waters that are less than 100 m in depth (Shoop et al., 1981; Fritts et al., 1983). During GulfCet aerial surveys, loggerheads were sighted throughout the northern GOM continental shelf waters out to the 100-m isobath (Davis et al., 2000). Loggerheads were also sighted in waters seaward of the 1,000-m isobath. Sightings indicate that loggerheads are more widely distributed in shelf waters than Kemp's ridley and green sea turtles, which are more closely associated with coastal waters (Landry and

Costa, 1999). Loggerhead abundance in continental slope waters of the Eastern GOM increased appreciably during winter (Davis et al., 2000). It is not clear why adult loggerheads occur in oceanic waters, unless they travel between widely distributed foraging sites in the GOM or seek warmer waters during winter (Davis et al., 2000). Shoop et al. (1981) suggested that loggerheads in oceanic waters off the Atlantic Coast of the U.S. were probably in transit to other areas. Witzell and Azarovitz (1996) suggested that some turtles may move offshore in winter to seek warm-core eddies.

Loggerheads are abundant in Florida waters (Fritts and Reynolds, 1981; Fritts et al., 1983; Davis et al., 2000). Underwater surveys made near artificial reefs and a sunken offshore platform near Panama City, Florida, noted 17 sightings of loggerheads. All turtles sighted were usually resting in a shallow pit of sand where the artificial reef formed a sheltering overhang (Rosman et al., 1987). In the Central GOM, loggerheads are abundant just offshore Breton and Chandeleur Islands (Lohoefener et al., 1990). Subadult loggerheads tagged with satellite transmitters at the Flower Garden Banks near the shelf-edge off Texas were found to persist there over several years (Hickerson, 2000).

Loggerheads feed primarily on benthic invertebrates, but they will also forage on a wide variety of organisms (Ernst et al., 1994). Juvenile and subadult loggerheads are omnivorous, foraging on pelagic crabs, molluscs, jellyfish, and vegetation captured at or near the surface (Dodd, 1988; Plotkin et al., 1993). Adult loggerheads forage on benthic invertebrates (Dodd, 1988). The banks off central Louisiana and near the Mississippi Delta are important sea turtle feeding areas (Hildebrand, 1982). Subadult loggerheads use the Flower Garden Banks near the shelf-edge off Texas as feeding habitat during all seasons (Hickerson, 2000). Genetic evidence suggests that at least two subpopulations intermingle on the foraging grounds of the U.S. Atlantic Coast (Byles et al., 1996).

Leatherback Sea Turtle (Family *Dermochelyidae*)

Leatherback Sea Turtle (Dermochelys coriacea)

The leatherback (*Dermochelys coriacea*) is the largest and most distinctive sea turtle. This species possesses a unique skeletal morphology, most evident in its flexible, ridged carapace. Leatherbacks maintain a core body temperature several degrees above ambient in cold water. They also have unique deep-diving abilities (Eckert et al., 1986). This species is the most wide-ranging sea turtle, undertaking extensive migrations from the tropics to boreal (cold-temperate regions of the northern latitudes) waters (Morreale et al., 1996; Hughes et al., 1998). Though considered oceanic, leatherbacks occasionally enter bays and estuaries (Hoffman and Fritts, 1982; Knowlton and Weigle, 1989; Shoop and Kenney, 1992). Using satellite telemetry, female leatherback turtles were tracked migrating through the Pacific Ocean following similar and in some cases virtually identical pathways or ocean corridors to travel (Morreale et al., 1996). Leatherbacks feed primarily on gelatinous zooplankton such as jellyfish, siphonophores, and salps (Brongersma, 1972), although they sometimes ingest some algae and vertebrates (Ernst et al., 1994). Contents from leatherbacks' stomachs have been analyzed and indicate that leatherbacks feed at the surface, at depth within deep scattering layers, and on benthos. Florida is the only site in the continental U.S. where leatherbacks regularly nest (USDOC, NMFS and USDOI, FWS, 1992; Ernst et al., 1994; Meylan et al., 1995). The leatherback is currently listed as an endangered species.

Sightings of leatherbacks are common in oceanic waters of the northern GOM (Leary, 1957; Fritts et al., 1983; Lohoefener et al., 1988 and 1990; Collard, 1990; Davis et al., 2000). Based on a summary of several studies, Davis and Fargion (1996) concluded that the primary area utilized by the leatherback in the northwestern GOM is oceanic waters (>200 m). In contrast, overall densities of leatherbacks in the Eastern GOM in shelf and slope waters were similar (Davis et al., 2000). It has been suggested that the region from Mississippi Canyon east to DeSoto Canyon appears to be an important habitat area for leatherbacks (Davis and Fargion, 1996). Most sightings made of leatherbacks during GulfCet surveys occurred slightly north of DeSoto Canyon (Davis and Fargion, 1996; Davis et al., 2000). Nearly disjunct summer and winter distributions of leatherback sightings in continental slope waters of the Eastern GOM during GulfCet II indicate that certain areas may be important to this species either seasonally or for shorter periods. These areas are probably related to oceanographic conditions and concentrations of prey. Large numbers of leatherbacks in waters off the northeast U.S. have been associated with concentrations of jellyfish (Shoop and Kenney, 1992). Similar sightings with increased jellyfish densities have been made in the GOM: 100 leatherbacks were sighted just offshore Texas and 7 were seen at a watermass boundary in the Eastern GOM (Leary, 1957; Collard, 1990). Other sightings of surfaced leatherback aggregations have been reported for the northern GOM: 8 leatherbacks were sighted one day in DeSoto Canyon (Davis and Fargion, 1996), 11 during one day just south of the Mississippi River Delta (Lohoefener et al., 1990), and 14 on another day in DeSoto Canyon (Lohoefener et al., 1990).

Leatherbacks nest on coarse-grain beaches in tropical latitudes (Pritchard, 1971). Analysis of haplotype frequencies has revealed that nesting populations of leatherbacks are strongly subdivided globally, despite the leatherback's highly migratory nature (Dutton et al., 1999). Those findings provisionally support the natal homing hypothesis for leatherbacks. Leatherbacks nest annually in U.S. territories within the Caribbean, principally at St. Croix (U.S. Virgin Islands) and Isla Culebra (Puerto Rico) (USDOC, NMFS and USDOI, FWS, 1992). Designated critical habitat for the leatherback includes the waters adjacent to Sandy Point, St. Croix. Other leatherback nesting beaches in the region are located in Georgia and Florida. Based on an average of 5-7 nests per female per season observed at other rookeries, Meylan et al. (1995) estimated there to be 16-31 individual leatherbacks nesting annually in small numbers on the East Coast of Florida.

On the Gulf Coast of Florida, documented leatherback nesting activity is rare, but increasing. One leatherback nest was reported between Phillips Inlet and Destin in September 1962 (Yerger, 1965). Another leatherback nest was documented in 1974 on St. Vincent Island, Franklin County. From 1993 to 2000, only 15 nests were reported—10 in Franklin County, 3 in Okaloosa County, and 1 each in Gulf and Escambia Counties (Brost, personal communication, 2001). Seven leatherback nests were found during 2000 in Franklin, Okaloosa, and Escambia Counties. Eight nests were documented in Franklin, Gulf, and Bay Counties during 2001.

Nesting occurs from February through July from Georgia to the U.S. Virgin Islands. The leatherback sea turtle nesting and hatching season for northwest Florida beaches extends from May 1 through October 31. For confirmed nesting, the earliest nest was documented on April 29 and the latest nest documented on June 19. Documented nest incubation in northwest Florida ranges from about 63 to 84 days (Brost, personal communication, 2001; Miller, personal communication, 2001; Nicholas, personal communication, 2001). Statewide in Florida, nesting has been reported for leatherbacks as early as February 22 (Meylan et al., 1995). Although the number of leatherbacks nesting on Florida beaches is small relative to those nesting in St. Croix and Puerto Rico, they are the only nesting beaches regularly utilized by this endangered species in the continental U.S.

3.2.2.1. Sea Turtle Distributions on the Northern Gulf of Mexico OCS

Surveys conducted during the GulfCet I and II studies represent the most recent assessments of sea turtle distribution and abundance within the oceanic northern GOM (Davis et al., 1998 and 2000). During these surveys, only three species of sea turtles were sighted: loggerheads, Kemp's ridleys, and leatherbacks.

GulfCet I and II found the numbers of sea turtles in the northern GOM to be considerably higher over the continental shelf and within the eastern GOM, east of Mobile Bay (Lohoefener et al., 1990; Davis et al., 2000). Kemp's ridleys were sighted only along the shelf. Sightings of loggerheads were considerably higher over the continental shelf than on the continental slope. However, there were sightings of loggerheads in water depths >1,000 m. The importance of oceanic habitat to loggerheads was not clear from GulfCet, although it was suggested that turtles cross these waters to distant foraging sites or seek warmer waters during winter (Davis et al., 2000). From historic sightings, leatherbacks appear to use both shelf and slope habitat areas in the northern GOM (Fritts et al., 1983; Collard, 1990; Davis et al., 1998). GulfCet studies suggested that the region from Mississippi Canyon to DeSoto Canyon, near the shelf edge, may be important habitat for leatherbacks (Davis et al., 2000).

Loggerheads are widely distributed across the continental shelf during both summer and winter, though their abundance over the slope is much higher during winter surveys than in summer (Davis et al, 2000). Temporal variability in leatherback distribution and abundance suggests that specific areas may be important to the species, either seasonally or for short periods. Overall, leatherbacks occurred in ample numbers during both summer and winter surveys, and the variability in the numbers sighted within specific areas suggest that their distribution patterns were irruptive in nature (Davis et al., 2000).

3.2.3. Fisheries

3.2.3.1. Fish Resources

Ichthyoplankton

Most fishes inhabiting the GOM, whether benthic or pelagic as adults, have pelagic larval stages. For various lengths of time (10-100 days depending on the species), these pelagic eggs and larvae become part of the planktonic community. Variability in survival and transport of pelagic larval stages is thought to be an important determinant of future year-class strength in adult populations of fishes and invertebrates (Underwood and Fairweather, 1989; Doherty and Fowler, 1994). For this reason, larval fishes and the physical and biological factors that influence their distribution and abundance have received increasing attention from marine ecologists. In general, the distribution of fish larvae depends on spawning behavior of adults, hydrographic structure and transport at a variety of scales, duration of the pelagic period, behavior of larvae, and larval mortality and growth (Leis, 1991).

Ichthyoplankton sampling at a regional scale in the GOM began in the early 1970's with routine surveys for king and Spanish mackerel larvae (Wollam, 1970; Dwinell and Futch, 1973). Houde et al. (1979) conducted major surveys of ichthyoplankton in the Eastern GOM from 1972 to 1974. They sampled 483 stations located on a grid extending from 24º30′ N. latitude to 29º30′ N. latitude and from depths of 10-200 m (33-656 ft). Finucane et al. (1977) collected eggs and ichthyoplankton from areas off the Texas continental shelf over a three-year period (1975-1977) as part of the South Texas Outer Continental Shelf Studies. They sampled between Port Isabel and Matagorda Bay, Texas, covering an area of approximately 100 by 300 km. In 1977, the first comprehensive surveys of the Southeastern Area Monitoring and Assessment Program (SEAMAP) began collecting larval fishes in the GOM from a grid of sampling stations encompassing the entire northern GOM (Sherman et al., 1983; Richards et al., 1984; Kelley et al., 1986). More recently, larval fish researchers have been sampling well-defined hydrographic features such as the Mississippi River discharge plume (Govoni et al., 1989; Grimes and Finucane, 1991) and the Loop Current frontal boundary (Richards et al., 1989 and 1993). These studies have used real-time physical oceanographic data to guide sampling near the hydrographic features of interest. For the aforementioned surveys, most investigators sampled ichthyoplankton using towed bongo (water column) and neuston (sea surface) nets and occasionally discrete depth nets, with mesh sizes ranging from 0.333 to 1.00 mm (Ditty et al., 1988). Taxonomic resolution in most published studies is at the family level.

Richards (1990) estimates that there are 200 families with more than 1,700 species whose early life stages may occur in the GOM. In addition to the resident fauna, many eggs, larvae, and juveniles may be advected into the Gulf from the Caribbean Sea via the Loop Current. In their study of the Loop Current front, Richards et al. (1993) identified 237 taxa representing 100 families. They considered this a remarkable family-level diversity when compared with previous surveys made in the GOM and other oceans. The diversity was attributed to a mix of fauna from tropical and warm temperate oceanic, mesopelagic, and coastal demersal and pelagic species. The larval sampling surveys by Houde et al. (1979) yielded over 200 taxa from 91 families in the Eastern GOM. Ditty et al. (1988) summarized information from over 80 ichthyoplankton studies from the Northern GOM (north of 26º N. latitude) and reported 200 coastal and oceanic fishes from 61 families. Preliminary SEAMAP cruises collected 137 genera and species from 91 families (Sherman et al., 1983). The most abundant families collected in the Eastern Gulf by Houde et al. (1979) were clupeids (herrings), gobiids (gobies), bregmacerotids (codlets), carangids (jacks), synodontids (lizardfishes), myctophids (lanternfishes), serranids (seabasses), ophidiids (cusk eels), and labrids (wrasses). These families contributed 64 percent of the total taxa collected by Houde et al. (1979). Finucane et al. (1977) reported the most dominant taxa from their south Texas collections occurred in the myctophids (lanternfishes) followed by the sciaenids (drums) and scombrids (mackerels and tunas). Sherman et al. (1983) compared the rank order of the 21 most abundant families overall and by quadrant (northeast, northwest, southeast, southwest) taken during early SEAMAP cruises (Table 3-4).

Table 3-4

The 21 Most Abundant Families in Ichthyoplankton Samples from Quadrants of the Gulf of Mexico

Family	Rank Northeast Quadrant	Southeast Quadrant	Northwest Quadrant	Southwest Quadrant	Overall
Myctophidae	1	1	1	1	1
Gonostomatidae	2	2	2	2	2
Bregmacerotidae	4	3	3	5	3
Scombridae	3	6	10	8	4
Paralepididae	6	18	7	7	5
Stromateidae	5	16	6	6	6
Gobiidae	15	8	4	9	7
Bothidae	8	5	11	4	8
Serranidae	11	15	8	10	9
Synodontidae	9	14	9	18	10
Scaridae	10	4	18	16	11
Clupeidae	21	21	5	21	12
Apogonidae	13	17	16	3	13
Carangidae	7	11	13	14	14
Labridae	14	7	17	15	15
Engraulidae	17	20	12	12	16
Gempylidae	12	10	15	11	17
Tetraodontidae	19	9	20	19	18
Anguilliformes	16	19	14	13	19
Ophidiidae	20	12	19	20	20
Scorpaenidae	18	13	21	17	21

Source: Sherman et al., 1983.

Species such as Atlantic croaker, spot, and Gulf menhaden migrate to the outer shelf during winter months to spawn. Consequently, larvae of these species are often numerically dominant during winter months. Many families have numerous species within them, such as engraulids, searobins (Triglidae), tonguefishes (Cygnoglossidae), and pufferfishes (Tetradontiidae). Species from these families were collected during all months.

Many taxa were only collected over waters within certain depth ranges (Table 3-5). Species found exclusively in water depths shallower than 25 m (82 ft) were mostly inshore demersal species such as Atlantic bumper (*Caranx ruber*), spotted seatrout (*Cynoscion nebulosus*), pigfish (*Orthopristis chrysoptera*), and black drum (*Pogonias cromis*). At depths >100 m (>328 ft), several clupeids (*Brevoortia patronus*, *Opisthonema oglinum*, and *Sardinella aurita*), several serranids (*Centropristis striata*, *Diplectrum formosum*, and *Serraniculus pumilio*), Atlantic croaker (*Micropogon undulatus*), and spot (*Bairdiella chrysura*) were most common in collections. Two tunas (*Auxis* sp. and *Euthynnus*

Table 3-5

Primary Depth Distribution of Larval Fishes (<10 mm standard length) in the Gulf of Mexico North of 26º N. Latitude

Genus/Species	Depth				
	<25 m	<50 m	<100 m	50-200 m	>150 m
*Archosargus probatocephalus**	•				
Chaetodipterus faber	•				
Chloroscombrus chrysurus	•				
Cynoscion arenarius	•				
*C. nebulosus**	•				
Orthopristis chrysoptera	•				
Peprilus paru	•				
*Pogonias cromis**	•				
Anchoa spp.		•			
*Brevoortia patronus**		•			
Centropristis striata		•			
Diplectrum formosum		•			
Harengula jaguana		•			
*Lagodon rhomboides**		•			
*Leiostomus xanthurus**		•			
*Micropogonias undulatus**		•			
Opisthonema oglinum		•			
Sardinella aurita		•			
Scomberomorus maculatus		•			
Serraniculus pumilio		•			
Decapterus punctatus			•		
Peprilus burti			•		
Auxis sp.				•	
Caranx crysos				•	
Etrumeus teres				•	
Euthynnus alletteratus				•	
Hemanthias vivanus				•	
Lutjanus campechanus				•	
Scomberomorus cavalla				•	
Trachurus lathami				•	
Euthynnus pelamis					•
Istiophorus spp.					•
Xiphias gladius					•

* Indicates larvae are estuarine dependent.
Note: Depth ranges are those at which >75% of larvae were collected.
Adapted from: Ditty et al., 1988.

alletteratus), blue runner (*Caranx crysos*), round herring (*Etrumeus teres*), red barbier (*Hemanthias vivanus*), red snapper (*Lujanus campechanus*), king mackerel (*Scomberomorus cavalla*), and rough scad (*Trachurus lathami*) were collected only over water depths of 50-200 m (164-656 ft). Wide-ranging epipelagic species such as skipjack tuna (*Euthynnus pelamis*), sailfish (*Istiophorus platypterus*), and Atlantic swordfish (*Xiphias gladius*) were collected only in water depths exceeding 150 m (492 ft).

Two of the most important hydrographic features in the GOM are the Mississippi River discharge plume and the Loop Current. A series of investigations have shown that ichthyoplankton aggregate at the frontal zone of the Mississippi River discharge plume (Govoni et al., 1989; Grimes and Finucane, 1991; Govoni and Grimes, 1992). Grimes and Finucane (1991) sampled larval fishes, chlorophyll *a*, and zooplankton along transects traversing the discharge plume. Total ichthyoplankton catch per tow, individual surface chlorophyll *a* values, and zooplankton volumes were all considerably greater in frontal waters than adjacent shelf or plume waters. They found that when comparing catches of ichthyoplankton among shelf, frontal, and plume samples that frontal samples contained a higher average number of fish larvae than either plume or shelf waters. Hydrodynamic convergence and the continually reforming turbidity fronts associated with the discharge plume probably accounted for the concentration of larval fishes at the front. These investigators hypothesized that frontal waters provide feeding and growth opportunities for larvae. Bothids, carangids, engraulids, exocoetids, gobiids, sciaenids, scombrids, synodontids, and tetraodontids were the nine most frequently caught taxa in the plume/shelf samples off the Mississippi River Delta (Grimes and Finucane, 1991).

Richards et al. (1989 and 1993) examined the distribution of larval fishes along eight transects across the Loop Current boundary, as defined from satellite imagery of sea surface temperature. Most of the samples were off the continental shelf in water depths exceeding 200 m (656 ft). Although 100 fish families were identified, only 25 families were represented by >0.5 individuals/sample. Of these, the lanternfishes were most abundant. A cluster analysis of the 25 most-abundant families resolved three assemblages: oceanic, shelf, and frontal. The oceanic assemblage consisted of mesopelagic families such as hachetfishes (sternoptichyids), lanternfishes (myctophids), and bristlemouths (gonostomatids). The shelf group was subdivided into three groups including demersal taxa (e.g., sciaenids and bothids), coastal pelagic taxa (e.g., carangids and scombrids), and widely dispersing reef species (e.g., labrids, scarids, and scorpaenids). The frontal group consisted of both oceanic and shelf taxa. These studies suggest that water temperature is a major influence on the structure of larval fish assemblages (Richards et al., 1993).

All of the studies previously mentioned were conducted in the open GOM in shelf or oceanic waters. One survey by Ruple (1984) concentrated on the surf zone ichthyoplankton along a barrier island beach offshore Mississippi. Over the course of a year, Ruple (1984) sampled inner and outer surf zone regions and collected almost 40,000 larval fishes represented by 69 taxa. The most abundant taxa collected from the outer surf zone were anchovies (Engraulidae), Atlantic bumper, and tonguefishes. From the inner surf zone, engraulids, spot, Gulf menhaden, and hogchoker were most abundant. Seasonal peaks in abundance occurred at the outer surf zone stations during May and June and at the inner surf zone stations during December. The importance of the surf zone as habitat for larval fishes was not clear, but it appeared as though many of the larvae collected were large in size and may have been intercepted during their shoreward migration into Mississippi Sound where they would normally take up residence as benthic juveniles.

Larval fishes are highly dependent on zooplankton until they can feed on larger prey. In the Northern GOM, the diets of Atlantic croaker, Gulf menhaden, and spot consist mainly of copepods and copepod nauplii, larval bivalves, pteropods, and the dinoflagellate *Prorocentrum* sp. (Govoni et al., 1989).

Fishes

Finfish

The GOM supports a great diversity of fish resources that are related to variable ecological factors, including salinity, primary productivity, and bottom type. These factors differ widely across the GOM and between the inshore and offshore waters. Characteristic fish resources are associated with the various environments and are not randomly distributed. High densities of fish resources are associated with particular habitat types. Most finfish resources are linked both directly and indirectly to the vast estuaries that ring the GOM. Finfish are directly estuary dependent when the population relies on low-salinity brackish wetlands for most of their life history, such as during the maturation and development of larvae and juveniles. Even the offshore demersal species are indirectly related to the estuaries because they influence the productivity and food availability on the continental shelf (Darnell and Soniat, 1979; Darnell, 1988). Approximately 46 percent of the southeastern United States wetlands and estuaries important to fish resources are located within the GOM (Mager and Ruebsamen, 1988). Consequently, estuary-dependent species of finfish and shellfish dominate the fisheries of the central and north-central Gulf.

The life history of estuary-dependent species involves spawning on the continental shelf; transporting eggs, larvae, or juveniles to the estuarine nursery grounds; growing and maturing in the estuary; and migrating of the young adults back to the shelf for spawning. After spawning, the adult individuals generally remain on the continental shelf. Movement of adult estuary-dependent species is essentially onshore-offshore with no extensive east-west or west-east migration.

Estuary-related species of commericial importance include menhaden, shrimps, oyster, crabs, and sciaenids. Estuary communities are found from east Texas through Louisiana, Mississippi, Alabama, and northwestern Florida. Darnell et al. (1983) and Darnell and Kleypas (1987) found that the density distribution of fish resources in the Gulf was highest nearshore off the central coast. For all seasons, the greatest abundance occurred between Galveston Bay and the Mississippi River. The abundance of fish resources in the far Western and Eastern GOM is patchy. The high-salinity bays of the Western Gulf contain no distinctive species, only a greatly reduced component of the general estuary community found in lower salinities (Darnell et al., 1983).

Estuaries and rivers of the GOM export considerable quantities of organic material, thereby enriching the adjacent continental shelf areas (Grimes and Finucane, 1991; Darnell and Soniat, 1979). Populations from the inshore shelf zone (7-14 m) are dominated seasonally by Atlantic croaker, spot, drum, silver seatrout, southern kingfish, and Atlantic threadfin. Populations from the middle shelf zone (27-46 m) include sciaenids but are dominated by longspine porgies. The blackfin searobin, Mexican searobin, and shoal flounder are dominant on the outer shelf zone (64-110 m).

The degradation of inshore water quality and loss of Gulf wetlands as nursery areas are considered significant threats to fish resources in the GOM (Christmas et al., 1988; Horst, 1992). Loss of wetland nursery areas in the north-central Gulf is believed to be the result of channelization, river control, and subsidence of wetlands (Turner and Cahoon, 1988). Loss of wetland nursery areas in the far Western and Eastern Gulf is believed to be the result of urbanization and poor water management practices (USEPA, 1989).

Gulf menhaden and members of the Sciaenidae family such as croaker, red and black drum, and spotted sea trout are directly dependent on estuaries during various phases of their life history. The occurrence of dense schools, generally by members of fairly uniform size, is an outstanding characteristic that facilitates mass production methods of harvesting menhaden. The seasonal appearance of large schools of menhaden in the inshore Gulf waters from April to November dictates the menhaden fishery (Nelson and Ahrenholz, 1986). Larval menhaden feed on pelagic zooplankton in marine and estuarine waters. Juvenile and adult Gulf menhaden become filter-feeding omnivores that primarily consume phytoplankton, but they also ingest zooplankton, detritus, and bacteria. As filter-feeders, menhaden form a basal link in estuarine and marine food webs and, in turn, are prey for many species of larger fish (Vaughan et al., 1988).

Sciaenids are opportunistic carnivores whose food habits change with size. Larval sciaenids feed selectively on pelagic zooplankton, especially copepods. Juveniles feed upon invertebrates, changing to a primarily fish diet as they mature (Perret et al., 1980; Sutter and McIlwain, 1987; USDOC, NOAA, 1986).

Reeffish species occur in close association with natural or manmade materials on the seafloor. Live-bottom areas of low or high vertical relief partition reefal areas from surrounding sand/shell hash/mud bottom. A number of important reeffish species share the common life history characteristics of offshore spawning and transport of larvae inshore to settle in estuaries and seagrass meadows where they spend an obligatory nursery phase before recruiting to adult stocks offshore. Among these fishes are both winter and summer spawners, with gag (*Mycteroperca micolepis*) and grey snapper (*Lutjanus griseus*), respectively, being good examples. Gag have become a particularly significant species in the Eastern Gulf where spawning aggregations have been studied over a significant period. Gag spawn in February and March in a defined area west of the Florida Middle Ground, and larvae are transported inshore to settle in seagrass meadows 30-50 days later. Two new reserves have been designated (described in

Chapter 3.3.1) in this area where fishing activities have been prohibited. Juveniles remain in the seagrass nursery areas until October or November when they recruit to adult stocks offshore.

Other reeffish species are considered nonestuary dependent such as the red snapper, which remain close to underwater structure. Red snapper feed along the bottom on fishes and benthic organisms such as crustaceans and mollusks. Juveniles feed on zooplankton, small fish, crustaceans, and mollusks (Bortone and Williams, 1986; USDOC, NOAA, 1986).

Many of the commercially important fish species in the GOM are believed to be in decline because of overfishing (USDOC, NMFS, 2001a). Continued fishing at the present levels is likely to result in eventual failure of certain fisheries. Competition between large numbers of fishermen, between fishing operations employing different methods, and between commercial and recreational fishermen for a given resource may reduce standing populations. Fishing techniques such as trawling, gill netting, or purse seining, when practiced nonselectively, may reduce the standing stocks of the desired target species as well as substantially affect fish resources other than the target. Standing stocks of some traditional fisheries, such as shrimp, shark, and tuna, have declined in the past and have required additional management restrictions resulting in some successes (Goodyear and Phares, 1990; USDOC, NMFS, 1999a; Rothschild et al., 1997; Schirripa and Legault, 1997). Recruitment is by far the most important, yet the least understood, factor contributing to changes in the numbers of harvestable Gulf fish. Natural phenomena such as weather, hypoxia, and red tides may reduce standing populations. Finally, hurricanes may affect fish resources by destroying oyster reefs and changing physical characteristics of inshore and offshore ecosystems (Horst, 1992).

Shellfish

To a greater degree, estuaries determine the shellfish resources of the GOM. Life history strategies are influenced by tides, lunar cycles, maturation state, and estuarine temperature changes. Very few individuals live more than a year, and most are less than six months old when they enter the extensive inshore and nearshore fishery. Year-to-year variations in shellfish populations are frequently as high as 100 percent and are most often a result of extremes in salinity and temperature during the period of larval development. Shellfish resources in the Gulf range from those located only in brackish wetlands to those found mainly in saline marsh and inshore coastal areas. Life history strategies reflect estuary relationships, ranging from total dependence on primary productivity to opportunistic dependence on benthic organisms. Gulf shellfish resources are an important link in the estuary food chain between benthic and pelagic organisms (Darnell et al., 1983; Darnell and Kleypas, 1987; Turner and Brody, 1983).

Up to 15 species of penaeid shrimp can be expected to use the coastal and estuarine areas in the GOM. Brown, white, and pink shrimp are the most numerous. Pink shrimp have an almost continuous distribution throughout the Gulf but are most numerous on the shell, coral sand, and coral silt bottoms off southern Florida. Brown and white shrimp occur in both marine and estuarine habitats. Adult shrimp spawn offshore in high salinity waters; the fertilized eggs become free-swimming larvae. After several molts they enter estuarine waters as postlarvae. Wetlands within the estuary offer both a concentrated food source and a refuge from predators. After growing into juveniles, the shrimp larvae leave the saline marsh to move offshore where they become adults. The timing of immigration and emigration, spatial use of a food-rich habitat, and physiological and evolutionary adaptations to tides, temperature, and salinity differ between the two species (Muncy, 1984; Turner and Brody, 1983; USDOC, NOAA, 1986).

About eight species of portunid (swimming) crabs use the coastal and estuarine areas in the GOM. Blue crabs (*Callinectes sapidus*) are the only species, however, that is located throughout the Gulf and comprises a substantial fishery. They occur on a variety of bottom types in fresh, estuarine and shallow offshore waters. Spawning grounds are areas of high salinity such as saline marshes and nearshore waters.

Vast intertidal reefs constructed by sedentary oysters are prominent biologically and physically in estuaries of the GOM. Finfishes, crabs, and shrimp are among the animals using the intertidal oyster reefs for refuge and also as a source of food, foraging on the many reef-dwelling species. Reefs, as they become established, modify tidal currents and this, in turn, affects sedimentary patterns. Further, the reefs contribute to the stability of bordering marsh (Kilgen and Dugas, 1989). Additional information on shellfish and their life histories can be found in GMFMC (1998).

Pelagics

Pelagic fishes occur throughout the water column from the beach to the open ocean. Water-column structure (temperature, salinity, and turbidity) is the only partitioning of this vast habitat. On a broad scale, pelagic fishes recognize different watermasses based upon physical and biological characteristics. Three ecological groups, delineated by watermass, will be discussed individually:

- coastal pelagic species;
- oceanic pelagic species; and
- mesopelagic species.

Coastal pelagic species occur in waters from the shoreline to the shelf edge. Oceanic species occur mainly in oceanic waters offshore from the shelf break; however, some species venture onto the shelf with watermass (e.g., Loop Current) intrusions. Mesopelagic fishes occur below the oceanic species group in the open ocean, usually at depths of 200-1,000 m (656-1,280 ft) depending upon absolute water depth.

For coastal pelagic fishes, commercial fishery landings are one of the best sources of information because these species are an important component of nearshore net and hook-and-line fisheries. Some smaller nektonic fishes occupying the surf zone along exposed beaches have been collected with seines (Naughton and Saloman, 1978; Ross, 1983). Information on the distribution and abundance of oceanic species comes from commercial longline catches and recreational fishing surveys. In addition, NMFS has conducted routine surveys of the GOM billfishery since 1970 (Pristas et al., 1992). Mesopelagic species are not harvested commercially but have been collected in special, discrete-depth nets that provide some quantitative data on relative abundance (Bakus et al., 1977; Hopkins and Lancraft, 1984; Hopkins and Baird, 1985; Gartner et al., 1987).

Recently, additional restrictions have been placed on the harvest of some sharks. Effective July 1, 2000, it is prohibited to retain, possess, sell, or purchase the following sharks: white, basking, sand tiger, bigeye sand tiger, dusky, bignose, Galapagos, night, Caribbean reef, narrowtooth, Caribbean sharpnose, smalltail, Atlantic angel, longfin, mako, bigeye thresher, sevengill, sixgill, and bigeye sixgill.

Coastal Pelagics

The major coastal pelagic families occurring in the area of the proposed action are Carcarhinidae (requiem sharks), Elopidae (ladyfish), Engraulidae (anchovies), Clupeidae (herrings), Scombridae (mackerels and tunas), Carangidae (jacks and scads), Mugilidae (mullets), Pomatomidae (bluefish), and Rachycentridae (cobia). Coastal pelagic species traverse shelf waters of the GOM region throughout the year. Some species form large schools (e.g., Spanish mackerel), while others travel singly or in smaller groups (e.g., cobia). The distribution of most species depends upon water-column structure, which varies spatially and seasonally. Some coastal pelagic species show an affinity for vertical structure and are often observed around natural or artificial structures, where they are best classified as transients rather than true residents. This is particularly true for Spanish sardine, round scad, blue runner, king mackerel, and cobia (Klima and Wickham, 1971; Chandler et al., 1985).

Some coastal pelagic species are found along high-energy sandy beaches from the shoreline to the swash zone (Ross, 1983). An estimated 44-76 species, many of them coastal pelagics, occur in the surf zone assemblage. Surveys have shown a high degree of dominance, with 4-10 species accounting for 90 percent of the numbers collected. In the northern GOM, pelagic species such as scaled sardine, Florida pompano, and various anchovies are among the numerically dominant species in seine collections (Ross, 1983). Surf zone fish assemblages show considerable seasonal structuring in the northern GOM (Naughton and Saloman, 1978; Ross and Modde, 1981). The lowest abundance of all species occurs in winter, with peak numbers found during summer and fall. Larger predatory species (particularly bluefish, Spanish mackerel, and blue runner) may be attracted to large concentrations of anchovies, herrings, and silversides that congregate in the surf zone.

Coastal pelagic fishes can be divided into two ecological groups. The first group includes larger predatory species such as king and Spanish mackerel, bluefish, cobia, jacks, and little tunny. These species typically form schools, undergo migrations, grow rapidly, mature early, and exhibit high fecundity. The second group exhibits similar life history characteristics, but the species are smaller in body size and are planktivorous. This group is composed of Gulf menhaden, thread herring, Spanish sardine, round scad, and anchovies. Species in the second group are preyed upon by the larger species in the first group; thus, the two are ecologically important in energy transfer in the nearshore environment (Saloman and Naughton, 1983 and 1984).

Commercial purse seine fisheries generate high landings of several coastal pelagic species in the region. The Gulf menhaden fishery produces the highest fishery landings in the U.S. (USDOC, NMFS, 2001b). Menhaden form large, surface-feeding schools in waters near the Mississippi Delta from April through September. Fishermen take advantage of this schooling behavior, capturing millions of pounds each year with large purse nets. Other coastal pelagic species contributing high commercial landings are round scad and ladyfish.

Most of the large-bodied, predatory coastal pelagic species are important to commercial or recreational fisheries. King and Spanish mackerel, cobia, and jacks are sought by the charter and head-boat fisheries in the region. King mackerel occurring in the shelf waters of the region may actually come from two distinct populations (Johnson et al., 1994). The eastern population migrates from near the Mississippi Delta eastward, then southward around the Florida peninsula, wintering off southeastern Florida (Sutter et al., 1991). The western population travels to waters off the Yucatan Peninsula during winter. In summer, both populations migrate to the northern GOM, where they intermix to an unknown extent (Johnson et al., 1994). Spanish mackerel, cobia, bluefish, jack crevalle, and coastal sharks are migratory, but their routes have not been studied.

Oceanic Pelagics

Common oceanic pelagic species include tunas, marlins, sailfish, swordfish, dolphins, wahoo, and mako sharks. In addition to these large predatory species, there are halfbeaks, flyingfishes, and driftfishes (Stromateidae). Lesser-known oceanic pelagics include opah, snake mackerels (Gempylidae), ribbonfishes (Trachipteridae), and escolar.

Oceanic pelagic species occur throughout the GOM, especially in waters at or beyond the shelf edge. Oceanic pelagics are reportedly associated with mesoscale hydrographic features such as fronts, eddies, and discontinuities. Fishermen contend that yellowfin tuna aggregate near sea-surface temperature boundaries or frontal zones; however, Power and May (1991) found no correlation between longline catches of yellowfin tuna and sea-surface temperature (defined from satellite imagery) in the GOM. The occurrence of bluefin tuna larvae in the GOM associated with the Loop Current boundary and the Mississippi River discharge plume is evidence that these species spawn in the GOM (Richards et al., 1989). Many of the oceanic fishes associate with drifting *Sargassum*, which provides forage areas and/or nursery refugia.

Mesopelagics

Mesopelagic fish assemblages in the GOM are numerically dominated by myctophids (lanternfishes), with gonostomatids (bristlemouths) and sternoptychids (hachetfishes) common but less abundant in collections. These fishes make extensive vertical migrations during the night from mesopelagic depths (200-1,000 m or 656-3,280 ft) to feed in higher, food rich layers of the water column (Hopkins and Baird, 1985). Mesopelagic fishes are important ecologically because they transfer substantial amounts of energy between mesopelagic and epipelagic zones over each diel cycle.

Hopkins and Lancraft (1984) collected 143 mesopelagic fishes from the Eastern GOM during 12 cruises from 1970 to 1977. Most of their collections were made near lat. 27º N., long. 86º W. Lanternfishes were most common in the catches made by Bakus et al. (1977) and Hopkins and Lancraft (1984). Bakus et al. (1977) analyzed lanternfish distribution in the western Atlantic Ocean and recognized the GOM as a distinct zoogeographic province. Species with tropical and subtropical affinities were most prevalent in the GOM lanternfish assemblage. This was particularly true for the Eastern Gulf, where Loop Current effects on species distribution were most pronounced. Gartner et al. (1987) collected 17 genera and 49 species of lanternfish in trawls fished at discrete depths from stations in the South, Central, and Eastern Gulf. The most abundant species in decreasing order of importance were *Ceratoscopleus warmingii*, *Notolychus valdiviae*, *Lepidophanes guentheri*, *Lampanyctus alatus*, *Diaphus* *dumerili*, *Benthosema suborbitale*, and *Myctophum affine*. Ichthyoplankton collections from oceanic waters yielded high numbers of mesopelagic larvae as compared with larvae of other species (Richards et al., 1989). Lanternfishes generally spawn year-round, with peak activity in spring and summer (Gartner, 1993).

3.2.3.2. Essential Fish Habitat

Essential Fish Habitat Program in the Gulf of Mexico

As outlined in Chapter 1.5.6, the MFCMA of 1976, as amended through 1998, places new requirements on any Federal agency regarding EFH. The MMS must now describe how actions under their jurisdiction may affect EFH. All Federal agencies are encouraged to include EFH information and assessments within NEPA documents.

An EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, and growth to maturity. Because of the wide variation of habitat requirements for all life history stages (as described above), EFH for the GOM includes all estuarine and marine waters and substrates from the shoreline to the seaward limit of the U.S. EEZ.

The NOAA Fisheries also recommends that Fishery Management Plans (FMP's) identify habitat areas of particular concern (HAPC's). The general types of HAPC include the following: nearshore areas of intertidal and estuarine habitats that may provide food and rearing for juvenile fish and shell fish managed by the Fishery Management Council (FMC); certain offshore areas with substrates of high habitat value or vertical relief, which serve as cover for fish and shell fish; and marine and estuary habitat used for migration, spawning, and rearing of fish and shellfish. Marine sanctuaries and national estuary reserves have been designated in the area managed by the GOM FMC and are considered to be HAPC's that meet the general guidelines discussed above. These HAPC's are the Flower Garden Banks National Marine Sanctuary (FGBNMS), Weeks Bay National Estuarine Research Reserve (WBNERR), and Grand Bay, Mississippi.

The requirements for an EFH description and assessment are as follows: (1) description of the proposed action; (2) description of the action agency's approach to protection of EFH and proposed mitigation, if applicable; (3) description of EFH and managed and associated species in the vicinity of the proposed action; and (4) analysis of the effects of the proposed and cumulative actions on EFH, the managed species, and associated species.

Managed Species

The Gulf of Mexico Fishery Management Council (GMFMC) currently describes Fishery Management Plans (FMP's) for the following species. These species or species complexes are brown shrimp (*Penaeus aztecus)*, pink shrimp (*Penaeus duorarum)*, white shrimp (*Penaeus setiferus*), royal red shrimp (*Pleoticus robustus*), red drum (*Sciaenops ocellata*), black grouper (*Mycteroperca bonaci*), red grouper (*Epinephelus morio*), gag grouper (*Mycteroperca microlepis*), scamp (*Mycteroperca phenax*), red snapper *(Lutjanus campechanus*), gray snapper (*Lutjanus griseus*), yellowtail snapper (*Ocyurus chrysurus*), lane snapper (*Lujanus syngagris*), vermilion snapper (*Rhomboplites aurorubens*), gray triggerfish (*Balistes capriscus*), greater amberjack (*Seriola dumerili*), lesser amberjack (*Seriola fasciata*), tilefish (Branchiostegidae), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), bluefish (*Pomatomus saltatrix*), cobia (*Rachycentron canadum*), dolphin (*Coryphaena hippurus*), little tunny (*Euthynnus alleteratus*), stone crab (*Menippe spp*.), spiny lobster (*Panulirus spp*.), and coral (Anthoza). None of the stocks managed by the GMFMC are endangered or threatened.

Occurrence of these managed species, along with major adult prey species and relationships with estuary and bay systems in the Eastern GOM, is outlined in Table 3-6. Detailed presentations of species abundance, life histories, and habitat associations for all life history stages are presented in the Generic Amendment for Essential Fish Habitat by the GMFMC (1998).

Table 3-6

Gulf of Mexico Essential Fish Habitat Assessment (species under GOM FMP's)

Species	Presence in Destin Dome Unit	Bay and Estuary Relationships	Adult Prey Species
Invertebrates			
brown shrimp	adult present year-round	major nursery area	oivorous
white shrimp	occurs; only most northern part	nursery area	onivorous
pink shrimp	not present	nursery area	ornivorous
stone crab	uncommon; only most northern part	nursery area	oportunistic carnivore
spiny lobster	occurs	none noted	mollusks and arthropods
Fish (in Taxonomic Order)			
gag grouper	occurs	seagrass beds, nursery nearshore	primarily fish
red grouper	adult present year-round	none noted	primarily fish
scamp grouper	occurs	none noted	primarily fish
tilefish	rare; only in deepest waters	none noted	primarily crustaceans
cobia	adult present during summer	nursery nearshore	primarily crustaceans and some fish
lesser amberjack	occurs	none noted	cephalopods
greater amberjack	occurs	none noted	variety fish, crustaceans, and cephalopods
dolphin fish	adult present year-round	none noted	pelagic fish
lane snapper	occurs	nursery nearshore	fish, crustaceans, mollusks, algae
gray snapper	adult present year-round	nursery nearshore	fish, shrimp, and crabs
red snapper	adult present year-round	nursery nearshore	fish, shrimp
red drum	uncommon; only most northern part	nursery nearshore	crustaceans
yellowtail snapper	occurs	none noted	benthic fish and crustaceans
king mackerel	adult present year-round; spawning	none noted	mostly fish, anchovies, and herrings
spanish mackerel	uncommon; northern part only	nursery nearshore	mostly fish, anchovies, and herrings
gray triggerfish	occurs	none noted	mostly bivalves and barnacles; also polychaetes and echinoderms

Tuna (Scombridae), billfish (Istiophoridae), swordfish (Xiphiidae), and sharks (Squaliformes) are managed by NOAA Fisheries and not included as FMC managed species. The EFH areas for these highly migratory species (HMS) are described in separate FMP's, including the FMP for Atlantic tunas, swordfish, and sharks (USDOC, NMFS, 1999a) and the Atlantic billfish FMP Amendment 1 (USDOC, NMFS, 1996). These separately managed species include albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), bluefin tuna (*Thunnus thynnus*), skipjack tuna (*Euthynnus pelamis*), yellowfin tuna (*Thunnus albacares*), swordfish (*Xiphias gladius*), 32 shark species (Squaliformes), and billfish (Istiophoridae) including the blue marlin (*Makaira nigricans*), white marlin (*Tetrapturus albidus*), sailfish *Istiophorus platypterus*), and longbill spearfish (*Tetrapturus pfluegeri*). The Central and Western Gulf were reviewed for occurrences of EFH for the 42 species above. All of these species were determined to have at least one life history stage occurring in or near the area. The GMFMC (1998) did not indicate EFH for spiny lobster (*Panulirus spp*.) or yellowtail snapper (*Ocyurus chrysurus*), but both species are known to occur on topographic features such as the Flower Garden Banks and Sonnier Bank in the CPA.

As described by NOAA documents (USDOC, NMFS, 1999a and b), the current status of the scientific knowledge of these species is such that habitat preferences are largely unknown or are difficult to determine. As in the case with shark species, it is difficult to define the habitat of sharks of this temperate zone in the GOM because most species are highly migratory, using diverse habitats in apparently nonspecific or poorly understood ways. Temperature is a primary factor affecting the distribution of sharks, and their movement in coastal waters are usually correlated with unpredictable seasonal changes in water temperature. Similar to the species managed by the GMFMC described above, the occurrence of these 14 species managed by NOAA Fisheries, along with major prey species, is outlined in Table 3-7. Bay and estuary relationships are not cited in the FMP's except in one instance of the bull shark where estuary areas are used as a nursery area. As additional life history information is developed, additional use of inshore and estuary area may be included as EFH in the future.

Table 3-7

Gulf of Mexico Essential Fish Habitat Assessment (highly migratory species managed by NOAA)

Species	Presence in or Near Destin Dome Unit	Known Prey Species
Billfish		
blue marlin	Juvenile/subadult/adults occur beyond 100-m contour	Adults: fish at surface, and scombrids and cephalopods in deepwater
white marlin	Juvenile/subadult/adults occur beyond 50-m contour	Juveniles: fish Adults: squid and fish
sailfish	Juvenile/subadult only south of area beyond 200-m contour	Pelagic schooling fish and squids
Swordfish	Spawning and eggs/larvae and adults occur in area beyond 100-m contour	Larvae: zooplankton, fish larvae Juveniles: fish, squid, pelagic crustaceans Adults: pelagic fish, squid, demersal fish
Tunas		
bluefin tuna	Spawning and eggs/larvae occur in area no juvenile/subadult or adult noted	Juveniles: crustacea, larval, and small fish
shipjack tuna	Spawning, eggs/larvae occurs to south of area beyond 200-m contour	Larvae: small fish
yellowfin tuna	Spawning and eggs/larvae, subadult, and adult occurs to south of area beyond 200-m contour	Larvae: small fish Juveniles: fish Adults: crustacea and fish
Sharks		
blacktip	Late juvenile/subadult only noted nearshore	None noted (unknown)
bull	Late juvenile/subadult only noted nearshore	None noted (unknown)
dusky	Not noted, but area designated as research area	None noted (unknown)
silky	Neonate/early juvenile only noted south of area beyond 200-m contour	None noted (unknown)
tiger	Neonate/early juvenile, late juvenile, subadult, and adult occurs in area	None noted (unknown)
Atlantic Sharpnose	Adults only in area	None noted (unknown)
Longfin mako	Neonate/early juvenile, and juvenile/ subadult occur south of area beyond 200-m contour; adults occur in area beyond 100-m contour	None noted (unknown)

Some of these 14 highly migratory species occur beyond the 200-m water depth contour. Many of these HMS such as billfishes are associated with upwelling areas where canyons cause changes in current flow (upwelling) and create areas of higher productivity.

The GMFMC's *Generic Amendment for Addressing Essential Fish Habitat Requirements* (GMFMC, 1998) identifies threats to EFH and makes a number of general and specific habitat preservation recommendations for pipelines and oil and gas exploration and production activities within State waters and OCS areas. The general recommendations for State waters and wetlands are as follows:

(1) Exploration and production activities should be located away from environmentally sensitive areas such as oyster reefs, wetlands, seagrass beds, endangered species habitats, and other productive shallow water areas. Use of air boats instead of marsh buggies should be implemented whenever possible.

(2) Upon cessation of drilling or production, all exploration/production sites, access roads, pits and facilities should be removed, backfilled, plugged, detoxified, revegetated and otherwise restored to their original condition.

(3) A plan should be in place to avoid the release of hydrocarbons, hydrocarbon-containing substances, drilling muds, or any other potentially toxic substance into the aquatic environment and the surrounding area. Storage of these materials should be in enclosed tanks whenever feasible or, if not, in lined mud pits or other approved sites. Equipment should be maintained to prevent leakage. Catchment basins for collecting and storing surface runoff should be included in the project design.

Individual States, the COE, and the USEPA have review and permit authority over oil and gas development and production within State waters. All oil and gas activities in coastal or wetland areas must adhere to numerous conservation measures before receiving permits from these agencies. In order to minimize potential coastal impacts from OCS-related activities, the MMS has numerous safety, inspection, and spill response requirements in place to prevent an accidental release of hydrocarbons from either happening at all or from reaching land.

The *Generic Amendment* lists a number of measures that may be recommended in association with exploration and the production activities located close to hard banks and banks containing reef-building coral on the continental shelf. These recommendations are as follows:

(1) Drill cuttings should be shunted through a conduit and discharged near the seafloor, or transported ashore, or to a less sensitive, NOAA Fisheries-approved offshore locations.

(2) Drilling and production structures, including pipelines, generally should not be located within one mile of the base of a live reef.

(3) All pipelines placed in waters less than 300 ft deep should be buried to a minimum of 3 ft beneath the seafloor, where possible. Pipeline alignments should be located along routes that minimize damage to marine and estuarine habitat. Buried pipelines should be examined periodically for maintenance of adequate earthen cover.

(4) In anchorage areas, all abandoned structures must be cut off 25 ft below the mudline. If explosives are to be used, NOAA Fisheries should be contacted to coordinate marine mammal and endangered species concerns.

(5) All natural reefs and banks, as well as artificial reef areas, should be avoided.

The *Generic Amendment* makes an additional specific recommendation regarding OCS oil and gas activities under review and permit authority by MMS and USEPA. Specifically, for the conservation of EFH, activities should be conducted so that petroleum-based substances such as drilling mud, oil residues, produced waters, or other toxic substances are not released into the water or onto the seafloor. The MMS lease sale stipulations and regulations already incorporated many of the suggested EFH conservation recommendations. Lease sale stipulations are considered to be a normal part of the OCS operating regime in the GOM. Compliance with stipulations from lease sales is not optional; application of a stipulation(s) is a condition of the lease sale. In addition, MMS may attach mitigating measures to an application (exploration, drilling, development, production, pipeline, etc.) and issue an NTL.

Mitigating measures that are a standard part of the MMS OCS Program establish No Activity and Modified Activity Zones around high-relief live bottoms and require remote-sensing surveys to detect and avoid biologically sensitive areas such as low-relief live bottoms, pinnacles, and chemosynthetic communities.

In consideration of existing mitigation measures, lease stipulations, and a submitted EFH Assessment document, MMS entered into a Programmatic Consultation agreement with NOAA Fisheries on July 1, 1999, for petroleum development activities in the CPA and WPA. The NOAA Fisheries considered an EFH Assessment describing OCS development activities, an analysis of the potential effects, MMS's views on those effects, and proposed mitigation measures as acceptable and meeting with the requirements of EFH regulations at 50 CFR Subpart K, 600.920(g). For the 1999 Programmatic Consultation, NOAA Fisheries made the following additional recommendations (as numbered within the NOAA letter of agreement):

(5) When the Live Bottom (Pinnacle Trend) Stipulation is made a part of a pipeline laying permit, MMS shall require that: No bottom-disturbing activities, including anchors from a pipeline laying barge, may be located within 100 ft of any pinnacle trend feature with vertical relief greater than or equal to 8 ft.

(6) When the Topographic Features Stipulation is made a part of a permit that proposes to use a semisubmersible drilling platform, MMS shall require that: No bottom-disturbing activities, including anchors or cables from a semisubmersible drilling platform, may occur within 500 ft of the No Activity Zone boundary.

(7) When the Topographic Features Stipulation is made a part of a permit that proposes exploratory drilling operations, MMS shall require that: Exploratory operations that drill more than two wells from the same surface (surface of the seafloor) location at any one or continuous time and within the 3-Mile Restricted Activity Zone must meet the same requirements as a development operation (i.e., drilling discharges must be shunted to within 10 m of the seafloor).

(8) When the Topographic Features Stipulation is required for any proposed permit around Stetson Bank, now a part of the FGBNMS, the protective requirements of the East and West Flower Garden Banks shall be enforced.

(9) Where there is documented damage to EFH under the Live Bottom (Pinnacle Trend) or Topographic Features lease stipulation, MMS shall coordinate with the NMFS Assistant Regional Administrator, Habitat Conservation Division, Southeast Region for advice. Based on the regulations at 30 CFR Subpart N, 250.200, "Remedies and Penalties," the Regional Director of the MMS may direct the preparation of a case file in the event that a violation of a lease provision (including lease stipulations) causes serious, irreparable, or immediate harm or damage to life (including fish and other aquatic wildlife) or the marine environment. The conduct of such a case could lead to corrective or mitigative actions.

(10) The MMS shall provide NMFS with yearly summaries describing the number and type of permits issued in the WPA and CPA, and permits for activities located in the Live Bottom (Pinnacle Trend) and Topographic Features blocks for that year. Also, the summaries shall include a report of any mitigation actions taken by MMS for that year in response to environmental damage to EFH.

The MMS has accepted and adopted these six additional EFH conservation recommendations. Although the 1999 Programmatic Consultation agreement and associated EFH recommendations refer specifically to the CPA and WPA, the same mitigation measures and lease stipulations will be evaluated by NOAA Fisheries as part of the EFH Assessment contained in this multisale EIS for both planning areas. This will be the first multisale NEPA document including an EFH consultation with NOAA Fisheries.

Mitigating Factors

As discussed above, the GOM Fishery Management Council's EFH preservation recommendations for oil and gas exploration and production activities are specified and are currently being followed by MMS as mitigating actions to EFH. The MMS regulations and lease sale stipulations already incorporate many of the suggested EFH conservation recommendations. In some cases MMS works with other Federal agencies to mitigate effects in an area. In addition, MMS may attach mitigating measures as a condition of approval of an OCS plan or application (exploration, drilling, development, production, pipeline, etc.).

The subsurface portions of any structures in the areas of the proposed lease sales will act as reef material and a focus for many reef-associated species. Fisheries Management Plans specifically describe the use of artificial reefs as EFH. The EFH draft from the South Atlantic Fishery Management Council (1998) describes how manmade reefs are deployed to provide fisheries habitat in a location that provides measurable benefit to man. When manmade reefs are constructed, they provide new primary hard substrate similar in function to newly exposed hard bottom, with the additional benefit of substrate extending from the bottom to the surface. Reef structures of high profile seem t yield generally higher densities of managed and nonmanaged pelagic and demersal species than a more widespread, lower profile natural hard bottom or reef (South Atlantic Fishery Management Council, 1998). The benefits of artificial reefs created by the installation of energy production platform structures are well documented in Gulf waters of the coast of Texas and Louisiana.

3.2.4. Benthic Resources

Seafloor (benthic) habitats, including live-bottom areas, topographic features, and deepwater benthic communities, are essential components of the overall offshore community assemblage in the GOM. The benthic resources of the continental shelf has both floral and faunal components; floral representatives include bacteria, algae, and seagrasses. The abundance of benthic algae is limited by the scarcity of suitable substrates and light penetration. In exceptionally clear waters, benthic algae, especially coralline red algae, are known to grow in water depths to at least 180 m. Rezak et al. (1983) recorded algae from submarine banks off Louisiana and Texas. Offshore seagrasses are not conspicuous in the Central and Western Gulf; however, fairly extensive beds may be found in estuarine areas behind the barrier islands throughout the Gulf.

Benthic fauna include infauna (animals that live in the substrate, including mostly burrowing worms, crustaceans, and mollusks) and epifauna (animals that live on or are attached to the substrate; mostly crustaceans, as well as echinoderms, mollusks, hydroids, sponges, and soft and hard corals). Shrimp and demersal fish are closely associated with the benthic community. Substrate is the single most important factor in the distribution of benthic fauna (densities of infaunal organisms increase with sediment particle size) (Defenbaugh, 1976), although temperature and salinity are also important in determining the extent of faunal distribution. Depth and distance from shore also influence the benthic faunal distribution (Defenbaugh, 1976). Lesser important factors include illumination, food availability, currents, tides, and wave shock. Indeed, the density of offshore infaunal organisms has been found to be greater during the spring and summer as compared to the winter (Brooks, 1991).

In general, the vast majority of bottom substrate available to benthic communities in the Area of the Proposed Action consists of soft, muddy bottoms; the benthos here is dominated by polychaetes. Benthic habitats on the continental shelf at most risk to potential impacts from decommissioning operations are the live-bottom (pinnacle trend) communities and topographic features.

3.2.4.1. Live-Bottom (Pinnacle Trend) Communities

The northeastern portion of the Central GOM exhibits a region of topographic relief, known as the "pinnacle trend," at the outer edge of the Mississippi-Alabama shelf between the Mississippi River and DeSoto Canyon. The pinnacles appear to be carbonate reefal structures in an intermediate stage between growth and fossilization (Ludwick and Walton, 1957). The region contains a variety of features from low-relief rocky areas to major pinnacles, as well as ridges, scarps, and relict patch reefs. The heavily indurated pinnacles provide a surprising amount of surface area for the growth of sessile invertebrates and attract large numbers of fish. Additional hard-bottom features are located nearby on the continental shelf, outside the actual pinnacle trend.

The features of the pinnacle trend offer a combination of topographic relief, occasionally in excess of 20 m, and hard substrate for the attachment of sessile organisms and, therefore, have a greater potential to support significant live-bottom communities than surrounding areas on the Mississippi-Alabama Shelf. This potential to support live-bottom communities has made these features a focus of concern and discussion.

3.2.4.2. Topographic Features

The shelf edge, shelf, and mid-shelf of the Western and Central Gulf are characterized by topographic features that are inhabited by hard-bottom benthic communities (Table 3-8). Figure 3-5 depicts the location of 39 known topographic features in the GOM; 23 in the WPA and 16 in the CPA.

Table 3-8

Topographic Banks of the Central and Western Gulf of Mexico

Shelf-Edge Banks		Midshelf Banks		South Texas Banks
Western	Central	Western	Central	Western Only
East Flower Garden Bank	Bright Bank	Claypile Lump	Sonnier Bank	Big Dunn Bar
West Flower Garden Bank	McGrail Bank	32 Fathom Bank	Fishnet Bank	Small Dunn Bar
Geyer Bank	Alderdice Bank	29 Fathom Bank	29 Fathom Bank	Blackfish Ridge
Rankin Bank	Rankin Bank	Stetson Bank		Mysterious Bank
Elvers Bank	Rezak Bank	Coffee Lump		Baker Bank
MacNeil Bank	Sidner Bank			Aransas Bank
Appelbaum Bank	Ewing Bank			Southern Bank
				North Hospital Bank
				Hospital Bank
				South Baker Bank
				Dream Bank

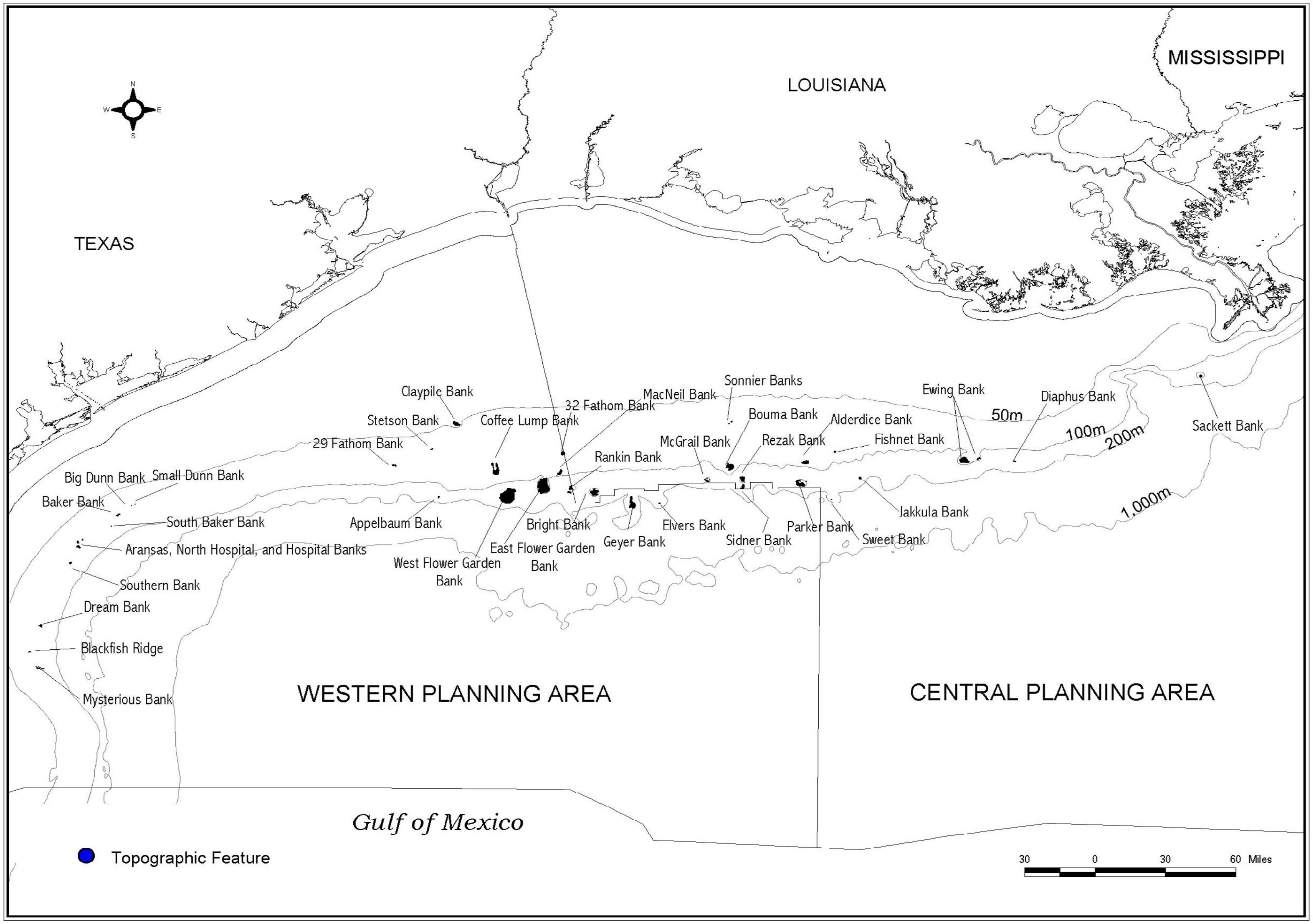


Figure 3-5. Topographic Features of the Central and Western Gulf of Mexico.

The habitat created by these topographic features is important for the following reasons:

(1) they support hard-bottom communities of high biomass, high diversity, and high numbers of plant and animal species;

(2) they support, either as shelter or food, or both, large numbers of commercially and recreationally important fishes;

(3) they are unique to the extent that they are small, isolated areas of such communities in vast areas of much lower diversity;

(4) they provide a relatively pristine area suitable for scientific research (especially the East and West Flower Garden Banks); and

(5) they have an aesthetically intrinsic value.

Benthic organisms on these features are mainly limited by temperature and light (lack of); extreme water temperature and light intensity are known to stress corals. Temperatures lower than 16 ^{o}C reduce coral growth, while temperatures in excess of 32 ^{o}C will impede coral growth and induce coral bleaching (loss of symbiotic zooxanthellae). While intertidal corals are adapted to high light intensity, most corals become stressed when exposed to unusually high light levels. Although corals will grow or survive under low light conditions, they do best submerged in clear, nutrient-poor waters. Light penetration in the Gulf is limited by factors that include depth and prolonged turbidity events. Hard substrates favorable to colonization by coral communities in the northern Gulf are found on outer shelf, high-relief features. These substrates are found above the nepheloid layer, are off the muddy seafloor, and are bathed most of the year in nutrient-poor waters.

For detailed descriptions of all of the benthic resources of the Central, Western, and Eastern Planning areas of the northern GOM, see Chapter 3.2.2 (Continental Shelf Benthic Resources) of the Central and Western GOM Multisale EIS (USDOI, MMS, 2002) and in Chapter 3.2.2 (Sensitive Offshore Benthic Resources) of the Eastern GOM Multisale EIS (USDOI, MMS, 2003).

3.3. OTHER RESOURCES AND ACTIVITIES

3.3.1. Commercial Fishing

The GOM provides slightly over 18 percent of the commercial fish landings in the continental U.S. by weight on an annual basis and over 22 percent by dollar value. The most recent, complete information on landings and value of fisheries for the U.S. was compiled by NOAA Fisheries for 2002. During 2002, commercial landings of all fisheries in the GOM totaled nearly 1.7 billion pounds, valued at over $704 million (USDOC, NMFS, 2003).

Menhaden, with landings of about 1.3 billion pounds and valued at $78.2 million, was the most important GOM species in terms of quantity landed during 2002. Landings remained nearly the same compared to 2000. Shrimp, with landings of about 231 million pounds valued at about $382 million was the most important GOM species in terms of value landed in 2002 but was substantially reduced from the total of 655 million pounds with a value of $478 million landed during 2000. The 2002, GOM oyster fishery accounted for over 90 percent of the national total of all oyster landings of 24 million pounds of meats, valued at about $51 million. The GOM blue crab fishery accounted for 39 percent of the national total with landings of 70 million pounds, valued at about $44 million (USDOC, NMFS, 2003). Detailed discussion of the commercial landings by state can be found in the previous lease sale EIS's for the Central and Western Planning Areas (USDOI, MMS, 2002) and/or the Eastern Planning Area (USDOI, MMS, 2003).

Seven commercial species harvested from GOM OCS waters are currently considered to be undergoing overfishing or are in an overfished condition in 2002 (USDOC, NMFS 2003). Recently, gag grouper and vermilion snapper were added to the 2001 NOAA Fisheries report's list of stocks for which overfishing is occurring in the GOM. In the 2002 report, gag grouper was moved from the overfished status to the lower rank of overfishing (USDOC, NMFS 2003). Five other species (e.g., red snapper, red grouper, amberjack, goliath grouper, and red drum) were listed in the report as overfished in the GOM.

Since the passage of the Sustainable Fisheries Act in 1996, NOAA Fisheries has made significant progress in our scientific knowledge of marine fisheries and in the general ability to manage these resources. Most of the nations stocks now have rebuilding plans in place. NOAA Fisheries is continuing work with the FMC's of the Gulf and nation wide to rebuild stocks to levels consistent with maximum sustainable yield. The 2002 report documents consistent progress of these efforts (USDOC, NMFS 2003).

The GOM shrimp fishery is the most valuable in the U.S., accounting for 73 percent of the total domestic production (USDOC, NMFS, 2002). Three species of shrimp, brown, white, and pink, dominate landings by weight. The shrimp fishery is indirectly affected by the presence of platforms in two ways; the presence of platforms eliminates potential shrimp trawling areas from shrimp harvesters and also creates defacto protected areas for shrimp living in the vicinity of structures. The shrimp industry has faced numerous problems in the past but the most critical issues recently include the rising cost of fuel and the drastic increase in imports of less expensive farm-raised shrimp from foreign countries. The required use of turtle excluder and by-catch devices are additional burdens causing reduced catch rates.

Commercial fishing at or near platforms is difficult to ascertain from catch statistics. Definitions appear in the MSFCA: "charter fishing" is defined as "fishing from a vessel carrying a passenger for hire who is engaged in recreational fishing." The term "commercial fishing" is defined as "fishing in which the fish harvested, either in whole or in part, are intended to enter commerce or enter commerce through sale, barter or trade." "Recreational fishing" means "fishing for sport or pleasure." The principal users of platforms as a target for fishing are recreational fishers and charter operations. Hiett and Milon (2001) report that, during 1999 alone, there were 2.2 million visits to oil and gas structures associated with recreational fishing and diving with a total of $172.9 million in direct economic expenditures associated with these visits. However, by definition, some fishing around or near platforms is definitely commercial in nature when fish that are caught are intended for sale. An older study funded by MMS (Ditton and Auyong 1984) used a network of offshore operator observers at 164 major platforms in the Central GOM to record fishing activities nearby. This study reported total numbers of boats engaged in fishing activities and classified as private, charter/party fishing boats, diving, and commercial boats. Only 1,030 boat observations out of a total of 8,983 (11.5%) recorded during a one-year period in 1980-1981 were classified as commercial fishing.

Red snapper is one of the principal species caught around offshore structures. The total catch for 2002 was 4,784,662 pounds with a value of $10,646,417. There are no separate statistics for how much of this commercial catch was directly related to platform habitat. A total of 26 percent of the total red snapper landings for 2002 (1,252,306 pounds) was taken using electric or hydraulic reels and 38 percent (1,838,923 pounds) was taken using handlines, both gear types that could be employed next to platforms.

One major commercial fishing technique that has clear potential negative interactions with offshore structures is long lining. Two large sections of the Gulf are currently closed to surface long-ling fishing. On August 4, 2000, NOAA Fisheries announced new regulations to reduce bycatch and bycatch mortality in the pelagic longline fishery. On November 1, 2000, NOAA Fisheries put into effect a new regulation to reduce bycatch and bycatch mortality in the pelagic longline fishery. Two rectangular areas in the GOM (one of which lies over a portion of the region known as DeSoto Canyon) are closed year-round to pelagic longline fishing. These closed areas cover 32,800 mi^2 (Figure 3-6). This region has been identified by NOAA Fisheries as a swordfish nursery area, where there has historically been a low ratio of swordfish kept to the number of undersized swordfish discarded, which over the period of 1993-1998 has averaged less than one swordfish kept to one swordfish discarded. The area closure is expected to produce approximately a 4 percent reduction in GOM and Atlantic undersized swordfish bycatch. The DeSoto Canyon area coordinates are as follows:

Upper Area		Lower Area	
North boundary:	30ºN. latitude	North boundary:	28ºN. latitude
South boundary:	28ºN. latitude	South boundary:	26ºN. latitude
East boundary:	86ºW. longitude	East boundary:	84ºW. longitude
West boundary:	88ºW. longitude	West boundary:	86ºW. longitude

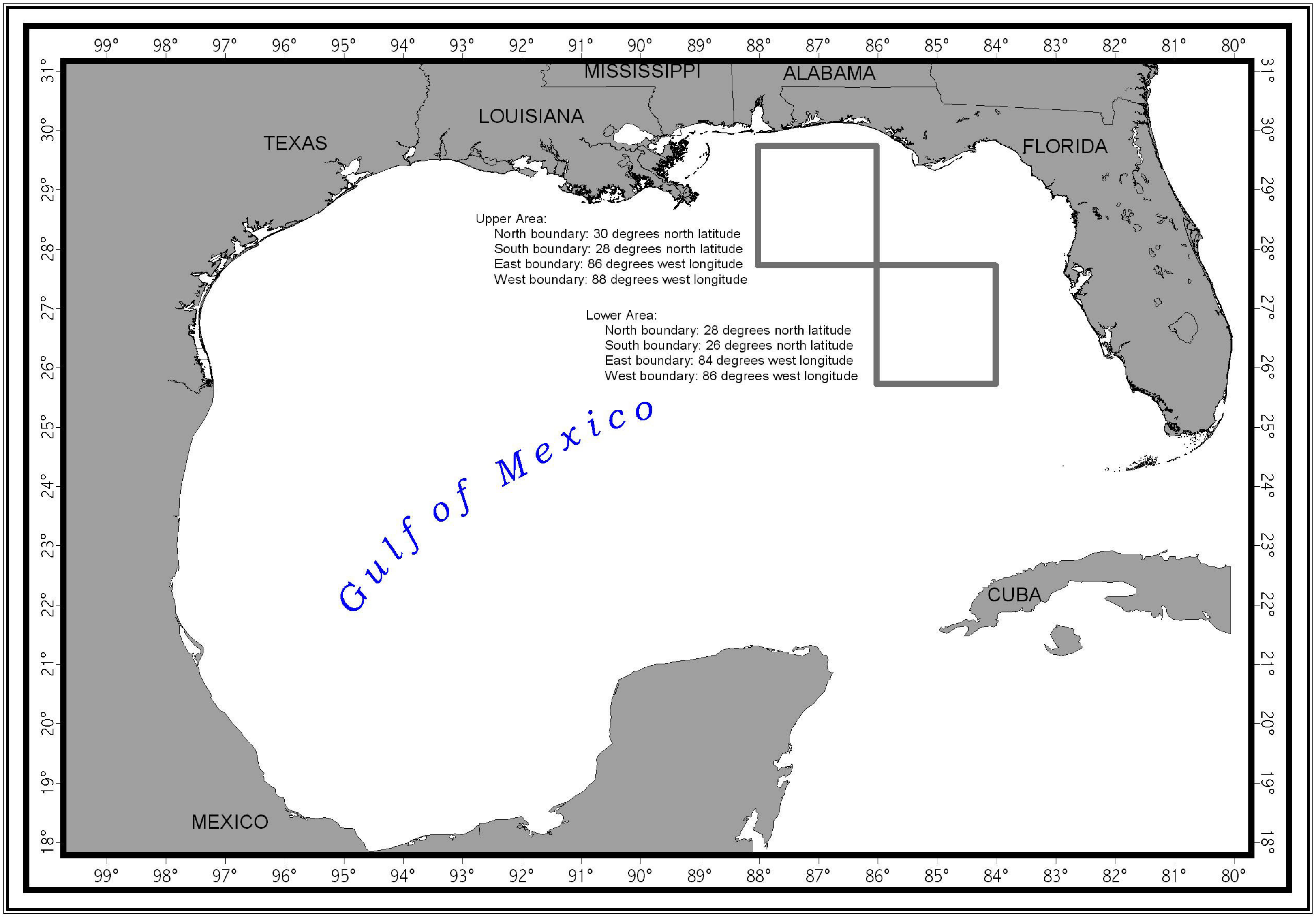


Figure 3-6. Areas Closed to Long Line Fishing in the GOM.

The “upper area” encompasses a large portion of the proposed lease sale area leaving only 96 blocks outside the exclusion zone south of 28° N latitude. A recent MMS publication, *Bluewater fishing and OCS activity: Interactions between the fishing and petroleum industries in deepwaters of the Gulf of Mexico* (CSA, 2002) reports on details of these potential space-use conflicts.

Commercial fishing for tilefish is done with bottom longlines. Tilefish species represent a typical deep-sea resource that is long-lived, slow to develop, and reproduce with limited numbers of offspring (Moore, 1999). Tilefish show an affinity for a sandy bottom, where they sit in indentations or burrows in the ocean floor. Because of their life history, tilefish are easily overfished and depleted. Harvest is intermittent and limited within the GOM because of depleted populations. Tilefish are found in water from 240 to 400 ft (73-122 m) in depth, which requires the use of highly selected gear.

3.3.2. Archaeological Resources

Archaeological resources are any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest (30 CFR 250.2). The Archaeological Resources Regulation (30 CFR 250.26) provides specific authority to each MMS Regional Director to require archaeological resource surveys, analyses, and reports. Surveys are required prior to any exploration or development activities on leases within the high probability areas (NTL 2001-G01).

3.3.2.1. Historic

With the exception of the Ship Shoal Lighthouse structure, historic archaeological resources on the OCS consist of historic shipwrecks. A historic shipwreck is defined as a submerged or buried vessel, at least 50 years old, that has foundered, stranded, or wrecked and is presently lying on or embedded in the seafloor. This includes vessels that exist intact or as scattered components on or in the seafloor. A 1977 MMS archaeological resources baseline study for the northern GOM concluded that two-thirds of the total number of shipwrecks in the northern Gulf lie within 1.5 km of shore and most of the remainder lie between 1.5 and 10 km of the coast (CEI, 1977). A subsequent MMS study published in 1989 found that changes in the late 19th- and early 20th-century sailing routes increased the frequency of shipwrecks in the open sea in the Eastern Gulf to nearly double that of the Central and Western Gulf (Garrison et al., 1989). The highest apparent frequency of shipwrecks occurred within areas of intense marine traffic, such as the approaches and entrances to seaports and the mouths of navigable rivers and straits.

Garrison et al. (1989) lists numerous shipwrecks that fall within the CPA, EPA, and WPA. The precise locations of these vessels remain unknown. Many of these reported shipwrecks may be considered historic and could be eligible for nomination to the National Register of Historic Places (NRHP). Most of these wrecks are known only through the historical record and, to date, have not been located on the ocean floor. The Garrison study lists 561 wrecks in the CPA, 615 wrecks in the WPA, and 286 wrecks in the EPA. These wrecks are listed by planning area in Table 3-9. Additionally, nearly 100 potentially important shipwrecks (Table 3-10) near the approaches to Mobile Bay have been documented in the historic record (Mistovich and Knight, 1983; Marx, 1983). These lists should not be considered exhaustive. Regular reporting of shipwrecks did not occur until late in the 19th century, and losses of several classes of vessels, such as small coastal fishing boats, were largely unreported in official records.

Submerged shipwrecks off the coasts Texas, Louisiana, Mississippi, Alabama, and Florida are likely to be moderately well preserved because of the high sediment load in the water column from upland drainage and wind and water erosion. Wrecks occurring in or close to the mouth of bays would have been quickly buried by transported sediment and therefore protected from the destructive effects of wood-eating shipworms (*Teredo navalis*) or storms (Anuskiewicz, 1989). A good example of this type of historic wreck is the *la Belle* a shallow draft French sailing vessel classified as a *barque longue* lost in 1686 and discovered in Matagorda Bay, Texas, in 1995 (Ball, personal communication, 2001). Wrecks occurring in deeper water also have a moderate to high preservation potential. In the deep water, temperature at the seafloor is extremely cold, which slows the oxidation of ferrous metals. The cold water would also eliminate wood-eating shipworms. There have been several recent deepwater shipwreck discoveries in the CPA off the mouth of the Mississippi River. These wrecks were discovered by the oil and gas industry during required MMS remote-sensing surveys.

Recent deepwater discoveries include an early 19th century wooden sailing vessel lying in nearly 2,700 ft of water; a late 19th century wooden sailing vessel lying in 1,300 ft of water; and an early 20th

century steam yacht lying in 4,000 ft of water. Over the last three years several merchant vessel casualties from the German U-boat campaign in the GOM also have been found in the deepwater area off the mouth of the Mississippi River, including the *Alcoa Puritan*, the *Robert E. Lee*, and the German submarine U-166. All of these wrecks have been investigated using a ROV from a surface vessel and are in an excellent state of preservation.

Table 3-9

Number of Shipwrecks by Planning and Lease Area

Lease Area	Number of Wrecks	Lease Area	Number of Wrecks	Lease Area	Number of Wrecks
Eastern Planning Area					
Apalachicola	27	Florida Middle Ground	17	Miami	5
Charlotte Harbor	21	Florida Plain	0	St. Petersburg	24
Desoto Canyon	11	Gainesville	8	Pensacola	21
Destin Dome	17	Henderson	6	Pulley Ridge	29
Dry Tortugas	18	Howell Hook	9	Tarpon Springs	56
The Elbow	6	Key West	1	Vernon Basin	4
		Lloyd Ridge	6		
Western Planning Area					
Alaminos Canyon	1	Garden Banks	1	Mustang Island	102
Brazos	49	High Island	57	North Padre Island	38
Corpus Christy	1	Keathley Canyon	3	South Padre Island	144
East Breaks	5	Matagorda Island	116	Sabine Pass (TX)	6
		Galveston	92		
Central Planning Area					
Bay Marchand	3	Lund	13	Ship Shoal	51
Brenton Sound	13	Mississippi Canyon	20	South Timbalier	46
Chandeleur	6	Mobile	27	Viosca Knoll	10
East Cameron	35	Main Pass	35	Vermilion	39
Eugene Island	51	South Pelto	5	West Cameron	72
Ewing Bank	1	Sabine Pass (LA)	22	West Delta	30
Green Canyon	3	South Marsh Island	19	Walker Ridge	2
Grand Island	18	South Pass	39		

Aside from acts of war, hurricanes cause the greatest number of wrecks in the Gulf. Wrecks occurring as a result of an extremely violent storm are more likely to be scattered over a broad area. The wreckage of the 19th-century steamer *New York*, which was destroyed in a hurricane, lies in 16 m of water and has been documented by MMS (Irion and Anuskiewicz, 1999) as scattered over the ocean floor in a swath over 1,500 ft long. Shipwrecks occurring in shallow water nearer to shore are more likely to have been reworked and scattered by subsequent storms than those wrecks occurring at greater depths on the OCS. Historic research indicates that shipwrecks occur less frequently in Federal waters. These wrecks are likely to be better preserved, less disturbed, and, therefore, more likely to be eligible for nomination to the NRHP than are wrecks in shallower State waters.

Table 3-10

Shipwrecks in Alabama State Waters

Name of Vessel	Description	Year Sunk
Bellone	French merchant ship	1725
Brownhall	English frigate	1780
El Volante	Spanish frigate-of-war	1780
Unknown	Spanish brigantine	1780
Unknown	Spanish settee (saetia)	1780
HMS Hermes	English ship-of-war	1814
Mississippi	American merchantman	1821
Margaret Ann	American merchantman	1822
Napoleon	Irish ship	1835
St. Denis	Ship, packet	1855
Tejuca	Ship, clipper	1855
Josephine	Sloop, blockade runner	1863
Isabel	Schooner, blockade runner	1863
Alphonsine	Schooner	1889
Carrie G.	Sloop	1893
Agnes	Schooner	1899
Aline	Schooner	1906
Eline	Bark, Norway	1906
Falcon	Schooner	1906
Grace Ellena	Schooner	1906
Lila	Sloop	1906
Mary Gray	Schooner	1906
Oliva	Schooner	1906
Warrior	Ship, 4th Class	1906
Names Unknown	40-60 oyster schooners and sloops	1906
Almira	Schooner	1913
Indian Chief	Sailing vessel	ca. 1916
J. C. Smith	Schooner	1916
Joseph P. Cooper	Schooner	1916
Mischief	Schooner	1916
Pol Ros	Sloop	1916
Name Unknown	Pleasure yacht	1916
Blanche Marie	Launch	1916
Dean E. Brown	Schooner	1917
Florence Harvey	Schooner	1921
Rachel	Schooner	1933
USCG Magnolia	Coast Guard lighthouse tender	1945

3.3.2.2. Prehistoric

Available evidence suggests that sea level in the northern GOM was at least 90 m, and possibly as much as 130 m, lower than present sea level and that the low sea-stand occurred during the period 20,000-

17,000 years Before Present (B.P.) (Nelson and Bray, 1970). Sea level in the northern Gulf reached its present stand around 3,500 years B.P. (Pearson et al., 1986).

During periods that the continental shelf was exposed above sea level, the area was open to habitation by prehistoric peoples. The advent of early man into the GOM region is currently accepted to be around 12,000 years B.P. (Aten, 1983). The sea-level curve for the northern GOM proposed by Coastal Environments, Inc. (CEI) suggests that sea level at 12,000 B.P. would have been approximately 45-60 m below the present day sea level (CEI, 1977 and 1982). On this basis, the continental shelf shoreward of the 45- to 60-m bathymetric contours have potential for prehistoric sites dating after 12,000 B.P. Because of inherent uncertainties in both the depth of sea level and the entry date of prehistoric man into North America, MMS adopted the 12,000 years B.P. and the 60-m water depth as the seaward extent of the prehistoric archaeological high-probability area.

Based on their 1977 baseline study, CEI (1977) proposed that sites analogous to the types of sites frequented by Paleo-Indians can be identified on the now-submerged shelf. Geomorphic features that have a high probability for associated prehistoric sites include barrier islands and back-barrier embayments, river channels and associated floodplains and terraces, and salt-dome features. Remote-sensing surveys have been very successful in identifying these types of geographic features, which have a high probability for associated prehistoric sites. Recent investigations in Louisiana and Florida indicate the mound-building activity by prehistoric inhabitants may have occurred as early as 6,200 B.P. (cf. Haag, 1992; Saunders et al., 1992; Russo, 1992). Therefore, manmade features, such as mounds, may also exist in the shallow inundated portions of the OCS.

Regional geological mapping studies by MMS allow interpretations of specific geomorphic features and assessments of archaeological potential in terms of age, the type of system the geomorphic features belong to, and geologic processes that formed and modified them. The potential for site preservation must also be considered as an integral part of the predictive model. In general, sites protected by sediment overburden have a high probability for preservation from the destructive effects of marine transgression. The same holds true for sites submerged in areas subjected to low wave energy and for sites on relatively steep shelves during periods of rapid rise in sea level. Though many specific areas in the Gulf with a high potential for prehistoric sites have been identified through required archaeological surveys, industry generally has chosen to avoid these areas rather than conduct further investigations.

Holocene sediments form a thin veneer or are absent over the majority of the continental shelf off western Louisiana and eastern Texas (USDOI, MMS, 1984). Many large, late Pleistocene, fluvial systems (e.g., the Sabine-Calcasieu River Valley) are within a few meters of the seafloor in this area. Further to the south and west, a blanket of Holocene sediments overlays the Pleistocene horizon. In the Western Gulf, prehistoric sites representing the Paleo-Indian culture period through European contact have been reported. The McFaddin Beach site, east of Galveston in the McFaddin National Wildlife Refuge, has produced late Pleistocene megafaunal remains and lithics from all archaeological periods, including a large percentage of Paleo-Indian artifacts (Stright et al., 1999). A study funded by MMS to locate prehistoric archaeological sites in association with the buried Sabine-Calcasieu River Valley was completed in 1986 (CEI, 1986). Five types of relict landforms were identified and evaluated for archaeological potential. Coring of selected features was performed, and sedimentary analyses suggested the presence of at least two archaeological sites.

Surveys from other areas of the western part of the CPA have produced evidence of floodplains, terracing, and point-bar deposits in association with relict late Pleistocene fluvial systems. Prehistoric sites associated with these features would have a high probability for preservation. Salt diapirs with bathymetric expression have also been recorded during lease-block surveys in this area. Solution features at the crest of these domes would have a high probability for preservation of associated prehistoric sites. The Salt Mine Valley site on Avery Island is a Paleo-Indian site associated with a salt-dome solution feature (CEI, 1977). The proximity of most of these relict landforms to the seafloor facilitates further investigation and data recovery.

3.3.3. Pipelines and Cables

Pipelines are the primary method used to transport a variety of liquid and gaseous products between OCS production sites and onshore facilities around the GOM. These products include unprocessed (bulk) oil and gas; mixtures of gas and condensate; mixtures of gas and oil; processed condensate, oil, or gas; produced water; methanol; and a variety of chemicals used by the OCS industry offshore. Pipelines in the

Gulf are designated as either trunklines or gathering lines. Gathering lines are typically shorter segments of small-diameter pipelines that transport the well stream from one or more wells to a production facility or from a production facility to a central facility serving one or several leases, e.g., a trunkline or central storage or processing terminal. Trunklines are typically large-diameter pipelines that receive and mix similar production products and transport them from the production fields to shore. A trunkline may contain production from many discovery wells drilled on several hydrocarbon fields. The OCS-related pipelines near shore and onshore may merge with pipelines carrying materials produced in State territories for transport to processing facilities or to connections with pipelines located further inland. Most of the active lengths of OCS pipelines transport mostly gas (64%); the reminder transport predominately oil (25%).

Pipelines and cables (e.g., power, communications, etc.) set in water depths <200 ft (60 m) are potential snags for anchors and trawls. At present, over 58 percent of OCS pipelines/cables are in water depths ≤200 ft (60 m) (USDOI, MMS, 2002). In the GOM, MMS has determined that all pipelines installed in water depths <200 ft (60 m) must be buried. The purpose is to reduce the movement of pipelines by high currents and storms, to protect the pipeline from the external damage that could result from anchors and fishing gear, to reduce the risk of fishing gear becoming snagged, and to minimize interference with the operations of other users of the OCS. For water depths ≤200 ft (60 m), any length of pipeline that crosses a fairway or anchorage in Federal waters must be buried to a minimum depth of 10 ft (3 m) BML across a fairway and a minimum depth of 16 ft (5 m) BML across an anchorage area. Some operators voluntarily bury these pipelines deeper than the minimum.

3.3.4. Military Use, Warning, and Test Areas

The air space over the GOM is used extensively by the Department of Defense (DOD) for conducting various air-to-air and air-to-surface operations. Sixteen military warning areas (MWA) and two water test areas (WTA) are located within the Area of the Proposed Action (Figure 3-7). The Navy uses the GOM waters for shakedown cruises for newly-built ships, for ships completing overhaul or extensive repair work in GOM shipyards such as Pascagoula, Mississippi, and for various types of training operations. While no aircraft carriers are currently home-ported in the GOM, carriers may from time-to-time conduct flight operations in the GOM. No areas in the GOM have been designated as Naval operating areas requiring restrictions on the navigation of other vessels. In addition to Naval uses of the GOM, other branches of the military and state Air National Guard units may also utilize the MWA's for training and shakedown exercises. Ultimately, these warning and water test areas are multiple-use areas where military operations and oil and gas development have coexisted without conflict for many years.

Within the Area of the Proposed Action:

- The Western Gulf has four MWA's that are used for military operations. The areas total approximately 21 million ac or 58 percent of the area of the WPA. In addition, six blocks in the Western Gulf are used by the Navy for mine warfare testing and training.
- The CPA has five designated MWA's that are used for military operations. These areas total approximately 11.3 million ac. Portions of the Eglin Water Test Areas (EWTA) comprise an additional 0.5 million ac in the CPA. The total 11.8 million ac is about 25 percent of the area of the CPA.
- The 181/189 lease sale area (1.5 million ac) is within either a MWA or an EWTA. The northeastern corner of the proposed lease sale area is in MWA 155. Portions of this military warning area comprise 0.9 million ac of the northeastern corner of the proposed lease sale area. Portions of EWTA 1 and 3 comprise the remaining 94 percent (1.4 million ac) of the proposed lease sale area.

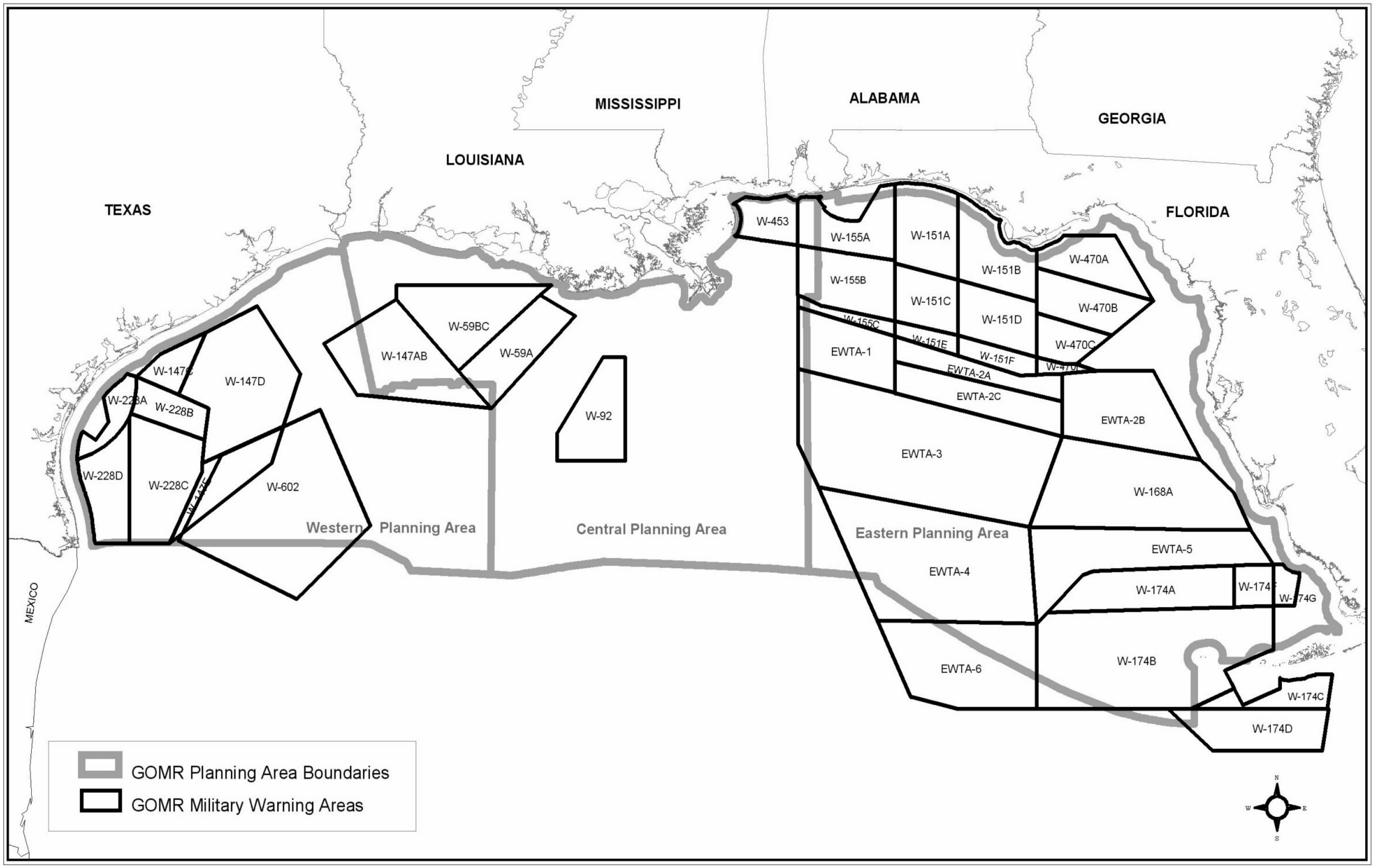


Figure 3-7. Military Warning Areas and Water Test Areas Located within the Area of the Proposed Action.

3.3.5. Navigation and Shipping

A widespread maritime industry exists in the northern GOM. Figure 3-8 shows the major ports and domestic waterways proximal to the Area of the Proposed Action. Maritime traffic is either domestic or foreign. There is a substantial amount of domestic waterborne commerce in the analysis area through the Gulf Intracoastal Waterway (GIWW), which follows the coastline inshore and through bays and estuaries, and in some cases offshore. In addition to coastwise transport between GOM ports, foreign maritime traffic is extensive. Major trade shipping routes between Gulf ports and ports outside the northern GOM occur via the Bay of Campeche, the Yucatan Channel, and the Straits of Florida.

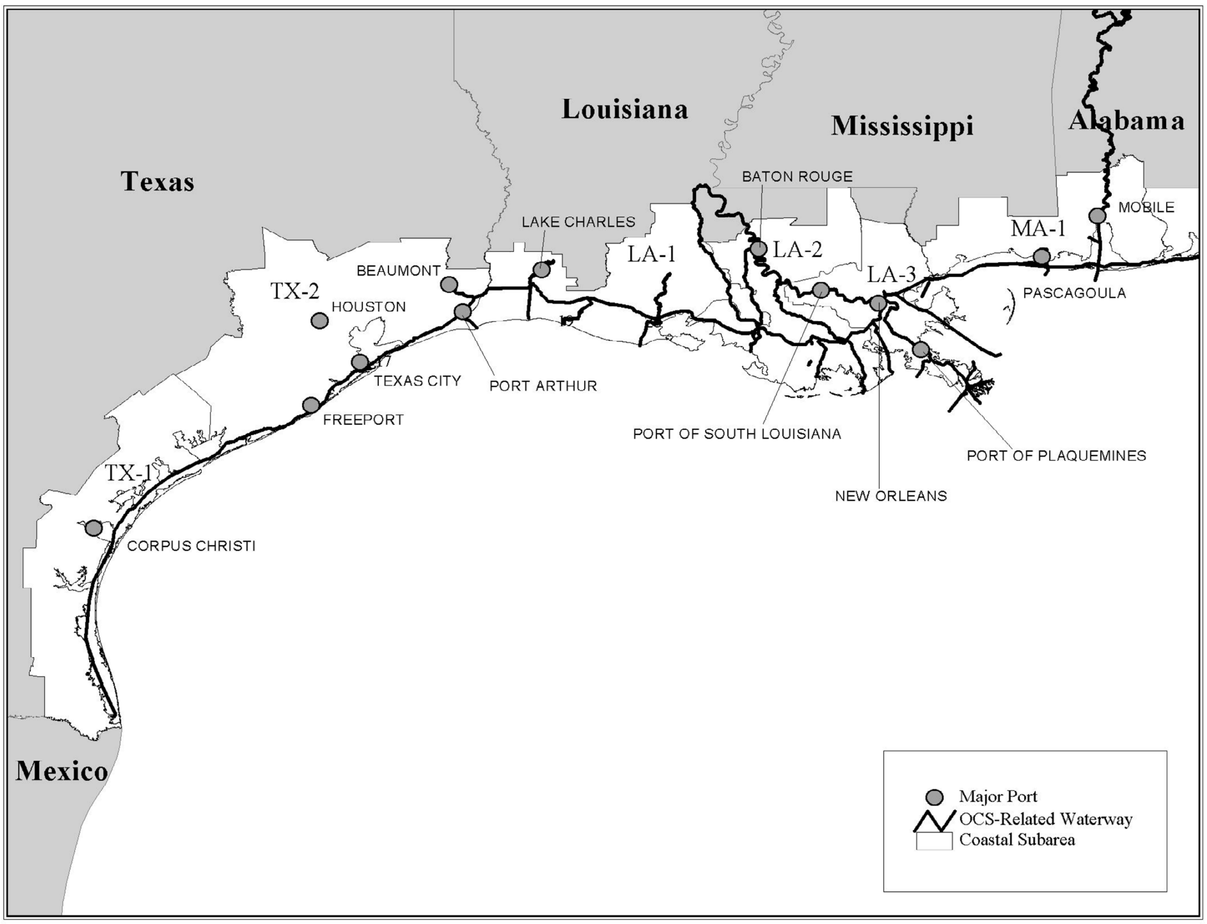


Figure 3-8. Major Ports and Waterways of the Northern GOM.

The ports and fairways of the northern GOM are also used extensively by vessels servicing the oil and gas infrastructure on the OCS. Service vessels are one of the primary modes of transporting personnel between service bases and offshore platforms, drilling rigs, derrick barges, and pipeline construction barges. In addition to offshore personnel, service vessels carry cargo (i.e., freshwater, fuel, cement, barite, liquid drilling fluids, tubulars, equipment, and food) offshore.

Helicopters are also used by oil and gas operators and contractors for transporting personnel, equipment, and supplies between service bases and offshore facilities equipped with helipads and necessary support equipment. Like maritime traffic and service vessels, helicopters routinely use established platforms and related facilities as navigation aids or "landmarks" when operating in certain areas on a regular basis (USDOI, MMS, 1987).

4. ENVIRONMENTAL CONSEQUENCES

4.1 SIGNIFICANCE CRITERIA

The objectives of the impact analysis are (1) to determine whether decommissioning operations have significant adverse impacts on the physical environments and living marine resources of the GOM and (2) to identify significant impacts, if any, for further NEPA analysis. Congruent with MMS's recent NEPA analyses, the potential impacts on all non-MPS resources were classified as either **significant** or **not significant**, while the impacts on marine mammals and sea turtles were classified into one of three impact levels, including

- significant;
- adverse but not significant; or
- negligible.

The impact levels categorize the negative effects on a resource and reflect the range of negative (or neutral) impacts. The thresholds for determining significant impact, termed **significance criteria**, vary depending upon several factors, which primarily include the potentially affected resource (e.g., water quality, fisheries, marine mammals) and the scope of each impact-producing factor (i.e., short- vs. long-term, localized vs. regional, etc.). Each resource analysis is preceded by its specific significance criteria and appropriate terminology and attribute definitions where defined and applicable. Additionally, since all of the activities described under Alternative A, B, and C are identical with the exception of explosive severance (Chapter 2.1.1), the analyses will only address the differences between alternatives in instances where explosive use directly effects the resource.

4.2. PHYSICAL ENVIRONMENT

4.2.1 Impacts on Air Quality

Significance Criteria for Air Quality

Exceedance of onshore ambient air quality standards is considered to be a **significant** impact. Specifically, this would include noncompliance with NAAQS and State standards for any of six criteria pollutants, including sulfur dioxide (SO_2), nitrogen dioxide (NO_2), respirable particulates (PM_{10}, particulates <10 microns in diameter), carbon monoxide (CO), ozone (O_3), and lead (Pb). Exceedance of significance levels established by the MMS and FWS is also considered to be significant. Exceedance of the MMS standard would be considered an exceedance of the maximum allowable concentration increases (or PSD increment) at a receptor located in a Class I area would be considered significant.

Terminology and Resource-Specific Definitions

Refer to 40 CFR Part 50 and 30 CFR Subpart C for NAAQS and MMS significance levels.

Gaseous emissions would be generated during structure-removal activities by transportation, onshore and offshore operations, and explosions. The quality of the air where structure removals are conducted could be degraded by exhaust emissions of the work barge, crewboats, aircraft, and the air emissions from the detonation of explosive charges. When structure-removal operations require the use of explosives (Alternatives A and B), the detonation by-products will vary, depending on the type of explosive used. However, it is expected that the following chemical by-products will be formed: carbon dioxide (CO_2), carbon monoxide (CO), nitrogen (N_2), hydrogen (H_2), and ammonia (NH_3). All of these by-products are in a gaseous form following detonation, and most are expelled to the surface and into the surrounding water column. The majority of the other by-products expected are solid carbon (C) and, in very small percentages, toxic or nontoxic hydrocarbons. In shallow explosions most of these by-products are introduced into the air. In very deep explosions (relative to charge size), most are retained in the water column (O'Keeffe and Young, 1984). Marine and helicopter traffic operating out of established onshore bases also add small amounts of emissions that could impact onshore air quality. Refer to Table 4-1 for emission rates typically generated by structure-removal activities and the emissions from associated marine and helicopter traffic operations. As shown in this table, the anticipated gaseous and particulates emissions from a typical structure-removal operation are relatively small. The impacts to both onshore and offshore air quality from transportation, operations, and explosive detonations are expected to be very low. When nonexplosive structure-removal methods are used, very low impacts would also be expected.

Table 4-1

Gaseous Emissions Typically Generated by Onshore and Offshore Operations for a Structure Decommissioning

Pollutant	Maximum Emission Rate (lb/day*)	
	Onshore	Offshore
Nitrogen Oxides (NO_x)	11.09	1,320.00
Carbon Monoxide (CO)	24.06	348.00
Volatile Organic Compounds (VOC)	2.55	38.00
Total Suspended Particulates (TSP)	1.57	127.00
Sulfur Dioxide (SO_2)	1.29	375.00

* Maximum emissions expected per day from use of 100 lb (45.4 kg) of explosive material and other activities associated with structure decommissioning (e.g., vessel emissions). Calculations are based on a listing of explosive by-products (O'Keeffe and Young, 1984) and from typical emissions obtained from the USEPA publication AP-42, *Compilation of Air Pollutant Emission Factors*, Fourth Edition (USEPA, 1986).

Summary and Conclusion

Considering the standard operations outlined in Chapter 1.4 (Description of the Proposed Action) and the analyzed alternatives (Chapter 2.2), the emission rates for the various air pollutants are well below the NAAQS and MMS exemption levels. Therefore, the potential impacts of the proposed action or Alternatives B and C on air quality are not expected to be significant.

4.2.2. Impacts on Water Quality

Significance Criteria for Water Quality

Exceeding of current effluent or discharge limitations established under existing regulatory discharge limitations (e.g., NPDES general permit for new and existing sources in offshore waters of the GOM or NPDES individual permit) would be considered a **significant** impact.

Terminology and Resource-Specific Definitions

For water quality impact assessment, "localized" impacts can be broadly defined as those that occur within 10 km (6 mi) of the source, whereas "regional" impacts occur on the order of 100 km (62 mi) or more from the source. Temporal attributes are not easily quantified. In general, the terms "long-term" and "short-term" correspond to the duration of a discharge and the longevity of any chemical species of concern found within.

The primary impact-producing factors associated with decommissioning operations in the GOM that could affect water quality are

- shore-based support facility discharges and nonpoint-source runoff;
- coastal and offshore support vessel discharges;
- sediment disturbances resulting from vessel anchoring, BML excavation, severance activities, and the structure's removal/toppling;
- releases of explosion byproducts such as metals from the detonator, heat, and the shock wave caused by the detonation of explosives; and
- nonexplosive severance waste by products.

4.2.2.1 Impacts on Coastal Waters

In coastal waters, the water quality would be impacted by the discharges from shore-based activities and from vessels in port and traveling on local waterways. Point-source discharges from shore-based support infrastructure are regulated by the USEPA or the equivalent State agency. The USEPA NPDES storm-water effluent limitations control storm-water discharges from support facilities. Nonpoint-source runoff, such as rainfall, which has drained from a public road, may contribute hydrocarbon and trace-metal pollutants. The USCG enforces the vessel discharge regulations.

Wastes generated by vessels include sanitary and domestic waste, trash and debris, and bilge and ballast waster. The USEPA and USCG regulations require that sanitary waste be treated prior to discharge and prohibit the disposal of trash or debris into the marine environment. In coastal waters, bilge water may be discharged with an oil content of 15 ppm or less. Other discharges include ballast water, drainage from the deck surface, and uncontaminated seawater from cooling, all of which are benign.

The level of shore-based activity and vessel activity associated with structure removal would not exceed the activity levels associated with prior start-up activities such as structure fabrication, transport, and the exploration and production phases. No overall increase in impacts to coastal water quality is anticipated to result from the proposed decommissioning activities.

Summary and Conclusion

The primary impacting sources to water quality in coastal waters are point-source and storm-water discharges from land-based support facilities and vessel discharges. These sources presently exist to support the oil exploration and production industry. There are no additional impacts to coastal water quality from activities associated with decommissionings. Potential impacts to coastal water quality from the proposed action or alternatives would be similar and are not expected to be significant.

4.2.2.2 Impacts on Marine Waters

The quality of marine waters may be influenced by waters transported from inland and coastal areas as well as impacts that occur offshore. Discharges from shore-based activities would have a greater impact on coastal waters than marine waters and were described in the preceding section.

Impacts from Vessel Discharges

Vessel discharges to marine waters include sanitary waste or sewage; domestic waste such as water from shipboard sinks, laundries and galleys; bilge and ballast waste; cooling water; and deck drainage. Section 312 of the CWA establishes sanitary waste discharge standards and is implemented jointly by the USEPA and USCG. The number of personnel involved in a structure removal is dependent upon the size of the project. Up to 6,000 gal/day domestic wastewater and 4,000 gal/day of sanitary wastewater could be generated from a large derrick barge. This volume estimate is based on a crew of 200 people and generation rates of 30 gal/person/day for domestic waste and 20 gal/person/day for sanitary waste (NERBC, 1976). Smaller vessels that employ smaller crews will produce smaller sanitary and domestic waste volumes. Trash and debris are retained and transported to shore for disposal in accordance with the Marine Plastic Pollution Research and Control Act, which implemented Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL).

Impacts from Sediment Disturbance and Excavation

Vessel anchoring, excavation for BML severing, the use of explosives, and lifting or toppling of the severed structure will cause sediment disturbances and an increase in turbidity within the water column. The area and depth of disturbed sediment would be dependent upon the number and size of service vessels and the number of anchors set, the size of the excavated area, the depth of the BML cut, the method of explosive severance (internal or external) and size of charge (USDOI, MMS, 1987).

The characteristics of the sediment would further influence the amount of disturbance that would occur. In waters 100-200 ft (30-60 m) deep, where most of the removals would occur, the majority of sediments are characterized as very soft (NRC, 1996). Conventionally piled platforms are likely to have mud mats near the bottom of the jacket, which provided temporary support before the piles were installed. If the structure has mud mats that increase the horizontal surface area, a larger area of sediments will be disturbed when the structure is toppled in place or removed.

Some sediment may contain trace concentrations of persistent organochlorine pesticides and metals from inland agricultural and industrial practices. These sediments were transported by the Mississippi River and other rivers and deposited in coastal/marine waters. The presence of pollutants carried by river discharges is much more common in the sediments of coastal waters and is less likely in deeper waters where the structure removals will occur. Low levels of petroleum hydrocarbons may also be present in sediments as the result of urban runoff, low-level discharges associated with oil transport, or offshore natural seeps. Petroleum hydrocarbons may also be present in sediments adjacent to wells from past practices or spills. Any remaining hydrocarbons would be the fractions within the crude that are less water soluble and most resistant to biodegradation. Sediments close to oil and gas wells may contain residuals of drilling muds and cuttings that settle to the seafloor adjacent to the point of discharge. Levels of barium, total mercury, and other metals above background levels may be present as a result of barite used in drilling.

The USEPA limited the toxicity and free oil content of the discharged muds and cuttings through the NPDES discharge permit. In 1993, the USEPA reduced the allowable level of total mercury in barite to 1 ppm. Mercury in sediments is a concern because it potentially bioaccumulates in aquatic organisms. Trace amounts of mercury in barite is predominantly inorganic mercuric sulfate and mercuric sulfide (Trefrey, 1998). Because barite is nearly insoluble in seawater, mercury and other trace metals are trapped in the barite mineral structure and would not become soluble in water or available for bioaccumulation.

Sediment disturbance and excavation will cause a temporary increase in suspended solids, or turbidity, in the immediate area of the activity and possibly the resuspension of sediment contaminants including petroleum hydrocarbons or metals. Sediment resuspension and transportation is an ongoing naturally-occurring process. Sediment disturbances during a structure-removal action would be similar to sediment displacement for the purpose of pipeline placement or water jetting and riserless drilling, standard practices employed during the initial drilling of a well. Sediment disturbance would occur in a very limited area over a time period of less than a week or month for the most extensive removal projects. Therefore, the resuspension of any sediment caused by anchoring, sediment excavation, or removal of severed structure would result in a temporary increase of suspended matter, which would rapidly disperse and resettle to the seafloor. Typical conditions would resume at the completion of the removal activity.

Impacts from Explosive Severance

The use of explosives would release explosive by-products and send a shock wave through the water and sediment. A wide range of explosives are available (Table 1-5). Two of the many factors that are considered when an explosive product is selected are water resistance and ability to sever metal. Organic nitrated compounds such as pentaerythritol tetranitrate (PETN), cyclonitrite (RDX), trinitrotoluene (TNT), Composition B, and C-4 are examples of explosives successfully used underwater (DEMEX, 2003).

Upon detonation, by-products of the explosive are released. Heat is generated and water, particulate carbon, and common atmospheric gases, such as carbon dioxide and nitrogen, are formed. Carbon monoxide gas is also formed. Carbon monoxide is a toxic gas that binds preferentially to the iron in hemoglobin. Varying concentrations of the common atmospheric gases are naturally present in water as the result of atmospheric exchange and biological processes. Carbon monoxide is a product of incomplete combustion and is not normally found in natural waters.

When released to the water, these gases will both dissolve in the water and escape to the surface atmosphere (Young, 1972). The increase of gaseous by-products of explosives in the water will cause very short-term, minor alterations to the dissolved gas concentrations in the water in the immediate area of the explosion. The impacts from the temperature increase and gas release would be negligible because the removal action is a single, short-term event.

Chemicals within the detonator are an additional source of chemical release related to the use of explosives. Detonators may include milligrams or less of lead and mercury. Less than 1 gram of detonator is used for military explosions, which are orders of magnitude larger than the mass of explosives used for structure removal (Young, 1972). The Mississippi River discharge and atmospheric deposition contribute greater amounts of lead and mercury to the Gulf each year than would be released from small detonators that would be used for structure removal. The amount of lead and mercury added to offshore waters from the use of some detonators would be too small to measure and would have no impact on water quality.

Impacts from Nonexplosive Severance

Nonexplosive severance methodologies, as described in Chapter 1.4.6.1, can be performed either AML or BML in either external or internal configurations. For abrasive cutting, seawater and an abrasive, either copper slag or industrial garnet, are used. These abrasives are both inert solids. Copper slag is an iron silicate waste generated during copper processing. As a waste product, it may contain several metals including copper, lead, and arsenic (USEPA, 1995). Because severing would occur only once and for a short time span, the amount of slag used would be insufficient to impact water quality. Industrial garnet is an abrasive silicate that is mined. It is not a waste product from another process and is reported to not contain heavy metals (Olson, 2000). The use of abrasives for cutting will result in the addition of inert grit particles and metal shavings to the seafloor.

For the other nonexplosive severing techniques—mechanical cutting, diamond wire cutting, and diver torch cutting—metal cuttings that will deposit on the seafloor will be the only residual produced. In all of the nonexplosive severing techniques, the cutting event would occur only once in the lifetime of the structure and clean materials would be used. No impacts to water quality are anticipated.

Summary and Conclusion

The primary impact-producing factors related to the proposed action (Alternative A) that could impact marine water quality are sediment disturbances from anchoring, excavation, and structure removal or toppling. Water quality would be temporarily degraded by the increased turbidity. Any contaminants within the sediments, such as PAH's or metals from river discharges or past oil and gas activities, would be disturbed and redistributed by the action.

Vessel discharges will impact offshore water quality during the time of the proposed activity. As long as all regulatory requirements are met, the vessel discharges will have an impact equal to or less than the discharges that occurred when the structure was in operation and will not result in impacts beyond the immediate area of the removal activity.

The use of explosives will release gaseous by-products into the environment. The gases, including carbon monoxide, will rapidly disperse within the water column and escape to the atmosphere. Any impact to water quality would be in the immediate area of the explosion. Trace quantities of several metals would be released by both explosive and nonexplosive severing procedures. Because severings are discrete events and the associated release of metals occurs in such small amounts, the proposed action is not expected to cause significant impacts to marine water quality.

Alternative B limits explosive severance to internal, BML cutting using charges ≤ 50 lb. Impacts caused by explosives would be smaller in Alternative B than three of the five blasting categories proposed under Alternative A because of the smaller quantity of explosives used. However, impacts to water quality from vessel discharges, sediment disturbances, and nonexplosive severance would be the same as those described above. Alternative C does not include the use of any explosives. The effects of Alternative C would be the same as those described under the proposed action for nonexplosive severing. Impacts to water quality from vessel discharges, sediment disturbances, and nonexplosive severing would be the same as those described under Alternative A except that impacts caused by explosive severance would not occur.

4.3. MARINE RESOURCES

4.3.1. Impacts on Marine Mammals

Significance Criteria for Marine Mammals

Any impact is **significant (**under NEPA) if (a) the potential biological removal (PBR) level is exceeded for any marine mammal stock (i.e., any mortality or serious injury would be considered an exceedance of the PBR level for any strategic stock or listed species); or (b) any listed species or strategic stock is displaced from critical habitat (or key habitat if critical habitat is not formally designated) for any length of time; or (c) there is long-term or permanent displacement of any species from preferred feeding, breeding, or nursery habitats (other than critical habitat); or (d) there is a substantial (or chronic) disruption of behavioral patterns to an extent that may adversely affect a species or stock through effects on annual rates of recruitment or survival.

Any impact is **adverse but not significant** if (a) mortality or serious injury occurs to marine mammals, but not in excess of the PBR (i.e., no deaths or serious injuries of strategic stocks or listed species); or (b) there is a short-term displacement of marine mammals from preferred feeding, breeding, or nursery grounds (but not critical habitat); or (c) there is some disruption of behavioral patterns, but to an extent that is unlikely to adversely affect a species or stock through effects on annual rates of recruitment or survival.

Any impact is **negligible** if there is (a) no mortality or serious injury to any marine mammal; (b) no displacement of listed species or strategic stocks from critical habitat; (c) no displacement of any species from preferred feeding, breeding, or nursery grounds; or (d) little or no disruption of behavioral patterns or other sublethal effects.

Terminology and Resource-Specific Definitions

For marine mammal impact assessment, a **"short-term" impact** can be defined as infrequent and temporary, one that is characterized by sudden onset and short duration. Short-term impacts may occur within fixed and varied geographic locations. Considering the average life span of marine mammals, the duration of a short-term impact would be one that may last seconds, hours, or perhaps even up to several days.

A **"long-term" impact** is an impact or series of impacts that is characterized by long duration or frequent reoccurrence, typically within a specific geographic location. Considering the average life spans of marine mammals, the duration of a long-term impact would be one which may last an appreciable fraction of an individual animal's lifetime (i.e., perhaps months to years).

A **"local" (or "localized") impact** is one that occurs within a defined location, is not widespread or general in extent, and affects only restricted numbers of individuals of one or more species but is unlikely to affect the population status of the impacted species or stock of a species.

A **"regional" impact** is one that may affect the status of a species or local stock of a species. The areal extent of a regional impact may vary greatly, ranging from a broad geographic area (one that encompasses one or more ecological habitats or systems) to a much smaller area, as in the case where a species, stock, or a life stage of a species is concentrated into a relatively small area (e.g., sperm whales off the Mississippi River Delta).

A **"strategic stock"** includes those stocks that are not listed under the Endangered Species Act but that have estimated human-caused mortality greater than PBR. The term "population stock" or "stock" means a group of marine mammals of the same species or smaller taxa in a common spatial arrangement that interbreed when mature.

The term **"PBR"** refers the total number of individuals of a particular species (or stock) that may be removed without seriously and irreversibly affecting that species' ability to maintain itself.

The primary impact-producing activities associated with the proposed action are explosive-severance activities. The use of explosives in decommissionings raises the possibility of lethal and sublethal impacts to marine mammals.

4.3.1.1. Potential Impacts of Underwater Explosions on Marine Mammals

Underwater explosions are the strongest manmade point sources of sound in the sea (Richardson et al., 1995). The underwater pressure signature of a detonating explosion is composed of an initial shock wave, followed by a succession of oscillating bubble pulses (if the explosion is deep enough not to vent through the surface) (Urick, 1983; Richardson et al., 1995). The shock wave is a compression wave that expands radially out from the detonation point of an explosion. High-explosive detonations have velocities of 5,000-10,000 ms^{-1} (Urick, 1975; Parrott, 1991; Demarchi et al., 1998), with pulse rise times of about 20 μsec and short pulse durations of 0.2-0.5 ms (CSA, 2004). Although the wave is initially supersonic, it is quickly reduced to a normal acoustic wave (TSB, 2000). The broadband source levels of charges measuring 0.5-20 kg are in the range of 267-280 dB re 1 μPa (at a nominal 1-m distance), with dominant frequencies below 50 Hz (Richardson et al., 1995; CSA, 2004).

The following sections discuss the potential impacts of underwater explosions on marine mammals, including the most serious effects, mortality or injury, hearing effects, and behavioral effects. Much of this information is discussed in greater detail in the information synthesis report prepared by Continental Shelf Associates, Inc. (CSA, 2004; see Chapter 5.4).

Mortality or Injury

It has been demonstrated that nearby underwater blasts can injure or kill marine mammals (Richardson et al., 1995). Injuries from high-velocity underwater explosions result from two factors: (1) the very rapid rise time of the shock wave; and (2) the negative pressure wave generated by the collapsing bubble, which is followed by a series of decreasing positive and negative pressure pulses (CSA, 2004). The extent of injury largely depends on the intensity of the shock wave and the size and depth of the animal (Yelverton et al., 1973; Craig, 2001).

The greatest damage occurs at boundaries between tissues of different densities because different velocities are imparted that can lead to their physical disruption; effects are generally greatest at the gas-liquid interface (Landsberg, 2000; CSA, 2004). Gas-containing organs, especially the lungs and gastrointestinal tract, are the most susceptible. Lung injuries (including lacerations and the rupture of the alveoli and blood vessels) can lead to hemorrhage, air embolisms, and breathing difficulties. The lungs and other gas-containing organs (nasal sacs, larynx, pharynx, and trachea) may also be damaged by compression/expansion caused by oscillations of the blast gas bubble (Reidenberg and Laitman, 2003). Intestinal walls can bruise or rupture, which may lead to hemorrhage and the release of gut contents. Less severe injuries include contusions, slight hemorrhaging, and petechia (Yelverton et al., 1973; CSA, 2004).

In recent studies (Ketten et al., 2003; Reidenberg and Laitman, 2003; CSA, 2004), dead marine mammals exposed to underwater blasts suffered apparent hemorrhages at the blubber-muscle interface and in gas-containing organs, ruptures of the liver and spleen, and contusions of the kidneys. The blubber, melon, and jaw fats have different densities than adjoining tissue and show distinct damage patterns (Ketten et al., 2003). In humans, compression of the thorax and abdomen by a shock wave would cause a rapid increase in venous pressure in the brain, leading to the rupture of small vessels, petechial hemorrhage, and edema (Landsberg, 2000); rapid decompression during the negative bubble phase could cause an air embolism to form (CSA, 2004).

Ears are the organs most sensitive to pressure and, therefore, to injury (Ketten, 2000; CSA, 2004). Severe damage to the ears can include rupture of the tympanic membrane, fracture of the ossicles, cochlear damage, hemorrhage, and cerebrospinal fluid leakage into the middle ear. By themselves, tympanic membrane rupture and blood in the middle ear can result in partial, permanent hearing loss. Permanent hearing loss can also occur when the hair cells are damaged by loud noises (ranging from single, very loud events to chronic exposure). Potential effects on marine mammal hearing are discussed below.

The effects of underwater explosions on pelagic marine vertebrates such as marine mammals depend on the size, type, and depth of the explosives charges; the size and depth of the animal in the water column; the overall water-column depth; and the "standoff" distance from the charge to the target animal.

Several procedures have been developed to calculate safe distances from underwater explosions for marine mammals (Richmond et al., 1973; Yelverton et al., 1973; Yelverton, 1981; Goertner, 1982; Wright, 1982; O'Keeffe and Young, 1984; O'Keeffe, 1985; Young, 1991; Craig and Hearn, 1998; Craig, 2001; CSA, 2004). These have been based on the degree of damage suffered by various submerged terrestrial mammals at various impulse levels (as determined primarily by Yelverton et al., 1973); on the physical dependencies of the impulse on charge weight, charge depth, range, and mammal depth; and, in some cases, on the relationship between the animal's weight and its susceptibility to injury and death (after Yelverton, 1981).

Young (1991) calculated safe distances for several marine animals from underwater explosions of various sizes, given a blast depth of 61 m (200 ft). These calculations were for open-water blasts and did not account for the dampening effects that could occur if a charge were detonated 5 m (16 ft) below the seafloor. For a 12.2-kg (27-lb) dolphin calf at the surface, the safe range from a 22.7-kg (50-lb) charge was estimated to be about 422 m (1,385 ft). The estimated safety distances for adult odontocetes and baleen whales were 530 m (1,739 ft) and 300 m (984 ft) respectively.

Goertner (1982) developed a model to fit the data collected by Yelverton et al. (1973) and Richmond et al. (1973) that considered lung volume, shock wave deviation, and impulse toleration as functions of animal weight and depth. Craig and Hearn (1998) and Craig (2001) used Goertner's method to determine the distance from underwater explosions to various injury levels, using lowest body mass and lowest impulses for the onset of slight lung injury, extensive lung hemorrhage, and extensive lung injury. The results of these calculations produce results slightly more conservative than the Yelverton equations. The calculations for these three injury levels were used to predict the zones of no injury, 1-percent mortality, and 50-percent mortality for marine mammals in the U.S. Navy's two most recent ship shock EIS's (U.S. Dept. of the Navy, 1998 and 2001).

Hearing Effects

The acoustic impacts of underwater explosions on marine mammals must be discussed in the context of what is known about marine mammal hearing. Mammalian hearing functions over a wide range of sound intensities, or loudness. The sensation of loudness increases approximately as the logarithm of sound intensity (Richardson and Malme, 1993). Sound intensity is usually expressed in decibels (dB), units for expressing the relative intensity of sounds on a logarithmic scale. Because sound pressure is easier to measure than intensity and intensity is proportional to the square of sound pressure, sound pressure level is usually reported in units of decibels relative to a standard reference pressure. For underwater sounds, this reference pressure is generally 1 micro-Pascal (μPa). The following paragraphs discuss marine mammal hearing separately for odontocetes and baleen whales.

Odontocetes

Most of the energy of odontocete social vocalizations is concentrated near 10 kHz, above the low-frequency range where most industrial sounds are concentrated. Source levels for whistles may be as high as 100-180 dB re 1 μPa at 1 m (Richardson et al., 1995). Odontocete echolocation pulses are generally much higher in frequency, 30-100 kHz or higher, and source levels may be above 200 dB re 1 μPa at 1 m (Au, 1980).

Understandably, the smaller odontocetes appear to be most sensitive to sounds at frequencies above about 10 kHz, with sensitivity deteriorating progressively below that level. Species whose hearing has been tested include the bottlenose dolphin (*Tursiops truncatus*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), harbor porpoise (*Phocoena phocoena*), Risso's dolphin (*Grampus griseus*), and killer whale (*Orcinus orca*) (Johnson, 1968; Andersen, 1970; Nachtigall et al., 1995 and 1996; Szymanski et al., 1999; Tremel et al., 1998). Although estimated auditory thresholds may be too high for frequencies less than 1-10 kHz because of problems inherent with the use of small holding tanks for testing, hearing sensitivity extends at least as low as 40-75 kHz in bottlenose dolphins (Johnson, 1968). The upper range of the tested species extends to 80-150 kHz in at least some individuals (Johnson, 1968; Andersen, 1970; Nachtigall et al., 1995 and 1996; Szymanski et al., 1999; Tremel et al., 1998; CSA, 2004).

Sperm whales (*Physeter macrocephalus*) produce clicks, which may be used to echolocate (Mullins et al., 1988), with a frequency range from less than 100 Hz to 30 kHz and source levels up to 230 dB re 1 μPa-m or greater (Møhl et al., 2000). There are no specific data on the hearing sensitivity of sperm whales, but immature animals, at least, appear to have medium- and high-frequency hearing abilities similar to the other odontocete species tested (Carder and Ridgway, 1990). Sperm whales often react by becoming silent when exposed to pulsed sounds at frequencies ranging from a few kHz up to at least 24 kHz (Richardson et al., 1995).

There are no published data on the hearing abilities of *Mesoplodon* or *Hyperoodon* spp. beaked whales (CSA, 2004). There is some evidence that northern bottlenose whales (*H. ampullatus*) can hear sounds ranging from at least 2-24 kHz (Hooker, 1999).

Mysticetes

Baleen whale vocalizations are composed primarily of frequencies below 1 kHz, and some contain fundamental frequencies as low as 16 Hz (Watkins et al., 1987; Richardson et al., 1995; Rivers, 1997; Moore et al., 1998; Stafford et al., 1999; Wartzok and Ketten, 1999). Thus, the dominant frequencies in baleen whale sounds overlap with those in many industrial sounds. Although there is apparently much variation, the source levels of most baleen whale vocalizations lie in the range of 150-190 dB re 1 µPa at 1 m.

The low-frequency vocalizations made by baleen whales and their auditory anatomy suggest that they have good low-frequency hearing (Ketten, 2000), although specific data on sensitivity, frequency or intensity discrimination, or localization abilities are lacking. Preliminary results in a study on the anatomy of cetacean ears do indicate that, while many species have ears with a relatively poor capacity below 50 Hz, several larger baleen whale species have cochlea tuned to peak sensitivities below 20 Hz, and that lateral soft-tissue channels exist that may be specialized for the transmission of lower frequencies (Ketten, 1992; Wartzok and Ketten, 1999). A model developed by Helweg et al. (1998) indicates that humpback whales may be sensitive to frequencies between 40 Hz and 16 kHz, with best hearing sensitivity between 100 Hz and 8 kHz (Sigurdson et al., 2001).

Behavioral evidence suggests that baleen whales also hear well at frequencies above 1 kHz (Richardson et al., 1995), and they are known to react to seismic pulses (e.g., Richardson et al., 1995; Greene et al., 1999; Miller et al., 1999; McCauley et al., 2000). Humpback and minke whales have been observed reacting to 3.5-kHz sounds at received levels of 80-90 dB re 1 µPa (Todd et al., 1996). Baleen whales also react to pingers at frequencies ranging from 15 Hz to 28 kHz, but not to pingers or sonar at frequencies in the 36- to 60-kHz range (Watkins, 1986).

Temporary Threshold Shift

The mildest form of hearing damage, temporary threshold shift (TTS), is defined as the temporary elevation of the minimum hearing sensitivity threshold at particular frequency(s) (Kryter, 1985; CSA, 2004). The TTS may last from minutes to days. Although few data exist on the effects of underwater sound on marine mammal hearing, in terrestrial mammals, and presumably in marine mammals, received levels must far exceed an animal's hearing threshold for TTS to occur (Richardson et al., 1995; Kastak et al., 1999; Wartzok and Ketten, 1999).

As discussed above, most studies involving marine mammals have measured exposure to noise in terms of sound pressure level (SPL), measured in dB_{rms} or dB_{peak} pressure re 1 µPa. Exposure to underwater sound can be expressed in terms of energy, also called sound exposure level (SEL), or acoustic energy (measured in dB re 1 μPa^2-s), which considers both intensity and duration. Because different researchers have used various exposure times and sound intensity levels in their TTS studies, data from the studies discussed below have been standardized in terms of energy (following CSA, 2004).

Schlundt et al. (2000) reported on TTS studies with two species of small odontocete, bottlenose dolphins and belugas (*Delphinapterus leucas*). They were able to induce threshold shifts of 6 dB or greater using intense 1-sec tones at 0.4, 10, 20, and 75 kHz. Slight TTS was generally observed at received levels of 192-201 dB re 1 µPa (approximately 188-203 dB re 1 μPa^2-s). However, at 0.4 kHz, no test animals exhibited shifts at levels up to the maximum of 193 dB re 1 µPa. The hearing of all test animals recovered to baseline threshold levels at the end of the study.

In a study conducted by Au et al. (1999), a bottlenose dolphin was subjected to an octave band of continuous noise at 5-10 kHz for 30 min or more over a 50-min period. No TTS was recorded when the noise was at 171 dB re 1 µPa (205 dB re 1 μPa^2-s), but TTS's of 12-18 dB were observed when the noise increased to 179 dB (213 dB re 1 μPa^2-s). The fatiguing stimulus was about 96 dB above the dolphin's pure tone threshold of 84 dB. This TTS threshold is higher than that recorded in seals exposed for 20-22 min (Kastak et al., 1999) but lower than for dolphins and belugas exposed for 1 sec (Schlundt et al., 2000).

In a related study (Finneran et al., 2000), bottlenose dolphins and a beluga exhibited no TTS (defined as a threshold shift of greater than 6 dB) when exposed to impulsive sounds approximating those predicted from 5- to 500-kg (11- to 1,102-lb) explosive charges at distances of 1.5-55.6 km (0.9-35 mi). However, the waveform produced by the piezoelectric transducers used as the sound source lacked energy in the lower part of the spectrum, where most of the energy generated by explosives occurs (CSA, 2004). Disruptions of trained behaviors were recorded at exposures corresponding to 5 kg (11 lb) at 1.5-9.3 km (0.9-5.8 mi) for the dolphins and 500 kg (1,102 lb) at 1.9 km (1.2 mi) for the beluga.

Nachtigall et al. (2003) exposed bottlenose dolphins to noise with peak amplitude at frequencies of 4-11 kHz for 55 min. The test animals experienced an average TTS of 11 dB upon exposure to a received level of 179 db re 1 μPa (213 dB re 1 μPa^2-s). Recovery occurred after 45 min.

Finneran et al. (2002) exposed bottlenose dolphins and belugas to sounds from a seismic gun with most of its energy below 1 kHz, but "substantial energy" at frequencies up to 40 kHz or greater. The beluga experienced a TTS of 7 dB at a received level of 186 dB re 1 μPa2-s, but most of the animals tested experienced no TTS.

Based on the studies described above, there appears to be a linear relationship between energy and the level of TTS, with duration and frequency seemingly unimportant (CSA, 2004). If TTS is defined as a measurable threshold shift of 6 dB or better (Finneran et al., 2000), the onset of TTS was associated with an energy level of about 184 dB re 1 μPa2-s (CSA, 2004). However, the data are very limited, and Finneran (2003) has cautioned that they should be interpreted with caution (CSA, 2004).

Permanent Threshold Shift

Permanent threshold shift (PTS) is a permanent decrease in the functional sensitivity of an animal's hearing system at some or all frequencies (CSA, 2004). The principal factors involved in determining whether PTS will occur include sound impulse duration, peak amplitude, and rise time. The criteria are location and species specific (Ketten, 1995) and are also influenced by the health of the receiver's ear.

At least in terrestrial animals, it has been demonstrated that the received level from a single exposure must be far above the TTS threshold for there to be a risk of PTS (Kryter, 1985, Richardson et al., 1995; CSA, 2004). Sound signals with sharp rise times (e.g., from explosions) produce PTS at lower intensities than do other types of sound (Gisiner, 1998; CSA, 2004).

For explosives, Ketten (1995) estimated that greater than 50-percent PTS would occur at peak pressures of 237-248 dB re 1 μPa and that TTS would occur at 211-220 dB re 1 μPa. The "safe" peak pressure level to avoid physical injury recommended by Ketten (1995) is 100 psi (237 dB re 1 μPa, or about 212 dB re 1 μPa2-s). PTS is assumed to occur at received levels 30 dB above TTS-inducing levels. Studies have shown that injuries at this level involve the loss of sensory hair cells (Ahroon et al., 1996; CSA, 2004).

Behavioral Effects

Based on the information presented in Richardson et al. (1995), the range of possible behavioral effects of noise from underwater explosions on marine mammals may be categorized as follows:

1) The noise may be too weak to be heard at the location of the animal (i.e., below the local ambient noise level, below the hearing threshold of the animal at the relevant frequencies, or both);
2) The noise may be audible, but not loud enough to elicit an overt behavioral reaction;
3) The noise may elicit behavioral reactions, which may vary from subtle effects on respiration or other behaviors (detectable only statistically) to active avoidance behavior; and
4) With repeated exposure, habituation (diminishing responsiveness) to the noise may occur. Continued disturbance effects are most likely with sounds that are highly

variable in their characteristics, unpredictable in occurrence, and associated with situations perceived by the animal as threatening.

Behavioral reactions of marine mammals to sounds such as those produced by underwater explosives are difficult to predict. Whether or how an animal reacts to a given sound depends on factors such as the species, hearing acuity, state of maturity, experience, current activity, reproductive state, time of day, and weather. If a marine mammal reacts to a sound by changing its behavior or moving a short distance, the impacts may not be significant to the individual, stock, or species as a whole. However, if a sound displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts could be significant (CSA, 2004).

Richardson et al. (1995) summarized available information on the reported behavioral reactions of marine mammals to underwater explosions. Observations following the use of seal bombs (i.e., small, Class C explosives used as seal deterrence) as scare charges indicate that pinnipeds rapidly habituate to and, in general, appear quite tolerant of noise pulses from explosives. Small charges and seal bombs with source levels of about 190 dB re 1 μPa have been used to frighten away dolphins, belugas, and pinnipeds with limited success (Fish and Vania, 1971; Frost et al., 1984; Jefferson and Curry, 1994). Whether hearing damage or other injuries have occurred during these situations are unknown.

Klima et al. (1988) reported that small charges were not consistently effective in moving bottlenose dolphins away from blast sites in the GOM. Since dolphins may be attracted to the fish killed by such a charge, rather than repelled, scare charges are not used in the GOM platform removal program (G. Gitschlag, personal communication, in Richardson et al., 1995).

There are few data on the reactions of baleen whales to underwater explosions. Gray whales were apparently unaffected by 9- to 36-kg charges used for seismic exploration (Fitch and Young, 1948). However, Gilmore (1978) felt that similar underwater blasts within a few km of the gray whale migration corridor did "sometimes" interrupt migration.

Humpback whales have generally not been observed to exhibit behavioral reactions (including vocal ones) to explosions, even when close enough to suffer injury (hearing or other) (Payne and McVay, 1971; Ketten et al., 1993; Lien et al., 1993; Ketten, 1995; Todd et al., 1996). In Newfoundland, humpbacks displayed no overt reactions within about 2 km of 200- to 2,000-kg explosions. Whether habituation and/or hearing damage occurred was unknown, but at least two whales were injured (and probably killed) (Ketten et al., 1993). Other humpback whales in Newfoundland, foraging in an area of explosive activity, showed little behavioral reaction to the detonations in terms of decreased residency, overall movements, or general behavior, although orientation ability appeared to be affected (Todd et al., 1996). Todd et al. (1996) suggested caution in interpretation of the lack of visible reactions as indication that whales are not affected or harmed by an intense acoustic stimulus; both long- and short-term behavior as well as anatomical evidence should be examined. The researchers interpreted increased entrapment rate of humpback whales in nets as the whales being influenced by the long-term effects of exposure to deleterious levels of sound.

As discussed above, Finneran et al. (2000) exposed captive bottlenose dolphins and belugas to single, simulated sounds of distant explosions. The broad-band received levels were 155-206 dB; pulse durations were 5.4-13 ms. This was equivalent to a maximum spectral density of 102-142 dB re 1 μPa2/Hz at a 6.1 Hz bandwidth. Behavioral alterations began at received levels of 181-194 dB (120-127 dB re 1 μPa2/Hz). Although pulse durations differed, the source levels required to induce these reactions were similar to those found by Ridgway et al. (1997) and Schlundt et al. (2000).

4.3.1.2. Impacts of the Proposed Action on Marine Mammals

Definitions of Take

Any impact assessment of the effects of underwater explosions on marine mammals must address the potential for "takes" of marine mammals as defined in the Marine Mammal Protection Act (MMPA), as amended in 1994 (16 CFR § 1431 et seq.). As discussed in this Chapter and elsewhere in the PEA, these "takes" could occur incidental to or unintentionally during normal decommissioning activities using explosive-severance tools In addition to lethal take, the Act allows for the incidental take of small numbers of marine mammals by harassment. Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as:

> any act of pursuit, torment, or annoyance which (1) has the potential to injure a marine mammal or marine mammal stock in the wild; or (2) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to migration, breathing, nursing, breeding, feeding, or sheltering.

The terms Level A and Level B harassment correspond to definitions 1 and 2, respectively. For the U.S. Navy's Seawolf and Winston Churchill ship shock tests (U.S. Dept. of the Navy, 1998 and 2001), NOAA Fisheries recognized the threshold for the onset of extensive lung hemorrhage in a 12.2-kg dolphin calf as the criterion for mortality (66 FR 22450, May 4, 2001). This corresponds to a 1-percent chance of mortality and, thus, is very conservative. The threshold is stated in terms of impulse (Goertner, 1982) and is indexed to a value of 30.5 psi-ms.

Criteria for nonlethal, injurious impacts (Level A harassment) are currently defined as the incidence of 50-percent tympanic-membrane (TM) rupture and the onset of slight lung hemorrhage for a 12.2-kg dolphin calf (69 FR 21819, April 22, 2004). Level A harassment take is assumed to occur:

1. at an energy flux density value of 1.17 in-lb/in^2 (which is about 205 dB re 1 μPa^2-s); and
2. if the peak pressure exceeds 100 psi for an explosive source; i.e., the "safe" peak pressure level to avoid physical injury recommended by Ketten (1995).

The horizontal distance to each threshold is determined and the maximum distance at which either is exceeded is taken to be the distance at which Level A harassment would occur (U.S. Dept. of the Navy, 2001). NOAA Fisheries recognizes two levels of noninjurious impacts (Level B harassment). One criterion for level B harassment is defined by the onset of TTS. Two thresholds are applied. TTS is assumed to be induced:

1. at energies greater than 182 dB re 1 μPa^2-s within any ⅓-octave band. Procedures for calculating critical distances for TTS were (a) to calculate the energy spectrum density for the waveform; (b) to integrate the spectrum in ⅓-octave bands; and (c) to determine whether the energy density in any ⅓-octave band exceeds 182 dB re 1 μPa^2-s (considering frequency ranges of $\geq$ 100 Hz for odontocetes and $\geq$ 10 Hz for mysticetes); and
2. if the peak pressure exceeds 12 psi for an explosive source.

As with Level A harassment, the horizontal distance to each threshold is determined and the maximum distance at which either is exceeded is taken to be the distance at which Level B harassment (TTS) would occur (U.S. Dept. of the Navy, 1998 and 2001; CSA, 2004).

Sub-TTS behavioral effects may also be considered to constitute a take by lower Level B harassment if a marine mammal reacts to an activity in a manner that would disrupt some behavioral pattern in a biologically significant way (66 FR 22450). NOAA Fisheries does not believe that single, minor reactions (such as startle or "heads-up" alert displays, short-term changes in breathing rates, or modified single dive sequences) that have no biological context qualify as takes. This would include minor or momentary behavioral responses to single events such as underwater explosions.

Acoustic Impact Model

To aid in the analysis of the potential impacts of explosive-severance activities in the GOM, MMS contracted with Marine Acoustics, Inc. (MAI) to apply its Acoustic Integration Model (AIM) for three-dimensional acoustic propagation and marine mammal movement modeling to estimate the take of marine mammals incidental to these activities. The AIM is a Monte Carlo model that considers the acoustic source characteristics and then calculates the sound field of the particular physical environment. Within that environment, numerous virtual animals (termed "animats") are moved in three dimensions and in time, simulating the movement patterns of real animals. To do this, AIM uses a set of behavioral parameters derived from a wide number of scientific papers (Frankel et al., 2002; Frankel and Ellison, 2004).

The AIM then combines the model-predicted sound field with the modeled animal movements to predict the exposure of each animat. This exposure history can be compared to the regulatory thresholds for Level B (i.e., TTS) takes to determine the number of animals that may be affected or "taken" by the proposed activity.

In order to model accurately the propagation of sound from the source to the animals, MMS contracted Applied Research Associates, Inc. (ARA) to develop a model and prepare a report to predict the effective source level and propagation of an explosion taking place above and below the mudline (Appendix B; Dzwilewski and Fenton, 2003). The ARA's "UnderWater Calculator" (UWC) is also capable of propagation modeling for explosives contained within pipes of varying diameters and wall thicknesses. Integration of the ARA UWC with AIM made it possible to perform comprehensive, three-dimensional modeling of the effects of explosive-removal activities on marine mammals.

For this analysis, 24 explosive-severance simulations were run over 10 sites selected to represent existing oil platform locations and areas of likely cetacean concentration. Level B take estimates were established based on the criteria described above—received levels exceeding 182 dB re 1 μPa^2-s in the appropriate ⅓-octave band and/or a peak pressure of 12 psi or greater. The ARA UWC calculated the received levels for both criteria.

Multiple explosive-severance scenarios were developed for some of the sites, where there are a number of different types of offshore structures that would require different removal methods. Each scenario was simulated with an individual model run. Each removal activity was considered to be an explosive event, and each model run predicted the exposure from a single event. Within each simulation, a simulated animal was considered to have been taken if the exposure exceeded either the 182 dB re 1 μPa^2-s in the appropriate ⅓-octave band and/or a peak pressure of 12 psi criteria. The number of takes in each model run was scaled with the ratio of modeled and estimated animal densities to produce a Take Estimate per Event (TEPE). The estimated densities used for the runs were based on two recent studies of cetacean distribution and abundance in the GOM (Fulling et al., 2003; Mullin and Fulling, 2004). The TEPE was calculated using the following formula:

TEPE = Number of Model Takes x (Real Density/Modeled Density)

Because the calculation was based on estimated animal densities, upper and lower bounds were calculated for the TEPE. This was done by multiplying the TEPE by the coefficient of variation (CV) for each species' density estimate, then adding or subtracting the product from the TEPE to produce the upper and lower bounds. The number of explosive-severance events needed to produce a take was calculated by taking the inverse of the upper bound of the TEPE. Tables 9-22 in Appendix D, *Explosive Removal Model Simulation Report*, list the number of TEPE's per scenario, the animal density estimates used, and other information related to each of the modeling runs. Using explosive-severance activity projections (Appendix A) in conjunction with the TEPE's and guidance provided in Appendix D, the total numbers of takes were estimated as follows:

Number of Takes = TEPE x Number of Events

Take Estimates

Incorporating the information presented above, Appendix E (Take-Estimate Calculations for Explosive-Severance Activities Conducted under the Proposed Action) describes the steps taken by MMS to conduct its incidental-take determination and estimation tasking. The items discussed include

- impact criteria/thresholds establishment;
- predictive modeling of detonation pressure/energy propagation (ARA UWC; Appendix B);

- propagation model verification and utilization (*in-situ* testing and measurements; Appendix C);
- predictive modeling of marine mammal take estimates (AIM results; Appendix D); and
- final take-estimate calculations and summaries.

The Level A and B potential take-estimate totals *without any mitigation* for all explosive-severance scenarios are given for 19 species or species groups in Table E-6. The Level B takes are broken down by each explosive severance scenario in Tables E-7 through E-23. Though additional mitigation information can be found in the next section and Appendix F, it is important to note that all take estimates presented in Appendix E and discussed in this analysis are calculated for the proposed action with no mitigation applied.

Marine mammal observations collected by NOAA Fisheries' Platform Removal Observer Program (PROP) between 1987 and 1999 included primarily unidentified dolphins and Atlantic bottlenose dolphins with some spotted dolphins and two large, unidentified marine mammals presumed to be whales (Gitschlag, 2002). The only commonly-occurring marine mammal in the offshore Gulf of Mexico waters that is listed as endangered is the sperm whale. The calculated high-range Level A (injury) take estimate for sperm whales over the five-year life of the petition is virtually nil (0.04). The Level B (harassment) take projection over the 5-year life of the petition is 10.5 animals. After rounding up the 5-year projections to 11 animals, the potential Level B takes still only represent less than 1 percent of the GOM sperm whale stock of 1,315 animals (USDOC, NOAA, 2004). Annually, the estimated (high) take by harassment of sperm whales is less than 0.2% of the GOM stock.

Baleen whales, believed to hear and use lower frequency sounds than other marine mammals, are poorly represented in the GOM. Bryde's whales are the only baleen whales that occur with any regularity and they seem to be confined to the eastern Gulf waters; mostly outside the area of the proposed action. With an estimated Gulf stock of 42 animals, these whales are not common. No Bryde's whales are projected to be taken by either Level A or Level B over the 5-year span of the petition.

Beaked whales have become species of interest in recent years because of several strandings that may be associated with military sonar sound. Two groupings of beaked whales were identified in the GOM for take estimations. Cuvier's beaked whales, of the genus *Ziphius,* have an estimated Gulf population of 88 animals. Like the Bryde's whales, there were no takes estimated for this species. The species grouping of *Mesoplodon* spp. includes "the undifferentiated complex of beaded whales (*Ziphius* and *Mesoplodon* spp.)" and is estimated at 98 individuals. Projected Level B takes over five years for this group is 1.4 for the high range and there are no Level A takes calculated.

The highest number of calculated takes for any species or species group is for the bottlenose dolphin with high-range, Level B take of 1,138 animals and high-range, Level A take of 5 animals over the 5-yr petition span. The estimated population for the GOM Outer Continental Shelf stock of this species is 26,852 individuals. Also, the more coastal habitat of bottlenose dolphins includes more of the structures that will be decommissioned in coming years than, for instance, the deep water oceanic habitat of pantropical spotted dolphins (which have an estimated Gulf population that is several times greater than that of bottlenose dolphins but fewer projected takes). The 5-yr projected high range Level B takes comprise 4% of the population (annual take at 0.85%), and the 5-yr projected high Level A takes comprise 0.02% of the population.

4.3.1.3. Mitigation

As detailed in Appendix E, recent *in-situ* measurement work used to verify the validity of the ARA UWC indicated that the theoretical pressure and energy projections were much greater than the actual readings. The MMS believes using the theoretical projections provides an extra measure of protection for potentially-impacted species and has used the UWC for both incidental-take projections and mitigation development. Appendix F provides descriptions of the mitigation developed for explosive-severance scenarios projected under the Proposed Action. Incorporating general blasting criteria and scenario-specific monitoring/survey requirements, these mitigations will greatly reduce the possibility of Level B takes and virtually eliminate the possibility of Level A takes. The programmatic mitigation developed for each scenario is tailored to the physical environment, conservative impact zones, and the species most likely to be impacted.

For instance, the sperm whale, as an endangered species, was the target species for mitigations in the depths where they were likely to occur (> 200 m). By taking into account such factors as long dive times and deep dives, as well as relatively short surface periods, mitigations were developed that would optimize the observers' chance to detect a sperm whale. At the same time, these mitigations are as appropriate and cautionary, or more so, for other species that might occur in the same scenario. Beaked whales and pygmy and dwarf sperm whales also inhabit deep water, and also have prolonged dive times. The long pre-detonation observation periods should serve equally well for both of those species groups. Also, both beaked whales and pygmy and dwarf sperm whales usually exhibit cryptic behavior in the GOM (USDOI, MMS, 2004). These animals tend to be very difficult to observe and study due to their apparent avoidance of ships. The increased level of activity in the period of time leading up to a decommissioning may keep these species out of the area.

As for the other species of marine mammals that might be present, their smaller size may make them more difficult to detect than sperm whales. But, the long observation times put in place to insure a surface interval for sperm whales will insure several surface intervals for the other species with shorter dive times, and thus, more opportunities for detection. Also, many of the marine mammal species in the Gulf usually occur in groups rather than solitarily. More animals are much easier to detect, and some group activities can create a surface disturbance that would be difficult to miss. The mitigations are designed around not only the severance scenarios, but also around the species that might be impacted. An analysis of the marine mammal observations collected during PROP observations between 1987 and 1999 indicates that aerial surveys were superior to non-aerial surveys in detecting the presence of marine mammals within a 1,000 yard radius (*status-quo* impact zone) around structure removals than did surveys conducted from the sea-surface (Gitschlag, 2002).

One other important point to make about the mitigation measures is that, although these are presented in a programmatic fashion with the intent of standardizing mitigation procedures for various severance scenarios, each explosive-severance activity proposal will be carefully reviewed via site-specific NEPA analysis prior to MMS permitting any removal operation. These analyses provide MMS the opportunity to vary mitigation or add further precautions as necessary.

Summary and Conclusions

Using a variety of state-of-the-art modeling tools and the best science available, the calculated high-range, 5-year Level A take rounds to 1 or more animals in only 3 of the 19 species or species groups analyzed. Those three species are the only marine mammal species in the GOM that inhabit water depths < 200m, which is also where the majority of the decommissioning activities over the span of this petition will occur. As mentioned above, the high Level A take estimate for bottlenose dolphins is less than 0.02% of the population. The high Level A take estimate for the next highest species, the pantropical spotted dolphin, is 1.66 over five years. This equals 0.003% of its estimated population. High-range Level B takes for these two species are projected to be 4.25% and 0.69%, respectively, over five years. The bottlenose dolphin has the highest Level B take projection, with the next highest population percentage at about half that of the spotted dolphin.

Based on this analysis and the established significance criteria, impacts to marine mammals from explosive-severance activities conducted under the proposed action (Alternative A) are potentially adverse but not significant. The projected Level A takes, even with no mitigation, are very unlikely and, for most species, none. No deaths or serious injuries to strategic stocks or listed species are projected. If any marine mammals are displaced from preferred grounds, it will be for the short term, and no critical habitat is involved. Level B harassment takes may disrupt behavioral patterns in a few individuals of a few species, but no effect is projected on annual recruitment or survival. With the mitigation measures described in Appendix F in place, the potential impacts on marine mammals are expected to be negligible.

Alternative B (*Status Quo*) is identical to the proposed action, with the exception that explosive severance would be limited to internal, BML cutting using charges ≤ 50 lb. Under current mitigation requirements, the possible impacts caused by explosives would be smaller in Alternative B than under Alternative A due to the smaller charges; however, they would remain potentially adverse but not significant. Since Alternative C limits severance activities to nonexplosive cutting tools only (i.e., no use of explosives), marine mammal impacts are not expected to occur.

4.3.2. Impacts on Sea Turtles

Significance Criteria for Sea Turtles

Any impact is **significant** if (1) the species-specific jeopardy threshold level is exceeded for any sea turtle; or (2) there is any displacement of sea turtle species from critical habitat (or key habitat, in the absence of a formally designated critical habitat); or (3) there is a long-term or permanent displacement of any sea turtle species from preferred feeding, breeding, or nursery habitats (other than critical habitat); or (d) there is a substantial (or chronic) disruption of behavioral patterns to an extent that may adversely affect a species or stock through effects on annual rates of recruitment or survival.

Any impact is **adverse but not significant** if there is (1) mortality or serious injury to sea turtles, but not exceeding jeopardy threshold standards; or (2) short-term displacement of sea turtles from preferred feeding, breeding, or nursery grounds (but not critical habitat); or (3) some disruption of behavioral patterns, but to an extent that is unlikely to adversely affect a species or stock through effects on annual rates of recruitment or survival.

Any impact is **negligible** if there is (1) no mortality or serious injury to any sea turtle; or (2) no displacement of any species from critical habitat; or (3) no displacement of any species from preferred feeding, breeding, or nursery grounds; or (4) little or no disruption of behavioral patterns or other sublethal effects.

Terminology and Resource-Specific Definitions

For sea turtle impact assessment, the spatial and temporal definitions are similar to those noted for marine mammals.

A "short-term" impact is one that is infrequent and temporary, characterized by sudden onset and short duration, and occurring within either fixed or varied geographic locations; the duration of a short-term impact ranges from seconds to several days.

A "long-term" impact is one or a series of impacts characterized by long duration or frequent reoccurrence, typically within a specific geographic location; the duration of a long-term impact may represent an appreciable fraction of an individual animal's lifetime (i.e., perhaps months to years).

A "local" (or "localized") impact is one that occurs within a defined location, is not widespread or general in extent, and affects only restricted numbers of individuals of one or more species but is unlikely to affect the population status of the impacted species or stock of a species.

A "regional" impact is one that may affect the status of a species or local stock of a species. The areal extent of a regional impact may vary greatly, ranging from a broad geographic area (one that encompasses one or more ecological habitats or systems) to a much smaller area, as in the case where a species, stock, or a life stage of a species is concentrated into a relatively small area.

The major impact-producing factors resulting from the activities associated with proposed decommissioning actions that may affect loggerhead, Kemp's Ridley, hawksbill, green, and leatherback turtles include water-quality degradation, vessel collisions, site-clearance trawling, and physical effects of underwater explosions.

Water Quality Degradation

Increased water turbidity and mobilization of sediments containing drilling muds and cuttings are both likely due to resuspension of bottom sediments following an explosive severance activity or structure salvaging. The magnitude and extent of sediment resuspension will depend on the hydrographic parameters of the area, the location of removal (above or below mudline), and the size and composition of the bottom sediments. The impacts to water quality from resuspension of hydrocarbon wastes is expected to be temporary and limited to the immediate, localized structure-removal site. Due to the temporary nature of water quality changes following decommissioning activities, no significant impacts to sea turtle populations in the GOM are expected.

Vessel Collisions

Data show that vessel traffic is one cause of sea turtle mortality in the GOM (Lutcavage et al., 1997). Numbers of OCS-related vessel collisions with sea turtles offshore are unknown, but are thought to be magnitudes of order less than other human causes (such as fishing related mortality) (Lutcavage et al., 1997). It is expected that some sea turtles could be impacted during decommissioning activities due to vessel traffic. However, based on structure removals and associated vessel traffic over the past five years and projections for the next five to twenty years this is not expected to increase measurably. Noise from service-vessel traffic and aircraft may elicit a startle reaction from sea turtles, resulting in a short-term disruption of activity patterns. Migratory corridors used by sea turtles may be impacted by increased vessel and aircraft disturbance.

Site-Clearance Trawling

After OCS structures are removed, many operators employ contractors to trawl the salvage area with commercial nets (i.e., otter/shrimp trawls) in order to retrieve any objects or obstructions (e.g., tools, containers, batteries) that may have been lost or discarded during the operational life of the structure. Current guidelines in MMS's Notice to Lessees and Operators (NTL) No. 98-26, Minimum Interim Requirements for Site Clearance (and Verification) of Abandoned Oil and Gas Structures in the Gulf of Mexico, instruct trawling contractors to remove turtle-excluder devises (TED's) from their nets to allow for debris collection. However, without TED's, sea turtles near the seafloor in a trawl path could be captured and drawn into the nets with the salvaged debris.

In addition to discomfort and/or possible non-lethal injuries from contact with the netted debris, captured sea turtles could become exhausted as struggling from forced submergence leads to energy consumption, oxygen depletion, and other stress-related impacts (NRC, 1990). Depending upon conditions at the time of capture, the turtle could drown if kept submerged, especially if tow times exceed 60 minutes (Henwood and Stuntz, 1987).

Physical Effects of Underwater Explosions

Impacts on sea turtles from decommissioning activities using explosives can be divided into three categories: noninjurious effects, nonlethal injuries, and lethal injuries. These impacts are dependent on many variables including the size, type, and depth of the explosive charge; the size and depth of the turtle in the water column; overall water column depth; and the distance of the explosive charge to the turtle (U.S. Dept. of the Navy, 2001).

Noninjurious Effects

The noninjurious effects of underwater explosions on marine turtles include acoustic annoyance and mild tactile detection or physical discomfort. Marine turtle auditory perception occurs through a combination of bone and water conduction (Lenhardt, 1982), and it is reasonable to assume that sounds produced by underwater explosions may be sufficient to elicit a response. If the detonation is of low intensity or at a considerable distance from the turtle, the response may include a momentary startle response or possible temporary disorientation of the turtle. Physical discomfort or tactile detection can occur in the soft tissue areas around the nose, eyes, mouth, nares, and vent. Because of the brevity of the shock waves from underwater explosions, tactile detection responses may vary from a momentary startle response to a slight "sting" of varying degrees.

Nonlethal Injuries

Nonlethal injuries include "minor" injuries to the turtle's auditory system and certain internal organs. The most sensitive organ is the auditory apparatus. Rupture of the tympanum is not a life-threatening injury but it does correlate to permanent hearing loss (Ketten, 1995). Organ injuries including lung hemorrhage and gastrointestinal tract contusions can occur as a result of underwater explosions; however, these organ injuries would not be debilitating and the turtle would be expected to recover on its own.

Delayed complications arising from nonlethal injuries may ultimately result in the death of the animal because of increased risks from secondary infection, predation, or disease.

Lethal Injuries

Lethal injuries result from massive trauma or combined trauma to internal organs as a result of close proximity of the marine turtle to the point of detonation. Lethal injuries can include massive lung hemorrhage, gastrointestinal tract injuries (contusions, ulcerations, and ruptures), and concussive brain damage, cranial and skeletal (shell) fractures, hemorrhage, or massive inner ear trauma (Ketten, 1995).

Summary and Conclusion

Sea turtles could be impacted by degradation of water quality and its associated short-term effects, vessel collisions, site-clearance trawling, and the physical effects of underwater explosions. The potential for lethal effects could occur from the detonations of explosive-severance tools (and associated pressure wave), chance collisions with OCS service vessels associated with decommissioning activities, and potential capture in site-clearance trawls. Existing protocols to detect the presence of sea turtles within a 1,000 yd radius around decommissioning sites are almost entirely based on monitoring the sea surface from vessels, platforms, and helicopters. Most of the sea turtles identified by NOAA Fisheries' PROP are loggerheads which have been shown to spend about 90-95% of their time underwater (Renaud & Carpenter, 1994). Since PROP began monitoring in 1987, there have been only four documented occasions of impacts to marine turtles (all loggerheads) from explosive severances on the OCS; one killed, one stunned, and two injured. Additionally, there have been no reported decommissioning-related vessel collisions or site-clearance trawling impacts on sea turtles. Appendix F of this PEA includes mitigation developed by MMS in coordination with NOAA Fisheries to decrease the likelihood that explosive-severance and/or site-clearance trawling activities will contribute to sea turtle injury or mortality in the GOM. Most decommissioning activities are expected to have sublethal effects on marine turtles. The impacts of the decommissioning activities projected under the proposed action (Alternative A) are expected to be negligible most of the time, with occasional impacts being potentially adverse but not significant. No significant adverse effects on the population size and recovery of any sea turtle species in the GOM are expected

Alternative B (*Status Quo*) is identical to the proposed action, with the exception that explosive severance would be limited to internal, BML cutting using charges ≤ 50 lb. Potential impacts caused by explosives would be smaller in Alternative B under Alternative A because of the smaller charges; however, impacts to sea turtles from water degradation, vessel collisions, and site-clearance trawling would be the same as those described above. Alternative C limits severance activities to nonexplosive cutting tools and does not include the use of explosives. Potential impacts to sea turtles from water degradation, vessel collisions, and site-clearance trawling would be the same as those described under Alternative A except that impacts caused by explosive severance would not occur.

4.3.3. Impacts on Fish Resources, Commercial and Recreational Fishing, and Essential Fish Habitat

Significance Criteria for Fish Resources/Fisheries

An impact on fish resources is considered to be **locally significant** if it is likely to directly or indirectly cause measurable change in (1) species composition or abundance beyond that of normal variability or (2) ecological function within a species range for 5 years or longer. The threshold for significance is determined by scientific judgment and takes into consideration the relative importance of the habitat and/or species affected.

Impacts of **regional significance** are judged by the same criteria as those for local significance, except that the impacts cause a change in the ecological function within the population or community. The number of fish affected, relative to those present in the region, is determined in the same way as that for locally significant impacts. This determination takes into consideration the importance of the species and/or habitat affected and its relative sensitivity to environmental perturbations. Consideration of Essential Fish Habitat (EFH) is an important and necessary component of any impact assessment.

Impacts to commercial fisheries are considered **significant** if (1) fishers are precluded from 2 percent or more of the fishing grounds during decommissioning operations; (2) 2 percent or more of the fishers are precluded from a fishing area for all or most of a fishing season; or (3) economic losses due to a decrease in catchability of target species exceeds 2 percent of the annual value.

Terminology and Resource-Specific Definitions

In fish resources impact assessment, "short term" refers to periods of a year or less, whereas "long term" encompasses a time period of more than a year, up to one or more decades. "Local" (or "localized") impacts extend from meters up to 1 km (0.6 mi), whereas "regional" ranges from 1 km to hundreds of kilometers (0.6 to 62+ mi).

In commercial fisheries impact assessment, spatial and temporal definitions are identical to those provided for fish resources. "Short term" refers to periods of a year or less, whereas "long term" encompasses a time period of more than a year, up to one or more decades. "Local" (or "localized") impacts extend from meters up to 1 km (0.6 mi), whereas "regional" ranges from 1 km to hundreds of kilometers (0.6 to 62+ mi).

Because of the overlap of subject matter in discussing impacts of platform removal with respect to fisheries and fishing, topics that are normally considered socioeconomic concerns and resources, *Commercial Fisheries* and *Recreational Resources* (i.e., offshore fishing), are addressed in this section.

For fish resources and EFH, the primary impact-producing activity associated with decommissioning obsolete offshore oil and gas structures is the use of explosives to sever the platform structures and wellheads. Bottom-disturbing activities such as anchoring and toppling structures may also damage habitat, suspend sediments, and increase turbidity. Furthermore, the offshore oil and gas platforms may provide valuable hard substrate habitat. If structures are not reefed after their removal, this hard-bottom and fish habitat will be lost, including the loss of those sites for fishing activities by commercial or recreational fishers.

Essential Fish Habitat

On August 12, 1999, MMS and NOAA Fisheries completed a GOM Programmatic EFH consultation. This consultation addresses pipeline rights-of-way, plans for exploration and production, and platform removals (including explosive removals) on the Federal OCS. The following Conservation Recommendations are pertinent to this analysis and have been adopted to avoid, minimize, and offset adverse impacts to EFH:

1. Existing environmental stipulations for the protection of live bottoms, pinnacles, topographic features, and chemosynthetic communities shall be incorporated in petroleum development approval documents prepared by the GOM OCS Region.
2. The Flower Garden Banks shall be deleted from areawide lease sales.
3. An oil-spill response plan shall be required of all owners and operators of oil handling, storage, or transportation facilities located seaward of the coastline.
4. Pursuant to existing regulations, lessees shall be responsible for the control and removal of pollution to avoid risks to EFH and associated fisheries.
5. When the Topographic Features Stipulation is required for any proposed permit around Stetson Bank, the protective requirements of the East and West Flower Garden Banks shall be enforced.
6. Where there is documented damage to EFH under the Live Bottom (Pinnacle Trend) or Topographic Features lease stipulations, MMS shall coordinate with the NMFS Assistant Regional Administrator, Habitat Conservation Division, Southeast Region for advice. Based on the regulations at 30 CFR Subpart N, 250.200, "Remedies and Penalties," the Regional Director of the MMS may direct the preparation of a case file in the event that a violation of a lease provision (including lease stipulations) causes serious, irreparable, or immediate harm or damage to life (including fish and

other aquatic life) or the marine environment. The conduct of such cases could lead to corrective or mitigative actions.

7. The MMS shall provide NMFS with yearly summaries describing the number and type of permits issued in the Western and Central Planning Areas, and permits for activities located in the Live Bottom (Pinnacle Trend) and Topographic Features blocks for that year. Also, the summaries shall include a report of any mitigation actions taken by MMS for that year in response to environmental damage to EFH.

By adopting the NMFS EFH conservation recommendations, MMS has fulfilled its requirement under Section 305(b)(2) of the MFCMA. Platform removals are a covered activity under the programmatic EFH consultation, and no additional EFH consultation is necessary.

Bottom-Disturbing Activities

The effects of bottom-disturbing activities, such as anchoring and toppling structures, on sensitive benthic habitat and resources have been analyzed in previous environmental documents (USDOI, MMS 2002 and 2003), and are incorporated here by reference. The effects may include physical damage to hard-bottom features, increased turbidity, and covering or smothering of sensitive habitats with re-suspended sediments. The Live Bottom (Pinnacle Trend) Stipulation and the Topographic Features Stipulation would minimize impacts in the vicinity of pinnacle trends and topographic features, both of which sustain sensitive offshore habitats. Both of these stipulations are now incorporated into a new NTL (No. 2004-G05; effective April 1, 2004). The overall impacts to fish resources from bottom-disturbing activities associated with decommissionings are expected to be negligible.

Habitat Loss

There are approximately 4,000 oil and gas structures on the northern GOM OCS. These platforms provide hard substrate habitat to an area that is largely devoid of naturally occurring hard-bottom habitat. Numerous hard-bottom features do exist on the continental shelf of the northwestern Gulf. The MMS has designated No Activity Zones for a total of 39 named topographic features. Pinnacle trend features are not individually identified or named but occur within a total of 70 lease blocks. Parker et al. (1983) estimate there are 2,780 km^2 (1,073 mi^2) of naturally occurring hard-bottom in the northern GOM between water depths of 18 and 91 m (59 and 299 ft). Petroleum platforms provide about 12 km^2 (4.6 mi^2) or about 0.4 percent of the natural reef area (LGL and SAIC, 1998). However, off the coast of Louisiana, where the majority of platforms are found, the bottom is mostly silt and clay from Mississippi River deposits, and locally, oil and gas platforms provide a large percentage of hard-bottom habitat for reef fishes. Several studies indicate that these platforms affect several regional ecosystem processes such as food availability, habitat, recruitment, competition, and predation (Menge and Sutherland, 1987; Doherty and Williams, 1988; Bohnsack et al., 1991; and Stanley and Wilson, 2000a). Platforms not too distant from shore are also a major destination for recreational fishers and divers (Hiett and Milon, 2002).

Louisiana and Texas have well-established artificial reef programs that make use of obsolete structures. To date, these two states have converted over 180 platforms to artificial reefs, representing over 95% of the total rigs-to-reef activity in the GOM. However, this total number represents less than 10 percent of all platforms that were decommissioned during that time; the remainder were taken to shore. Thus, a large amount of hard substrate habitat is removed annually. Currently, the number of platforms removed is roughly offset by new installations. But in the future, removals will outpace new installations.

The issue of how the removal of large numbers of oil and gas platforms will affect the existing fish stocks and ecology of the GOM is a very complex question that scientists are only just beginning to understand after many years and millions of dollars in research. This issue will be better understood in the coming decade and decisions can be adapted to reflect the new knowledge. In the meantime, we must consider that the platforms in the GOM represent artificial habitat that has only been available since the 1950’s. Certainly, artificial habitat can become critical to regional ecological health. However, many in the scientific community question the real ecological value of artificial reefs in general. Do artificial reefs increase productivity or just redistribute the available resources to known locations, making them easier for capture (Stone et al., 1979; Bohnsack and Sutherland, 1985; Bohnsack, 1989; Grossman et al., 1997;

Bortone, 1998)? The answer is clearly a combination of both. Obvious examples would be represented by large fish seen on newly installed platforms (attraction) compared to fish observed tending egg nests, clearly demonstrating that at least some species of fish living on platforms produce and export new biomass (more fish) rather than simply being attracted to the structure (Boland, 2002).

Historical data show that commercial landings of finfish and shellfish in Louisiana and Texas have grown from 115 million kg (126,765 tons) to 545 million kg (600,754 tons) since the first installation of offshore structures in 1947. And currently, 90 percent of commercial red snapper landings originate in Louisiana waters; however, because there is little natural hard substrate in the region for this reef species, it is assumed a significant portion is harvested at de facto reefs such as petroleum platforms (Stanley and Scarborough-Bull, 2003). The general scientific question remains whether the platform structures have made it easier to exploit the resource or has productivity been increased by the artificial reefs.

It is likely that, for the majority of fish species in the GOM, the regional impacts of removing the hard substrate habitat provided by oil and gas platforms would be small, at least for the level of removals expected for the next several years. But for some key species that are in decline because of overfishing and other factors, the removal of a large number of existing oil and gas platforms may have a more substantial effect. Hernandez et al. (2003) suggest that the major value of platforms as artificial habitat in the GOM lies in their increased carrying capacity for adult fishes and potential as spawning habitat. The vertical structure of the platform, while unique, is not as important for most larval and juvenile fishes, and may represent a "wall of mouths" to new recruits. But on the other hand, rubble fields surrounding platforms created by a rain of fouling community components (e.g., barnacles and bivalve shells) can provide critical habitat for recruited juvenile fishes such as red snapper. The presence of platforms also functions as a protective mechanism by diverting shrimp trawling.

The hard substrate habitat that platforms have provided to the GOM ecosystem for the past 50 years has enhanced and supported recreational and commercial fishing opportunities. In one sense, it does not seem logical that removing this artificial habitat from the GOM would have a significant environmental impact on the fish resources since it would be returning the area to its natural condition. But the lack of natural hard-bottom habitat in much of the northern Gulf must be considered at a smaller scale to predict the impacts on fish populations at scales smaller than Gulfwide. Some reef-associated species are likely limited by the availability of artificial reefs as recruitment sites. Assuming that all OCS structures provide habitat that increases productivity, the benefits are masked by other factors including bycatch in the Gulf shrimp fishery. The potential ecological consequences of removing all the hard substrate provided by platforms could be exacerbated by the opening of those areas that were previously sheltered from trawling. The impacts could be mitigated by applying appropriate fishery management policies, including converting more rigs to artificial reefs, creating marine management areas, designing new fishing gear to reduce bycatch, and setting more restrictive catch limits, shorter seasons, or fishery closures.

Underwater Explosives

In recent years, roughly 108 oil and gas structures are removed annually in the GOM. Of these, about 66 percent, or roughly 72 structures, are removed using explosives (TSB, 2000). Most commonly, 40- to 50 lb bulk charges (primarily Comp-B and C-4) are detonated inside pilings and well conductors at a depth of 15 ft (4.5 m) below the seafloor. However, future removals will increasingly include larger structures in deepwater. The large pilings of these structures may require double or triple the charge size to ensure that the severance is complete. However, it is important to remember that doubling the weight of an explosive charge does not double the effects. At close-in distances, shock wave effects in water follow a cube root scaling. Thus, it would take an 8-fold increase in charge size to yield a 2-fold increase in shock wave energy at the same distance from the detonation point (Young, 1991). Specialized shaped charges can also be used resulting in more effective severing using smaller charge sizes.

Blast Effects

The underwater pressure signature of a detonation is composed of an initial shock wave, followed by a succession of oscillating bubble pulses (if the explosion is deep enough not to vent through the surface) (Urick, 1983; Richardson et al., 1995). Pulse rise time is very brief, within about a microsecond. The shock wave is a compression wave that expands radially out from the detonation point of an explosion.

The wave is supersonic, but it is quickly reduced to normal acoustic waves (TSB, 2000). The rapid oscillation in the pressure waveform between a high overpressure and underpressure associated with detonation is probably responsible for fish mortality (Keevin and Hempen, 1997). This oscillation causes rapid contraction and overextension of the swimbladder resulting in internal damage and mortality. Invertebrates and fish with no swimbladder, or less well-developed swimbladders, are extremely resistant to underwater blasts. There is also limited information that fish weight may also influence vulnerability. Yelverton et al. (1975) tested a number of different fish species and found that a higher impulse was required to kill larger fish than smaller fish. This held true both within species and between different species tested. Other factors such as age, general health, water temperature, and reproductive condition may influence mortality (Keevin and Hempen, 1997).

To summarize, the potential for injury and mortality to fishes resulting from underwater blasts has been well documented (Hubbs and Rechnitzer, 1952; Ferguson, 1962; Teleki and Chamberlain, 1978). In general, the studies have demonstrated that nonswimbladder marine life (e.g., flounder, shrimp, oysters, lobsters, and crabs) are highly resistant to explosions. The resistance is probably because of the absence of air cavities. Fish with swimbladders are highly susceptible to injury and mortality from underwater blasts. Within this group, small fish are more vulnerable than large fish, and fish near the surface are more vulnerable than deep fish (Young, 1991).

Estimating Impacts

Environmental predictions are statistical in nature because of the natural variability of the ambient conditions and environment in addition to the normal movements of marine life, along with the range in size, age, and physical condition of the organisms. Thus, the environmental predictions are not expected to be precise, but the average results should be consistent with predictions.

Although several models have been developed to calculate the fish kill radius for underwater explosions (Sakaguchi et al., 1976; Baxter et al., 1982; Hill, 1978; Munday et al., 1986; Wright, 1982; Yelverton et al., 1975; Wiley et al., 1981), various factors including biological, environmental, and explosive parameters may influence their accuracy. Also, the models were developed using open water shot data. Most underwater detonations during platform removals occur within the steel pilings and casings. Thus, we must rely on other means of estimating the fish mortality from underwater blasts at platform removals. For the purposes of this analysis, MMS assumes that all platform-associated fish with swimbladders (within 50 m or 160 ft) will be killed by the underwater blast.

Several studies have estimated the fish abundance at oil and gas structures in the northern GOM using hydroacoustics and visual estimates (Wilson et al., 2003; Stanley and Wilson, 1997 and 2000b). Stanley and Wilson (1995, 1996, and 1997) calculated that there were on average 12,473 fishes at a site in 24 m (79 ft) of water. Stanley and Wilson (2000b) estimated that there were 13,472 fish at a site in 22 m (72 ft) of water; 28,952 fish at a site in 60 m (197 ft) of water; and 13,856 fish at a site in 219 m (719 ft) of water. And Wilson et al. (2003) estimated that there were 7,100 fish at a platform in 90 m (295 ft). These numbers include fish greater than 2.5 cm (~1 in) total length. Gitschlag et al. (2000) reported on extensive studies of the effect of explosions on platform fish during platform removals. This study estimated mortality at 9 platforms in depths from 14-32 m (46-105 ft) ranged from about 2,000-5,000 for fish greater than 8 cm (3 in) total length (Gitschlag et al., 2000). At one of the nine platforms all fish, regardless of size, were collected within a 1.5 x 1.5 m (5 ft x 5 ft) frame, and the Gitschlag study estimated that over 6,200 small fish (less than 8 cm or 3 in) were killed within the platform footprint. This in addition to an estimated total mortality (footprint area plus 100-m radius) of about 4,900 fish measuring greater than 8 cm (3 in) total length. An important caveat to consider when weighing the impacts is that fish less than 8 cm (3 in) total length are probably not adding to the spawning biomass and generally have a high natural mortality rate. Thus the estimated mortality presented in the Gitschlag study may present a more useful estimate from a fisheries impact viewpoint. For the purposes of this analysis, MMS assumes that on average 5,000 fish greater than 8 cm (3 in) total length would be resident at each platform (at comparable depths).

Just as there is variance in fish abundance, there is also variance in fish community structure at each platform. Gitschlag et al. (2000) studied fish mortality associated with explosive removals at nine GOM platforms in water depths from 14 to 32 m (46 to 105 ft). They observed that four species (Atlantic spadefish, blue runner, red snapper, and sheepshead) accounted for 86 percent of the estimated mortality (Table 4-2). Stanley and Wilson (2000b) found similar results in species composition at three GOM platforms; six species made up over 90 percent of the fishes observed at each site (Table 4-3). In trophic structure, each GOM platform is generally dominated by a planktivore such as blue runner, Atlantic spadefish, or creolefish. Stanley and Wilson (2000b) found that at each of three platforms, one species of planktivorous fish made up 55-87 percent of all observed fishes at the platform and piscivorous Serranids (groupers), Lutjanids (snappers), and Carangids (jacks) made up 10-24 percent.

Table 4-2

Total Estimated Mortality and Percent Species Composition of the Four Most Impacted Species at Nine GOM Platforms

Species	Total Estimated Mortality	Percent of Total Estimated Mortality
Atlantic spadefish	12,875	42
Blue runner	4,867	16
Red snapper	4,632	15
Sheepshead	4,094	13

Source: Gitschlag et al., 2000.

Table 4-3

Estimated Number and Percent Species Composition (in Parenthesis) of the Most Common Species at Three Platforms in the Northern GOM

Species	South Timbalier 54	Grand Isle 94	Green Canyon 18
Atlantic spadefish	5,019 (37)		
Bermuda chub			1,156 (8)
Bluerunner	2,689 (20)	25,188 (87)	2,462 (18)
Creolefish			4,924 (36)
Mangrove snapper	1,775 (13)	319 (1.1)	
Red snapper	995 (7)	869 (3)	
Sheepshead	2,326 (17)		
Gray triggerfish		290 (1)	
Horseye jack		869 (3)	
Almaco jack			2,261 (16)
Greater amberjack			1,052 (8)

These numbers represent the average from several trips taken to the platforms between August 1994-March 1997.

Source: Wilson et al., 2000.

Of the species commonly associated with oil and gas platforms, and thus susceptible to mortality from explosive removals, red snapper and groupers are of special interest to fishery managers. In the GOM, red snapper are overfished and red grouper are fully utilized (USDOC, NMFS, 1999b). If red snapper make up 15 percent of the total fish mortality at explosive removals, as seen by Gitschlag et al. (2000), and we estimate 5,000 fish per platform, then approximately 750 red snapper would be killed at each explosive removal—or approximately 54,000 red snapper per year at an average of 72 removals. This mortality figure is well within the variation of the current stock assessment analyses, and would not alter current determinations of status or current management recovery strategies. The even smaller changes in magnitude of groupers would not be detected by the current methods of assessment.

Effects on Fishing Activities

Although the loss of some portion of desirable fish populations is expected from explosive-severance activities, it has been determined not to affect the total stocks or their recovery status, the loss of individual platforms as fishing destinations could have more direct impact to recreational and for hire charter boats in some circumstances. A variety of surveys of recreational fishing groups was conducted as part of an MMS-funded economic study, *Economic Impact of Recreational Fishing and Diving Associated with Offshore Oil and Gas Structures in the Gulf of Mexico* (Hiett and Milon, 2002). When considered cumulatively, a total of more than 88 percent of charter boat and party boat operators responded that oil and gas structures were either very important or somewhat important. When asked if structures should be left in place after operations ended, 85 percent responded yes. Of the 4.5 million recreational fishing trips estimated in the Gulf States from Alabama through Texas in 1999, 21.9 percent of them were within 300 ft (91 m) of an oil or gas structure. Of the 83,780 estimated diving trips, 93.6 percent were within 300 ft (91 m) of such a structure. Limited numbers of removals in the near future should have a negligible impact on fishing or recreational diving activities, but this impact could increase substantially when structure removals greatly exceed new installations, particularly in near shore areas.

In conclusion, the use of explosives to sever platform pilings and well conductors would, in most cases, involve the detonation of several 40- to 50-lb charges 15 ft (4.5 m) below the seafloor. Previous experience has shown the lethal effects of these charges on the fish population resident at the platforms. Although several species of fish could be affected, red snapper are of special interest because they are presently overfished and they are commonly found at offshore platforms. Based on visual and hydroacoustic surveys and an explosive removal study, an average of 750 red snapper could be killed at each platform severance activity; or approximately 54,000 red snapper could die each year, assuming 72 explosive removals per year. This estimated mortality is within the variation of current stock assessments, and would not alter current determinations of the status of red snapper or current management recovery strategies. Thus, the effects to fish resources from explosive removals in the northern GOM are expected to be short-term and minor, and the mortality levels would likely be masked by natural variations in stock abundance.

Summary and Conclusions

Effects to fish resources from natural hard-bottom habitat loss and damage resulting from activities associated with offshore oil and gas structure removals are expected to be localized and are considered to be insignificant. The Live Bottom (Pinnacle Trend) and Topographic Features Stipulations would further minimize the impacts. At the present rate of development, new structure emplacements are roughly keeping pace with removals so that there is no net loss of artificial hard substrate habitat provided by oil and gas platforms. Thus, over the next decade, the overall effects to fish resources from removing large numbers of oil and gas platforms in the GOM would be negligible. Platforms used as destinations for fishing or recreational diving activities can typically be displaced to other nearby remaining structures. This will likely change in the next decade when removals will outpace new emplacements. The scientific community is still researching the true ecological value of artificial marine habitats. The MMS-funded studies show that GOM oil and gas platforms support fish biomass at a rate equal or greater than natural reefs, even when toppled or after partial removal when the top 26 m (85 ft) of a structure is removed. Although not a true measure of a platform's overall ecological value, this high density of fish may be important for some key species that are of special interest from a management point of view. As scientists and managers gain a better understanding of the role artificial reefs, and in particular oil and gas platforms, play in the GOM, decisions can be adapted to reflect the new knowledge. The MMS has recently funded a additional project to compile and review the available research on the biology and ecology of natural and artificial reefs in the Gulf of Mexico. The primary goal of the project is to use the available research to evaluate the Gulf-wide ecological impacts of the offshore oil and gas platforms, and the consequences of removing the structures from the Gulf of Mexico.

The use of explosives to sever oil and gas structure components is known to kill a portion of many of the fish assemblages associated with the structure. Of special concern to fishery managers is the red snapper, which is overutilized in the GOM and which is a common resident at the platforms in water depths to at least 200 m (656 ft). Studies indicate that the estimated number of red snapper killed annually during explosive severances would fall within the variation of current stock assessments and would not alter current recovery strategies. In summary, the impacts of the proposed action (Alternative A) on fish resources, commericial and recreational fishing, and essential fish habitat are not expected to be significant.

Alternative B (*Status Quo*) is identical to the proposed action, with the exception that explosive severance would be limited to internal, BML cutting using charges ≤ 50 lb. Potential impacts on fish resources caused by explosives would be smaller in Alternative B under Alternative A because of the smaller charges.

Alternative C limits severance activities to nonexplosive cutting tools and does not include the use of explosives. Potential impacts on fish resources, commericial and recreational fishing, and essential fish habitat from Alternative C would be the same as those described under Alternative A except that impacts caused by explosive severance would not occur.

4.3.4. Impacts on Benthic Resources

Significance Criteria for Benthic Resources

An impact on benthic resources is considered to be locally **significant** if it is likely to directly or indirectly cause measurable change in (a) species composition or abundance beyond that of normal variability or (b) ecological function within a species range for 5 years or longer (i.e., long-term). Measurable changes occurring for less than 5 years would be considered short-term, locally significant impacts. For an impact to be locally significant, the extent of the impact would be relatively small compared to total population or community size in the immediate region. The threshold for significance is determined by scientific judgment and takes into consideration the relative importance of the habitat and/or species affected. Impacts of regional significance are judged by the same criteria as those for local significance, except that the impacts cause a change in the ecological function within the population or community. The expected extent of the impact (e.g., total numbers affected), relative to those present in the region, is determined in the same way as that for locally significant impacts. This determination takes into consideration the importance of the species and/or habitat affected and its relative sensitivity to environmental perturbations.

Terminology and Resource-Specific Definitions

For benthic resources impact assessment, the term “short term” can be broadly defined as a time period of 5 years or less, whereas “long term” would include time periods greater than 5 years. Spatial attributes are not as easily quantified. “Local” (or “localized”) impacts can be broadly defined as those that occur in a relatively small area, compared to the broad or limited extent of the community or population of concern. “Regional” impacts would encompass broader aerial extent, yet would also consider the extent of the community or population.

The following section discusses potential impacts to benthic resources specific to decommissioning activities. A more-detailed discussion of all OCS impacts can be found in Chapter 4.2.1.2.1 (Pinnacle Trend) and Chapter 4.2.1.2.2 (Topographic Features) in the Central and Western Gulf of Mexico Multisale EIS (USDOI, MMS, 2002) and Chapter 4.2.1.4.1 (Continental Shelf) in the Eastern Gulf of Mexico Multisale EIS (USDOI, MMS, 2003).

4.3.4.1. Impacts on Live-Bottom (Pinnacle Trend) Communities

The region defined as the pinnacle trend includes 70 blocks located in the northeastern portion of the CPA and adjacent areas of the EPA. The blocks are located in water depths between 53 and 110 m (174 and 361 ft) water depths in the Main Pass and Viosca Knoll lease areas. Past lease sales have mandated the Live-Bottom Stipulation, designed to prevent structure and anchor emplacement (the major potential impacting factors on these live bottoms resulting from offshore oil and gas activities) from damaging the pinnacles. Under the stipulation, the operators' plans and applications were reviewed on a case-by-case basis to determine whether a proposed operation could impact a pinnacle feature. If it was determined from site-specific information derived from MMS studies, published information from other research programs, geohazards survey information, or another source that the operation would impact a pinnacle feature, the operator would have been required to relocate the proposed operation or adopt avoidance-mitigation measures. Although the stipulation is regarded as a highly effective protection measure, infrequent accidental impacts are possible. Accidental impacts may be caused by operator positioning errors or when studies and/or geohazards information are inaccurate or fail to note the presence of pinnacle features. In the case of structure removals, which often occur years or decades after structure emplacements, many of the mitigation measures placed on the initial lease development are not maintained or mandated for the decommissioning operations. In addition, some of the structures currently requiring decommissioning were installed before the Live-Bottom Stipulation was enacted.

In situations where incorrect positioning or geohazard information was used, initial mitigation measures were not maintained, and/or structure emplacements occurred prior to the Live-Bottom Stipulation, a number of decommissioning-related factors may cause adverse impacts on the pinnacle trend communities and features. Damage caused by anchoring, jack-up vessel emplacement, structure severance and removal, progressive transport (jacket-hopping), and sight-clearance trawling can cause the immediate mortality of live-bottom organisms or the alteration of sediments to the point that recolonization of the affected areas may be delayed or impossible.

Anchoring may damage lush biological communities or the structure of the pinnacles themselves, which attract fish and other mobile marine organisms. Anchor damage from lift and support vessels greatly disturb areas of the seafloor and are the greatest threats to live-bottom areas. The size of the affected area would depend on water depth, anchor and chain sizes, chain length, method of placement, wind, and current. Anchor damage includes, but is not limited to, crushing and breaking of the pinnacles and associated communities. Anchoring often destroys a wide swath of habitat by being dragged over the seafloor, or the vessel swings at anchor, causing the anchor chain to drag the seafloor.

When used, the emplacement of the leg assemblies of jack-up vessels on the seafloor will crush the organisms directly beneath the legs or mats used to support the structure. Similarly, the areas affected by the temporary, seabed placement of the platforms during progressive transport could result in crushed organisms and/or pinnacle features. The subsequent retrieval of the leg assemblies and "hopped" platforms from soft-bottom regions could also directly affect the benthic communities through burial and disruption of the benthos and through resuspension of sediments. These resuspended sediments may obstruct filter-feeding mechanisms and gills of fishes and sedentary invertebrates.

Depending upon their configuration, both explosive and nonexplosive severance activities could disturb the seafloor and potentially affect nearby pinnacle communities. In addition to the pre-severance jetting of sediments from within and/or around piles, jacket legs, and well structures, the force of explosive and some nonexplosive severance activities will suspend sediments throughout the water column impacting the nearby habitats as described above. Explosive detonations create shock waves, which also harm resident biota in the immediate vicinity. O'Keeffe and Young (1984) have described the impacts of underwater explosions on various forms of sea life. They found that sessile organisms of the benthos (such as barnacles and oysters) and many motile forms of life (such as shrimp and crabs) that do not possess swim bladders are remarkably resistant to the blast effects from underwater explosions. Many of these organisms not in the immediate blast area should survive. In the case of BML cuts, benthic organisms would be further protected from the impacts of explosive detonations by the rapid attenuation of the underwater shock wave through the seabed. The shock wave attenuation is significantly less in mud than in the water column, where it is known to impact fish up to 60 m (197 ft) away from an 11.3-kg charge detonated at a 100-m (328-ft) depth (Baxter et al., 1982).

After OCS structures are severed from the seabed and salvaged, operators are required to perform site-clearance work to ensure that the seafloor in and around the removal area is restored to prelease conditions. One option involves trawling the salvage area with commercial nets and equipment to retrieve and remove any objects or obstructions (e.g., tools, containers, batteries, etc.) that may have been lost or discarded during the operational life of the structure. As the trawling vessel drags the nets and rigging taut along the seabed, the resultant seafloor scraping has the potential to damage both benthic organisms and the pinnacle features.

Summary and Conclusions

For decommissionings on structures emplaced after the Live-Bottom Stipulation was implemented, pinnacle features should incur few, if any incidences of anchor, jack-up leg, or platform positioning damage from support vessels or during progressive transport activities. However, the incidence of occurrence would remain low only if any initial mitigation and avoidance measures were carried over to the decommissioning operation. Absent of these avoidance criteria, accidental anchor, leg, or placement impacts resulting from the proposed action could be extensive, with recovery taking 5-10 years depending on the severity. As previously discussed, emplacement of recent and future platforms will likely have no impact on the pinnacles because of the restraints placed by the Live-Bottom Stipulation, some infrastructure may have been emplaced inaccurately and/or prior to the stipulation.

Barring improper and/or inaccurate emplacement of structures under the Live-Bottom Stipulation and with sufficient pre-mobilization surveying for pre-stipulation facilities and progressive-transport routes, removal activities should not deleteriously impact the pinnacle trend area considering the following:

- benthic organisms are resilient to blasts, so only restricted regions would be affected by shock waves from explosives;
- the resuspension of sediments would be limited both in time and space (24 hr for the water column 4 m (13 ft) off the bottom and above, and 7-10 days for the water layer contained in the first 4 m (13 ft) off the seafloor; resuspension of sediments would extend about 1,000 m (3,281 ft) away from the activities);
- only a limited number of structures would be removed in the pinnacle area; and
- most of the structures to be removed would have been placed away from any sensitive resources.

It is also anticipated that any damage to the benthic resources of the pinnacle trend area that may occur as a result of structure removals would be followed by a recovery to pre-interference conditions within two years. In summary, conditional to the mitigation listed in Appendix F, impacts on pinnacle features from the proposed action or the alternatives are not expected to be significant.

4.3.4.2. Impacts on Topographic Features

The topographic features sustaining sensitive offshore habitats in the area of the proposed action are listed and described in Chapter 3.2.4.2. A Topographic Features Stipulation has been included in appropriate leases since 1973 and establishes a No Activity Zone within which no bottom-disturbing activities are allowed. Decommissioning-related factors that may cause adverse impacts on topographic features are support vessel anchoring, jack-up vessel emplacement, structure severance and removal, progressive transport (jacket-hopping), and sight-clearance trawling. These disturbances have the potential to disrupt and alter the environmental, commercial (fisheries), recreational, and aesthetic values of topographic features.

The anchoring of lift vessels, load barges, or service vessels, as well as the leg positioning of jack-up barges/boats would result in mechanical disturbances of the benthic environment. Anchor damage has been shown to be the greatest threat to the biota of the offshore banks in the Gulf (Bright and Rezak, 1978; Rezak et al., 1985). Such anchoring/positioning damage, however, would be prevented within any given No Activity Zone by the observation of the Topographic Features Stipulation. Facility removal and/or repositioning during progressive-transport activities could resuspend sediments. The Topographic Features Stipulation would also prevent these activities from occurring in the No Activity Zone, thus preventing most of these resuspended sediments from reaching the biota of the banks.

The sediment jetting required for both explosive and nonexplosive removal operations would disturb the seafloor by generating considerable turbidity. The deposition of resuspended sediments has the potential of choking and causing mortality of sessile benthic organisms. Turbidity could both reduce light levels and obstruct filter-feeding mechanisms, leading to reduced productivity, susceptibility to infection, and mortality.

The shock waves produced by explosive-severance activities could also harm associated biota. Corals and other sessile invertebrates have a supposedly high resistance to shock. O'Keeffe and Young (1984) described the impacts of underwater explosions on various forms of sea life using, for the most part, open-water explosions much larger than those used in typical decommissioning operations. They found that sessile benthic organisms, such as barnacles and oysters, and many motile forms of life, such as shrimp and crabs, that do not possess swim bladders were remarkably resistant to shock waves generated by underwater explosions. Oysters located 8 m (26 ft) away from the detonation of 135-kg charges in open water incurred only a 5 percent mortality. Crabs distanced 8 m (26 ft) away from the explosion of 14-kg charges in open water had a 90 percent mortality rate. Few crabs died when the charges were detonated 46 m (151 ft) away. O'Keeffe and Young (1984) also noted ". . . no damage to other invertebrates such as sea anemones, polychaete worms, isopods, and amphipods." Benthic organisms appear to be further protected from the impacts of BML explosive detonations by rapid attenuations of the underwater shock wave traversing the seabed away from the structure being removed. The shock-wave attenuation is significantly less in mud than in the water column where it is known to impact fish up to 60 m (197 ft) away from an 11.3-kg charge blasted at a 100-m (328-ft) depth (Baxter et al., 1982). Theoretical predictions suggest that the shock waves of BML detonations would further attenuate blast effects. In addition, the Topographic-Features Stipulation discussed above would help to preclude platform installation in the No Activity Zone, thus preventing adverse effects from nearby removals; however, any site-specific, pre-installation mitigation (e.g., avoidance criteria, anchoring restrictions) would need to be similarly applied to the decommissioning operations. Additional protection to topographic features is provided by guidance resulting from Essential Fish Habitat consultation agreements between NOAA Fisheries and MMS. In order to avoid additional project specific EFH consultations, operators must avoid no-activity zone boundaries by a distance of 153 m (500 ft).

Site-clearance trawling is often performed by the operator to retrieve any objects or obstructions that may have been lost or discarded on the seabed in the vicinity of the removed structure. Similar to pinnacle impacts, topographic features and biota could be damaged by the door assemblies and/or the "footrope" as they are dragged along the seabed. Even though the Topographic Features Stipulation would preclude a structure from being emplaced within a No Activity Zone, both the site-clearance radii (e.g., 1,320 ft, 600 ft, and 300 ft) and the area needed to maneuver the trawling vessel over the site coordinates could bring the trawl dangerously-close to the sensitive features. If, however, detailed information on the No Activity Zone coordinates and any pre-emplacement avoidance mitigation could be directed to the trawling contractor, accidental contact could be avoided and any trawling-related impacts would likely be minimal.

Summary and Conclusions

All of the 39 topographic features (shelf edge banks, mid-shelf banks, and low-relief banks) in the GOM represent only a small fraction of the area of the proposed action. As noted above, the proposed Topographic Features Stipulation should prevent most of the potential impacts from decommissioning operations on the biota of topographic features, including direct contact during anchoring or temporary positioning activities. Operations outside of the No Activity Zones could still affect topographic features through turbidity-amplifying activities such as sediment jetting, structure lifting and removal, and severance detonations. However, conditional to the mitigation listed in Appendix F, impacts on topographic features from the proposed action or the alternatives are not expected to be significant.

4.4. OTHER RESOURCES AND ACTIVITIES

Significance Criteria for Other Resources and Activities

There are no established, quantitative criteria available for impacts to other uses and activities. A qualitative criterion for a **significant** impact includes long-term interference with other uses of the Gulf by commercial and/or military interests.

Terminology and Resource-Specific Definitions

For other resources and activities impact assessment, the absence of quantitative significance criteria is problematic; however, similarities can be established between other resources/uses and specific resource areas. In general, a "short-term" impact refers to an impact duration of 5 years or less, whereas "long term" is defined as any impact that exceeds 5 years. "Local" (or "localized") is defined as an impact that occurs within 15 km (9 mi) of the impact source. In general, "regional" encompasses those impacts that are manifest within an area greater than 15 km (9 mi) from the source of the impact.

4.4.1. Impacts on Archaeological Resources

This section discusses potential impacts from proposed decommissioning activities. Major impact-producing factors that could affect both prehistoric and historic archaeological resources are direct physical contact from anchoring, progressive-transport (i.e., jacket-hopping), and trawling activities associated with site clearance.

Blocks with a high probability for the occurrence of prehistoric and/or historic archaeological resources are listed in the CPA, EPA, and WPA EIS's. Prehistoric archaeological resources include sites, structures, and objects such as shell middens, earth middens, campsites, kill sites, tool manufacturing areas, ceremonial complexes, and earthworks. Blocks with a high probability for prehistoric archaeological resources are found landward of a line that roughly follows the 60-m bathymetric contour.

The areas of the northern GOM that are considered to have a high probability for historic period shipwrecks were defined as a result of an MMS-funded study (Garrison et al., 1989). The study expanded the 1977 shipwreck database in the GOM from 1,500 to more than 4,000 wrecks. Statistical analysis of shipwreck location data identified two specific types of high-probability areas—the first within 10 km (6.2 mi) of the shoreline, and the second proximal to historic ports, barrier islands, and other loss traps. High-probability search polygons associated with individual shipwrecks were created to afford protection to wrecks located outside of the two aforementioned high-probability areas (USDOI, MMS, 2001b).

An Archaeological Resources Stipulation was included in all GOM lease sales from 1974 through 1994. The stipulation was incorporated into operational regulations effective November 21, 1994. The language of the stipulation was incorporated into the operational regulations under 30 CFR 250.194 with few changes, and all protective measures offered in the stipulation have been adopted by the regulation.

NTL 2002-G01, issued in December 2001 with an effective date of March 15, 2002, outlines MMS's archaeological survey and report requirements. Survey line-spacing at 50 m (164 ft) is required for historic shipwreck surveys in water depths of 200 m (656 ft) or less. Survey line-spacing of 300 m (984 ft) is required for prehistoric site surveys and for shipwreck surveys in water depths greater than 200 m (656 ft). All lease blocks requiring an archaeological survey and assessment can be found at: http://www.gomr.mms.gov/homepg/regulate/environ/archaeological/surveyblocks.pdf

The MMS, by virtue of operational regulations under 30 CFR 250.194, requires that an archaeological survey and archaeological assessment be conducted prior to development of leases within the high-probability zones for historic and prehistoric archaeological resources. This requirement is believed to be highly effective at identifying possible archaeological sites.

Many of the activities associated with structure removals on the OCS have the potential to impact archaeological resources. Physical contact with a prehistoric site would cause a disturbance of the site stratigraphy and artifact provenance that would adversely affect the integrity of the site and its research potential. Direct physical contact with a shipwreck site could destroy fragile ship remains, such as the hull and wooden or ceramic artifacts, and could disturb the site context. The result would be the loss of archaeological data on ship construction, cargo, and the social organization of the vessel's crew, and the concomitant loss of information on maritime culture for the time period from which the ship dates.

Structure removal activities with the most potential to impact archaeological resources include anchoring, jacket hopping, and trawling associated with the site clearance process. Anchoring associated with platform removal may physically impact prehistoric and/or historic archaeological resources. The removal of offshore structures through progressive-transport (or jacket-hopping) has the ability to impact prehistoric and/or historic archaeological resources along the path used to move into shallow water.

The activity most likely to have the greatest impact on prehistoric and/or historic archaeological resources comes from trawling associated with the site clearance and verification process. The use of shrimp trawlers to verify seafloor clearance can seriously impact any archaeological resources encountered, particularly in lease blocks that were developed prior to the requirement of an archaeological survey and assessment.

Summary and Conclusion

The greatest potential impact to an archaeological resource as a result of a proposed structure removal action would result from a contact between an OCS offshore activity (anchoring, progressive-transport, or trawling associated with the site clearance process) and an archaeological resource. The archaeological survey and archaeological clearance of sites required prior to an operator beginning oil and gas activities on a lease are estimated to be highly effective at identifying possible archaeological resources. However, there are still many lease areas in the GOM that have not had archaeological surveys and assessments completed. For any lease blocks that require an archaeological assessment, but have not had one completed, the potential for impact to an archaeological resource greatly increases. However, conditional to implementing the anchoring, progressive-transport, and site-clearance trawling mitigation described in Appendix F, the impacts of the proposed action (Alternative A) on archaeological resources are not expected to be significant.

Since the major impact producing factors associated with Alternative B (*Status Quo*) and Alternative C are identical to the proposed action, the potential impacts on archeological resources would be the same as those described under Alternative A.

4.4.2. Impacts on Pipelines and Cables

As part of the decommissioning process, MMS requires that all pipelines coming from and going to the structure being removed be purged, severed, and/or removed in accordance with OCSLA regulations found at 30 CFR 250.1750 to 250.1754. Likewise, cable service (e.g., electrical and telephones) to and from the facility must be secured and removed prior to removal. For this reason, potential impacts to the platform- or facility-related pipeline and cable infrastructure are expected to very low or almost nonexistent. However, seafloor-disturbing activities conducted during a structure or facility decommissioning have the potential to damage other unrelated pipelines and cables located in the vicinity of the operations.

Besides costly repair requirements, cables damaged during decommissionings may lead to the loss of support (e.g., communications, power, and hydraulics) to adjacent facilities or subsea equipment. Damaged pipelines could lead to added environmental degradation and costly economic impacts if the transported hydrocarbons are released into the coastal and marine environments. If damage occurs on pipelines carrying “sour” petroleum (i.e., oil or gas containing significant amounts of hydrogen sulfide—H_2S), the probability also exists for serious human health and safety concerns. The primary impacting factors related to pipeline and cables are support vessel anchoring/siting, severance activities, progressive transport (i.e., jacket-hopping), and site-clearance trawling.

Lift and Support Vessel Anchoring

In most OCS decommissionings, conventionally-anchored lift vessels are mobilized at the structure site to host operations and effect the lifting of the severed structure and its component onto transport vessels. An average derrick barge requires at least 4 anchors to be deployed from forward and aft positions on both port and starboard beams, with many of the larger barges possessing enough winches/ capstans to support 8-10 or more anchors. Set by the onboard deck crane or support tugs, the anchors and associated chains and lines are winched taught and often dragged along the seabed for dozens of feet/ yards before the anchor’s flukes are set in the sediments. Support vessels and load barges likewise, anchor during certain circumstances when not mooring to the lift vessel itself. When jack-up barges and boats are utilized, similar sea bottom disturbances occur when the stanchion "feet" or "pads" are ratcheted down to the seabed and take on the load of the hull being lifted from the water.

Severance Activities

The severance activities involved with decommissionings have the potential to impact pipeline/cables in close proximity to the structure being removed. The pressures involved with explosive severance have the potential to damage nearby infrastructure. For buried lines and related components, the generally-unconsolidated sediments found in the area of the proposed action would act to dampen most of the pressure from a detonation since the material would provide poor energy transmission. For unburied infrastructure in water depths >200 ft (61 m), and/or when the explosive severance occurs AML, the increased hydrostatic "head" (i.e., overlying water pressure) serves to dampen the pressure generated by the detonation to a point where impacts are not expected (Young, 1972). Since most nonexplosive-severance tools are deployed methodically and possess cutting capabilities that are limited to the target alone (Chapter 1.4.6.1), no pipeline/cable impacts are expected to result from their use.

Progressive Transport

In instances where large structures are being removed in areas of increased water depth (>200 ft or 61 m) or when limited capacity of the lift vessel prevents the complete removal of the severed structure from the water, operators might choose the option of performing progressive-transport operations. During the operation, the structure is "deballasted" (i.e., made buoyant by forcing air into the tubulars), hoisted several to tens of feet from the seabed, lashed to the lift vessel, and then towed/propelled to shallower water (generally landward). At the new site, the structure is ballasted and set on the seabed, where the exposed section is severed and placed on the load vessel. The procedure is then repeated until a complete lifting can be accomplished. Impacts to pipelines and cables could occur either during the transport phase of the operations or when the structure is ballasted at the new location if pre-operation routing does not take the pipeline/cable infrastructure into consideration.

Sight-Clearance Trawling

After OCS structures are severed from the seabed and salvaged, operators are required to perform site-clearance work to ensure that the seafloor in and around the removal area is restored to prelease conditions. One option often used by operators involves trawling the salvage area with commercial nets and equipment to retrieve and remove any objects or obstructions (e.g., tools, containers, batteries, etc.) that may have been lost or discarded during the operational life of the structure. Similar to trawling activities conducted by commercial fishermen/shrimpers, the nets are attached to weighted wooden or metal "doors" that pull the net down to the seafloor as the entire assembly is drug behind a boat. The "footrope" attached to the bottom of the net is pulled taught between the doors with the forward motion of the vessel, dragging the rope along the seabed as the area is trawled. Cables, pipelines, and their components (e.g., valves, unions, and crossings) could be snagged and/or damaged by trawl doors and footropes. As discussed previously, if the damage leads to the release of hydrocarbons, there is the potential for serious environmental degradation and safety concerns.

Summary and Conclusions

The current hazard survey NTL No. 98-20 lists guidelines that operators are to follow that would minimize potential impacts for all OCS operations occurring near pipelines and cables. Procedures such as buoying proximal hazards/pipelines prior to anchoring activities, reduces the chance of contact and subsequent damage. Operators proposing (at anytime prior to or during decommissioning operations) use of progressive transport, will be required to perform pre-deployment surveys and reporting on the transport route and 'set-down' sites, noting the location of pipelines, cables, and other seafloor hazards. In addition, companies choosing the option of performing site-clearance via trawling will be required to follow the current site-clearance NTL No. 98-26, which includes instructions on avoiding contact with pipelines and cables in the vicinity of the removed structure. Therefore, conditional to the guidelines set forth by the MMS and the programmatic mitigation listed in Appendix F, no significant impacts to pipeline and cables are expected to result from the proposed action or the alternatives.

4.4.3. Impacts on Military Use, Warning, and Test Areas

Since the late 1970's, MMS has been incorporating stipulations into leases to help reduce potential conflicts between military and oil and gas activities. The Military Areas Stipulation is applicable to all three planning areas within the GOM and contains three clauses: (1) hold and save harmless (to protect the U.S. Government from liability in the event of an accident involving the military); (2) electromagnetic emissions (to reduce the impact of oil and gas activities on military communications and weapon operations); and (3) an operational clause (requiring notification of the military of upcoming oil and gas operations). To aid in notification and coordination between the lessees and the military, the Operational Clause lists commands responsible for each Military Warning and Water Test Area covered in the stipulation. For leases in the Mustang Island Area of the Western Planning Area, an additional military stipulation, Operations in the Naval Mine Warfare Area, is applied to ensure coordination between lessees and the Navy Mine Warfare Command prior to and during exploration and development activities. In the Eastern Planning Area, two other stipulations dealing with the Eglin Water Test Areas would require evacuation of facilities during emergency situations, and coordination with military authorities prior to exploration activities.

Ultimately, the guidance provided with the four stipulations has aided in allowing military operations and oil and gas activities to coexist without conflict or incident for over 25 years. Based upon the stipulations' effectiveness, decommissioning operations performed under the proposed action or the alternatives are not expected to have a significant impact on Military Use, Warning, or Test Areas.

4.4.4. Impacts on Navigation and Shipping

Through careful siting conditions and restrictions overseen by both the MMS and U.S. Army Corps of Engineers, the established safety fairways and anchorage areas within the GOM have remained virtually free of oil and gas structure emplacement. A few exceptions exist; however, decommissioning operations on structures within or in the vicinity of fairways are not expected to cause any impacts on navigation and shipping due to the limited and temporary nature of the activities. In contrast, removing structures near or within fairways could result in positive impacts such as improved vessel mobility and reduction of potential structure-vessel collisions. Since most GOM maritime traffic, oil and gas service vessels, recreational and commercial fishermen, and helicopters routinely use established platforms and facilities as navigation aids or "landmarks," some minor effects related to course disorientation could result from the structures' removal (USDOI, MMS, 1987). Overall, impacts to navigation and shipping resulting from activities conducted under the proposed action or the alternatives are not expected to be significant.

4.5. CUMULATIVE IMPACTS

The MMS has extensively addressed the cumulative effects of OCS- and non-OCS-related activities on the GOM OCS in recent multisale EIS's prepared for the Central and Western Planning Areas (USDOI, MMS, 2002) and the Eastern Planning Area (USDOI, MMS, 2003). Since the area of the proposed action is identical to that analyzed in the EIS's, this PEA incorporates by reference the OCS-related impact-producing scenarios (Chapter 4.1.1 (offshore)/Chapter 4.1.2 (coastal)), non-OCS-related impact-producing scenarios (Chapter 4.1.3), and cumulative impact assessments (Chapter 4.5) from the multisale documents. Tiering from the EIS information, the following cumulative impact analyses summarize the information on relevant cumulative effects, giving emphasis to the activities that are most likely to cause the most significant cumulative impacts; i.e., activities with the potential to produce similar effects to those of the proposed action.

4.5.1. Impacts on Air Quality

Cumulative impacts to air quality could occur from the proposed action (Chapter 4.2.1), OCS platforms/facilities and support vessels, non-OCS vessels (i.e., cargo, tanker, military, and commercial and recreational fishing/boating), and onshore/urban sources such as power generation plants and industry centers. Total OCS emissions in the WPA/CPA for the cumulative scenario are presented in Table 4-55 (USDOI, MMS, 2002) and total OCS emissions in the EPA for the cumulative scenario are presented in Table 4-43 (USDOI, MMS, 2003).

As noted in the EIS's cumulative impact assessments, platforms/facilities are the primary source of OCS emissions. Since the primary purpose of the proposed action is to allow for the removal of these structures from the GOM, the net effect of decommissionings would be a reduction of cumulative air quality impacts that would offset any short-term emission impacts from removal activities.

Based on the cumulative impact scenarios and assessments presented in the multisale EIS's, it is expected that the incremental contribution of potential impacts from decommissioning activities (i.e., emissions from support vessels, onshore and offshore operations, and explosions) would not result in significant cumulative impact on air quality on the GOM OCS.

4.5.2. Impacts to Water Quality

Coastal Waters

Cumulative impacts to coastal water quality could occur from the proposed action (Chapter 4.2.2.1), OCS and State oil and gas activities, infrastructure discharges, and all other sources that affect water quality, both natural and anthropogenic. Non-OCS sources include industrial, recreational, agricultural, and natural activities as well as oil and gas activities in State waters. Dredging activities and channel erosion stemmed from OCS support vessels as well as commercial fishing and shipping uses can add to the suspended load of coastal waters. Nonpoint-source discharges can affect coastal water quality, but they are currently not regulated and, therefore, data do not exist to evaluate the magnitude of their impact.

Marine Waters

Water quality in marine waters could also be impacted from the proposed action (Chapter 4.2.2.2) and by discharges from OCS (i.e., support vessels, platforms/facilities, drilling muds and produced waters, etc.) and non-OCS activities. Non-OCS sources that can impact marine water quality include bilge water discharges from large ships and tankers; pollutants from coastal waters that are transported away from shore, which includes runoff, river input, sewerage discharges, and industrial discharges; and natural seepage of oil and trace metals.

Cumulative impacts on the water quality of coastal and marine environments resulting from decommissionings are not expected to be significant as long as discharge criteria are met. As with air quality concerns, since the primary purpose of the proposed action is to allow for the removal of GOM structures/facilities, decommissionings would aid in reducing potential discharge sources, ultimately offsetting any minor, short-term impacts resulting from removal activities. Based on the cumulative impact scenarios and assessments presented in the multisale EIS's, it is expected that the incremental contribution of potential impacts from decommissioning activities (i.e., vessel discharges, resuspended sediments, and expended explosive-/nonexplosive-severance products) would not result in significant cumulative impact on the water quality of the GOM OCS.

4.5.3. Impacts on Marine Mammals

Cumulative impacts to marine mammals could occur from the proposed action (Chapter 4.3.1), other OCS activities, commercial fisheries, ship strikes, military activities (i.e., sonar use and ordnance detonation), live captures and relocations, habitat alteration, and pollution. The OCS activities that have the potential to impact marine mammals include the degradation of water quality resulting from operational discharges; service-vessel strikes; noise generated by platforms, drillships, and vessels; seismic surveys; oil spills; oil-spill response activities; loss of debris from OCS sources; commercial fishing; capture and removal; and pathogens.

Very few deaths are expected from oil spills, chance collisions with OCS service vessels, ingestion of plastic material, commercial fishing, and pathogens. Oil spills of any size are estimated to be recurring events that would periodically contact marine mammals. Impacts resulting from seismic surveys are expected to be minor or to not occur at all because of current mitigation measures. The U.S. military uses the GOM OCS for sonar operations and ordnance-detonation exercises that could release noise and shock waves that have the potential to harass, injure, or kill marine mammals. Exposure to sublethal levels of toxins and anthropogenic contaminants may stress animals, weaken their immune systems, and make them more vulnerable to parasites and diseases that normally would not be fatal. Collisions between cetaceans and ships, though expected to be rare events, could cause serious injury or mortality. In addition, commercial fishing activities accidentally entangle, injure, or drown marine mammals during fishing operations or by lost and discarded fishing gear.

Based on the cumulative impact scenarios and assessments presented in the multisale EIS's, it is expected that the incremental contribution of potential impacts from decommissioning activities (i.e., vessel strikes and explosive severance) would result in potentially adverse but not significant cumulative impacts on marine mammals on the GOM OCS.

4.5.4. Impacts on Sea Turtles

Cumulative impacts to sea turtles could occur from the proposed action (Chapter 4.3.2), other OCS activities, State oil and gas activity, ship strikes (i.e., from tanker, commercial, military, and recreational vessels), dredging operations, water quality degradation, natural catastrophes, pollution, recreational and commercial fishing, beach nourishment, beach lighting, power plant entrainment, and human consumption.

The OCS-related impacts include water quality and habitat degradation, trash and flotsam, vessel collisions, noise from seismic surveys, oil spills, and oil-spill-response activities. Sea turtles could be killed or injured by chance collision with service vessels or eating marine debris, particularly plastic items, lost from OCS structures and service vessels. The presence of, and noise produced by, service and seismic vessels and by the construction and operation of drilling/production rigs may cause physiological stress and make animals more susceptible to disease or predation, as well as disrupt normal activities. Contaminants in waste discharges and drilling muds might indirectly affect sea turtles through food-chain biomagnification. Oil spills and oil-spill-response activities are potential threats that may be expected to cause turtle deaths. Contact with, and consumption, of oil and oil-contaminated prey may seriously impact turtles. Sea turtles have been seriously harmed by oil spills in the past. The majority of OCS activities are estimated to be sublethal (behavioral effects and nonfatal exposure to intake of OCS-related contaminants or debris). Chronic sublethal effects (e.g., stress) resulting in persistent physiological or behavioral changes and/or avoidance of impacted areas could cause declines in survival or productivity, resulting in either acute or gradual population declines.

Similar to OCS operations, non-OCS-related impacts could also result from vessel collisions, water degradation, and trash/waste. The U.S. military uses the GOM OCS for sonar operations and ordnance-detonation exercises that could release noise and shock waves that have the potential to harass, injure, or kill sea turtles. In addition, Federal and State dredging activities have the potential for taking sea turtles from both the dredging apparatuses and pre-activity trawling activities designed to relocate animals in the vicinity of the operation. Similar impacts could occur from the potential entrapment, hooking, and entanglement in commercial fishing trawls, driftnets, and lines. Despite TED mandates for shrimp trawls and other guidelines placed on longline fishing and gillnets, commercial fishing remains the leading cause of sea turtle mortality in the GOM, with take estimates ranging in the thousands.

Based on the cumulative impact scenarios and assessments presented in the multisale EIS's, it is expected that the incremental contribution of potential impacts from decommissioning activities (i.e., vessel strikes, site-clearance trawling, and explosive severance) would result in potentially adverse but not significant cumulative impacts on sea turtles on the GOM OCS.

4.5.5. Impacts on Fish Resources, Commercial and Recreational Fishing, and Essential Fish Habitat

Cumulative impacts to fish resources, commercial and recreational fishing, and essential fish habitat could occur from the proposed action (Chapter 4.3.3), OCS and State oil and gas activities, dredging and discharge of dredged material, coastal development, crude oil imports by tanker, agricultural and urban run-off, marine bioinvasions, and commercial and recreational fishing. Finally, sources such as red tides and tropical storms may also add to the cumulative impacts on fish resources in the northern GOM.

Coastal Wetlands Loss

The effect of human activity on the coastal wetlands and habitat of the Gulf Coast has been substantial. Dahl (1990) reports that there has been a regionwide loss of over 50 percent (~35 million acres) of the Gulf States' wetlands since the 1780's. Besides direct alteration or destruction of habitat, substantial losses have occurred and continue to occur from point- and nonpoint-source pollution. Louisiana accounts for about 55 percent of the total area of vegetated coastal wetlands in the states bordering the Gulf of Mexico (Johnston et al., 1995) and 40 percent of all salt marshes in the lower 48 states (Coalition to Restore Coastal Louisiana, 2000). These wetlands provide critical habitat and food resources for Gulf of Mexico fisheries. The wetlands also serve as natural filters of sewage and other pollutants. Since the 1930's, more than 1 million acres of wetlands have disappeared from coastal Louisiana. Today, 25-30 square miles of land disappear each year. Most of the current wetland loss is because of altered hydrology due to navigation, flood control, mineral extraction, and transport projects. Studies show that over the last 50 years about 11 percent of coastal landloss in Louisiana is associated with oil and gas pipeline canals. Combined with the natural forces of subsidence and erosion, loss of coastal wetlands in the Gulf of Mexico is a serious problem facing the Gulf States, and this places at risk the fisheries that rely on the wetlands for habitat and food.

Offshore Oil and Gas Activities

As noted in the multisale EIS's, the GOM has one of the highest concentrations of oil and gas activities in the world (USDOI, MMS, 2002 and USDOI, MMS, 2003). Several activities associated with OCS exploration, production, and development may have adverse impacts on fish resources. The main impact-producing activities include

- structure commissionings;
- placing and removing pipeline infrastructure;
- support vessel traffic;
- anchoring, pipeline trenching, and other bottom-disturbing activities;
- offshore discharges of drilling muds and produced water; and
- accidental petroleum spills.

The resulting impacts to fish and fish resources include lethal and sublethal effects because of pollution from oil spills and discharges, habitat loss or degradation because of bottom-disturbing activities such as those associated with structure removals and implacements, and erosion or saltwater intrusion associated with vessel traffic and pipeline canals along the coast and wetlands of the Gulf of Mexico. The MMS anticipates that the existing onshore infrastructure is sufficient to handle current and future exploration, development, and production of Gulf of Mexico oil and gas resources and that the placement of new pipelines coming to shore is designed to cause no net loss of wetlands.

Non-OCS Activities

The GMFMC (GMFMC, 1998) identified several activities that impact Gulf Coast wetlands and EFH:

- extraction of underground water and oil and gas resulting in faulting and subsidence of coastal wetlands;
- ship channel construction and maintenance;
- dredging and filling associated with residential, commercial, and industrial development;
- accidental spills of oil and toxic and hazardous chemicals;

- deliberate illegal dumping that impacts bays and estuaries;
- loss of seagrass beds because of prop-scarring and grounding of recreational fishing vessels;
- bottom trawling resulting in increased turbidity and bottom substrate destruction and change;
- construction of dams causing changes in timing, volume, and quality of freshwater inflows to estuaries and bays;
- construction of levees resulting in blocked or restricted river flow in natural distributary delta channels, which provide barrier islands and the delta plain with delta-building sediments;
- construction and maintenance of casinos and ports;
- tourism-associated beach expansion that buries nearshore hard-bottom habitat;
- point-source discharges from industry, wastewater treatment plants, power plants, septic tank leachates, and stormwater runoff;
- marine bioinvasions that alter community structure; and
- global warming, which may cause sea-level rise, stronger and more frequent tropical storms, coral reef bleaching, exacerbation of the "dead zone" phenomenon, and conditions that are unfavorable to several native fish and shellfish species.

Several fish stocks in the GOM are depressed. Given the current state of some fish populations in the GOM, the cumulative impacts of all anthropogenic and nonanthropogenic activities and phenomena have had a significant impact on fish resources of the Gulf. Unfortunately, it is difficult to apportion the reasons for a fishery's decline among overfishing, habitat degradation, pollution, ocean climate change, and natural variability of the population. The 1996 amendments to the MFCMA address sustainable fisheries and set guidelines for protecting marine resources and habitat from fishing- and nonfishing-related activities. Also, resource management agencies, both State and Federal, set restrictions and permits in an effort to mitigate the effects of development projects, industry activities, and commercial and recreational fishing. The Federal and State governments are also funding research and coastal restoration projects. It may take decades of monitoring to ascertain the long-term feasibility of these management and restoration efforts.

Based on the cumulative impact scenarios and assessments presented in the multisale EIS's, it is expected that the short-term, incremental contribution of potential impacts from decommissioning activities (i.e., vessel discharges, explosive severance, and habitat removal/salvage) would not result in significant cumulative impact on fish resources, commercial and recreational fishing, and essential fish habitat of the GOM OCS.

4.5.6. Impacts on Benthic Resources

Cumulative impacts to benthic resources could occur from the proposed action (Chapter 4.3.4) in addition to routine OCS activities such as vessel anchoring, structure and pipeline emplacement, drilling discharges, discharges of produced waters, and discharges of domestic and sanitary wastes. In addition, accidental subsea oil spills or blowouts associated with OCS activities can cause damage to benthic organisms. Non-OCS-related impacts, including commercial fisheries (bottom trawling), recreational boating and fishing, import tankering, and natural events such as extreme weather conditions, and extreme fluctuations of environmental conditions (e.g., nutrient pulses, low dissolved oxygen levels, and seasonal algal blooms) also have the potential to impact benthic resources.

Impact-producing factors resulting from OCS activities are not expected to adversely impact benthic resources if the factors are restrained by the continued implementation of protective lease stipulations, site-specific mitigations, and NTL guidelines. Since these stipulations/guidelines would prevent the installation of platforms and pipelines in the immediate vicinity of sensitive areas, there is little probability that a subsurface oil spill would impact the resources. Physical damage and resuspended sediments resulting from non-OCS influences would lack the frequency of OCS actions, but they may be equal in severity.

Based on the cumulative impact scenarios and assessments presented in the multisale EIS's and the potential effectiveness of protective NTL's and lease stipulations, it is expected that incremental contribution of potential impacts from decommissioning activities (i.e., vessel anchoring, progressive transport, site-clearance trawling, and sediment redistribution) would not result in significant cumulative impact on benthic resources on the GOM OCS.

4.5.7. Impacts on Archaeological Resources

Cumulative impacts to historic and prehistoric archaeological resources could occur from the proposed action (Chapter 4.4.1), other OCS activities, bottom trawling, sport diving, commercial treasure hunting, and tropical storms. Specific OCS activities considered in the EIS analyses include drilling rig and platform emplacement, seismic surveys, pipeline emplacement, anchoring, oil spills, dredging, and ferromagnetic debris. Aforementioned requirements such as archaeological surveys, analyses, and clearances necessary prior to beginning oil and gas activities on the GOM OCS are expected to be highly effective at identifying potential archaeological resources and preventing their disturbance. Commercial fishing activities such as bottom trawling are expected to increase sediment disturbance at, and potential damage to, unknown resource locations; however, it is not expected to exceed disturbances caused by storms/wave-generated forces.

Based on the cumulative impact scenarios and assessments presented in the multisale EIS's, it is expected that incremental contribution of potential impacts from decommissioning activities (i.e., vessel anchoring, progressive transport, site-clearance trawling, and explosive-severance impacts) conducted in accordance with MMS guidelines would not result in significant cumulative impact on historic/prehistoric archaeological resources on the GOM OCS.

4.5.8. Impacts on Pipelines and Cables

Cumulative impacts to pipelines and cables could occur from any bottom-disturbing activities resulting from the proposed action (Chapter 4.4.2) and other OCS activities such as support vessel/barge anchorage, drilling operations, geological surveying, structure commissioning, and additional pipeline/cable emplacements. Non-OCS-related impacts would include commercial and recreational fishing (primarily bottom trawling) and vessel anchorage (i.e., cargo, tanker, military, and commercial and recreational fishing), in addition to nonanthropogenic impacts such as tropical storms and geologic-seafloor events (i.e., faulting, slumping, etc). Current pipeline/cable burial guidelines for infrastructure in less than 200 ft assist in reducing the likelihood of either an OCS or non-OCS impact. In the shallower GOM areas, the burial requirements also help to prevent damage during storms.

Based upon the effectiveness of MMS's hazard survey NTL (No. 98-20) on OCS operations and current burial requirements, it is expected that the incremental contribution of potential impacts from decommissioning activities (i.e., support vessel transport, severance activities, and salvage operations) would not result in significant cumulative impact on pipelines and cables in the GOM.

4.5.9. Impacts on Military Use, Warning, and Test Areas

Cumulative impacts to military use, warning, and test areas could occur as a result of the proposed action (Chapter 4.4.3), OCS activities and support vessels, and non-OCS vessels (i.e., cargo, tanker, military, and commercial and recreational fishing/boating). While utilizing the use, warning, and test areas, the military has provided sufficient coordination to deal with non-OCS vessel traffic. In addition, MMS has been incorporating lease stipulations to help reduce potential conflicts between military and all OCS oil and gas activities, which has aided in allowing military operations and oil and gas activities to coexist without conflict or incident for over 25 years.

Based on past military coordination and the effectiveness of MMS's lease stipulations, it is expected that the incremental contribution of potential impacts from decommissioning activities (i.e., support vessel transport, severance activities, and salvage operations) would not result in significant cumulative impact on military use, warning, and test areas in the GOM.

4.5.10. Impacts on Navigation and Shipping

Minor impacts to navigation and shipping could occur as a result of the proposed action (Chapter 4.4.4). Since nearly all OCS surface structures that could qualify as a "landmark" or "navigation aid" would fall under MMS jurisdiction, any "course disorientation" impacts would be solely attributed to the proposed action. In addition, for structures/facilities sited near or within shipping fairways and anchorages, the proposed action would result in the advantageous removal of obstructions that would improve vessel mobility and reduce potential structure-vessel collisions for all OCS users.

It is therefore expected that the incremental contribution of potential impacts from decommissioning activities (i.e., temporary support vessel anchorage and "landmark" removal) would not result in significant cumulative impact on navigation and shipping in the GOM.

5. CONSULTATION AND COORDINATION

5.1. RECENT/EXISTING CONSULTATION EFFORTS

In 1988, MMS requested formal consultation from NOAA Fisheries pursuant to Section 7 of the ESA concerning potential impacts on endangered and threatened species associated with explosive-severance activities conducted during structure-removal operations. The NOAA Fisheries issued a BO and ITS for the consultation (commonly called the "generic" consultation) on July 25, 1988, limiting "takes" to the five species of sea turtle found on the shallow shelf. In addition to a maximum charge limit of 50 lb and minimum reporting guidelines, specific mitigation measures to be conducted prior to severance detonations included (1) the use of qualified NOAA Fisheries observers, (2) aerial surveys, (3) detonation delay radii, (4) night-time blast restrictions, (5) charge staggering and grouping, and (6) possible diver survey requirements.

While preparing this PEA, in June 2003, MMS requested that NOAA Fisheries establish a minimum or "de minimus" explosive weight limit of 5 lb to reflect the decreased impact zone and limited mitigation needed to ensure adequate protection of MPS. The MMS believed that a "de minimus" limit would provide industry with an incentive to design and use smaller but more efficient shaped-explosive charges. The Southeast Regional Office (SERO) of NOAA Fisheries entered into an informal Section 7 consultation with MMS and issued a second BO on October 10, 2003, offering industry the opportunity to reduce mitigation and conduct their own predetonation monitoring (in lieu of NOAA Fisheries staff and aerial surveys) if they use explosive charges of 5 lb or less. According to ESA regulations and guidelines noted in the BO's, a new consultation must be reinitiated if

This PEA will become the primary resource for a new formal, ESA, Section 7 consultation (50 CFR 402.14) on explosive-severance and site-clearance trawling activities. The 1988 "generic" and 2003 "de minimus" consultations (both effective at the time of this printing) will be replaced with a single/new BO and ITS reflecting the updated information presented in this document when the consultation is complete.

In 1989, the American Petroleum Institute (API) petitioned NOAA Fisheries under Subpart A (§228) of the MMPA for the incidental take of spotted and bottlenose dolphins during structure-removal operations. The Incidental Take Authorization regulations were promulgated by NOAA Fisheries in October 1995 (60 FR 53139, October 12, 1995), and on April 10, 1996 (61 FR 15884), the regulations were moved to Subpart M (50 CFR 216.141 *et seq*.). Effective for five years, the take regulations detailed conditions, reporting requirements, and mitigative measures similar to those listed in the 1988 ESA BO requirements for sea turtles. After Subpart M expired in November 2000, NOAA Fisheries and MMS advised operators to continue following the guidelines and mitigative measures of the expired subpart pending a new petition and subsequent regulations. At the prompting of industry, NOAA Fisheries released Interim regulations (Subpart M) in August 2002, which expired on February 2, 2004 (67 FR 49869, August 1, 2002).

5.2. DEVELOPMENT OF THE PROPOSED ACTION

On January 11, 2002, MMS held a public meeting on structure-removal activities in New Orleans, Louisiana, following its 21st Annual GOM Information Transfer Meeting (ITM) and announced that the agency would begin gathering information for use in the development of this PEA, a MMPA incidental-take regulation petition, and ESA consultation work. The meeting was attended by the public, representatives of the oil and gas industry, decommissioning contractors, environmental consultants, academics, and regulatory scientists from MMS and NOAA Fisheries. Attendees assisted in identifying current decommissioning issues and concerns, potential mitigation, and preliminary scoping on future removal requirements. Industry and agency contacts were established for subsequent coordination, and tasking was assigned for specific information related to potential targets, blasting requirements, and activity projections.

During the preparation of this PEA, MMS also contracted several decommissioning-related reports and forecasting studies necessary to gather additional information on removal activities and its potential impacts on the marine environment. Under NOAA Fisheries guidance and using the best-available science, MMS engaged two separate firms to prepare modeling studies related to the pressure/acoustic propagation of explosive-severance activities and its estimated-take projections on GOM marine mammals. Table 5-1 lists the study/report work employed by MMS for the preparation of this PEA.

Table 5-1

Studies/Reports Funded by MMS for the Preparation of the Structure-Removal Operations PEA

Study/Report/(Citation)	Preparer(s)	Primary Information
Shock Wave/Sound Propagation Modeling Results for Calculating Marine Protected Species impact Zones During Explosive Removal of Offshore Structures (Dzwilewski and Fenton, 2003)	Applied Research Associates, Inc. (ARA)	The associated UnderWater Calculator (UWC) model for back-calculating range (radii) for threshold values in peak pressure and acoustic energy.
Explosive Removal Model Simulation Report (Frankel and Ellison, 2004)	Marine Acoustics, Inc. (MAI)	Application of Acoustic Integration Model (AIM) for three-dimensional acoustic propagation and marine mammal movement modeling to estimate "take" of marine mammals incidental to explosive-severance activities.
Operational and Socioeconomic Impact of Non-Explosive Removal of Offshore Structures (TSB and CES, LSU, 2004)	Twachtman, Snyder, and Byrd, Inc. (TSB) and Center for Energy Studies, Louisiana State University (CES, LSU)	General decommissioning processes, nonexplosive-severance tools, processes involved in progressive transport (i.e., jacket-hopping), and economics related to and driving nonexplosive severance.
Explosive Removal of Offshore Structures — Information Search and Synthesis Report (CSA, 2004)	Continental Shelf Associates, Inc. (CSA)	Explosive-severance methodology and information on regulations, physics, and potential negative impacts of explosive use in the marine environment.
Modeling Structure Removal Processes in the Gulf of Mexico (Kaiser et al., in preparation)	Center for Energy Studies, Louisiana State University	Statistical descriptions of GOM structure-removal processes/explosive-severances and model development discussions and results for projecting removal activities.

An additional project developed and managed by MMS's Technology Assessment and Research (TAR) Program, *Oil Platform Removal Using Engineered Explosive Charges: In Situ Comparison of Engineered and Bulk Explosive Charges*, involved the development and testing of small, linear-shaped charges for severance operations (Saint-Arnaud et al., 2004). Staff from MMS GOMR, in coordination with NOAA Fisheries acousticians, was able to work with TAR and the project contractors in modifying the testing phase of the operation to include shock wave and acoustic properties measurement. Staff participation was also used in the preparation of an appendix (Annex B) to the final TAR report comparing the in-situ measurements with calculated ARA UWC results (Appendix C of this PEA). The comparison data was critical in establishing the ARA UWC as a viable model for this PEA's marine mammal and sea turtle analyses (Chapters 4.3.1 and 4.3.2) and related take-estimation work and mitigation development (Appendixes E and F).

Working in coordination with industry representatives from the OOC and with guidance from MMS, the three primary GOM explosive-severance contractors (e.g., DEMEX, ESI, and JRC) developed the *Explosive Technology Report for Structure Removals in the Gulf of Mexico* (DEMEX, 2003). In addition to descriptions of target structures, explosive-charge designs, suggested mitigation, and general safety concerns, the ETR provided MMS with industry/contractor recommendations for blasting categories (minimum and maximum charge sizes) and methodologies necessary to address current and future severance needs. The ETR information was reviewed by NOAA Fisheries and MMS and considered when developing the explosive-severance and mitigation scenarios covered under this proposed action.

During MMS's 22nd Annual GOM ITM in January 2003, two additional public sessions were held to discuss decommissioning-related issues and concerns. The sessions provided attendees opportunity to review and comment on (1) the previously-mentioned studies, reports, and modeling; Session 1B—Explosive Removal of Offshore Structures (EROS) Studies, and (2) potential mitigation for explosive-severance activities; Session 1E—Explosive Removal of Offshore Structures (EROS) Experimental Mitigation Measures. All of the related session presentations, study details, and presenter biographies can be found in the ITM Proceedings (McKay and Nides, 2004).

5.3. NOTICE OF PREPARATION OF AN EA AND COMMENTS RECEIVED

On August 16, 2003, a "Notice of Preparation of a Programmatic Environmental Assessment for Structure Removal Operations in the Gulf of Mexico" was published in the *Federal Register* (68 FR 18670). The Notice contained a general discussion of the severance and salvage activities covered in the PEA, invited public comment concerning additional items or issues that should be addressed in the assessment, and provided contact/comment submittal information. A similar public notice was posted on MMS's Internet website (http://www.gomr.mms.gov/homepg/regulate/environ/nepa/nepaprocess.html) and published in the following Gulf States' newspapers:

- Biloxi (Mississippi) Sun Herald;
- Galveston (Texas) County Daily News;
- Houma (Louisiana) Daily Courier;
- Houston (Texas) Business Journal;
- Mobile (Alabama) Register;
- Morgan City (Louisiana) Daily Review;
- New Orleans (Louisiana) Times-Picayune; and
- Pensacola (Florida) News Journal.

The 30-day comment period on the Notice of Preparation ended on May 16, 2003, during which time, MMS received three sets of comments from (1) the LADEQ, (2) the Gulf Restoration Network (GRN — an environmental protection organization), and (3) the Louisiana Department of Natural Resources (LADNR). Both the LADEQ and the LADNR comments centered on remarks that established oil and gas structures contribute to the marine environment of the northern GOM by providing important habitat for a multitude of invertebrate, fish, sea turtle, and marine mammal species. Because of the environmental benefits, the LADEQ commenter also suggested that none of the OCS structures should be removed. The GRN comments centered on the procedural aspects of a NEPA analysis and suggested that MMS prepare an EIS instead of an EA because of the proposed action's potential to cause significant impact. In addition, the GRN commenter suggested that the PEA's analyses consider multiple alternatives, protected species and habitat impacts, effective mitigation, and indirect/cumulative impacts. All of the comments received by MMS were reviewed and taken into consideration during the development of the proposed action and in the PEA's preparation.

5.4. COOPERATING AGENCY AGREEMENT

To aid in the review of PEA information pertinent to the MMPA incidental-take petition and ESA Consultation reinitiation, MMS entered into a Cooperating Agency Agreement (CAA) with NOAA Fisheries on March 10, 2004. Defined under CEQ regulations at 40 CFR 1501.6, the CAA will also allow for efficient tiering/adoption of the PEA by NOAA Fisheries into the NEPA process required under MMPA rulemaking procedures. Ultimately, the CAA aided MMS's PEA preparation by involving

NOAA Fisheries' reviewers possessing special expertise concerning marine mammals, underwater acoustics, and other protected marine resources. As the lead agency, MMS's primary CAA responsibilities included the following:

- setting up and holding any public/Subject-Matter-Expert (SME) meetings related to the PEA;
- preparing all sections of the PEA;
- providing working-draft copies of PEA sections for NOAA Fisheries review; and
- considering all NOAA Fisheries comments during preparation of the final document.

As the cooperating agency, NOAA Fisheries' primary CAA responsibilities included the following:

- reviewing/commenting on PEA sections, making every effort to comply with the PEA schedule;
- participating, as deemed appropriate, in any public/SME meetings related to the PEA; and
- retaining the ability to comment on the PEA once released to the general public.

In addition to providing document review and guidance in the development of many of the aforementioned reports/projects, protected-species scientists from NOAA Fisheries' Headquarters and SERO participated in an Explosive-Severance Mitigation Workshop held in New Orleans on May 11-12, 2004. Organized by MMS as a SME meeting, attendees also included explosive-severance contractors, industry representatives, and MMS engineers and scientists. The purpose of the workshop was to present, discuss, and substantiate mitigation necessary to adequately protect MPS during explosive-severance activities performed for structure decommissionings. The suggested monitoring and survey methodologies and associated time requirements agreed upon by the SME's were taken into consideration during the development of this PEA's programmatic mitigation (Appendix F).

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Appendix A

Explosive-Severance Activity Projections

Explosive-Severance Activity Projections

Introduction

The Minerals Management Service (MMS), in the course of preparing this programmatic environmental assessment (PEA), has determined that the pressure wave and acoustic energy generated by the detonation of explosive-severance charges are the primary impact-producing factors on marine protected species (MPS). To assess the impacts of these activities in the PEA's analyses and during subsequent Endangered Species Act (ESA) Consultation efforts, MMS had to estimate the annual number explosive-severance activities that could occur as a result of the proposed action. Since PEA information will also be used to petition for incidental-take regulations under Subpart I of the Marine Mammal Protection Act (MMPA), estimates also had to be projected over a standard rulemaking cycle of 5 years.

Explosive-severance activities, as described under the proposed action, are grouped into five blasting categories (e.g., very small, small, standard, large, and specialty). Since the level of detonation pressure and energy is primarily related to the amount of the explosives used, the categories were developed based upon the specific range of charge weights needed to conduct current and future Gulf of Mexico (GOM) Outer Continental Shelf (OCS) decommissionings (Chapter 2.2.1). Depending on the design of the target and other variable marine conditions, the severance charges developed under each of these categories could be designed for use in either a below-mudline (BML) or above-mudline (AML) configuration. These factors, combined with an activity location within either the shelf (<200 m) or slope (>200 m) species-delineation zone, results in 20 separate severance scenarios (Table A-1).

Table A-1

Blasting Category Parameters and Associated Severance Scenario Numbers

Blasting Category	Charge Range	Configuration	Species-Delineation Zone	Scenario Number
Very-Small Blasting	0-10 lb	BML	Shelf (<200 m)	A1
			Slope (>200 m)	A2
	0-5 lb	AML	Shelf (<200 m)	A3
			Slope (>200 m)	A4
Small Blasting	>10-20 lb	BML	Shelf (<200 m)	B1
			Slope (>200 m)	B2
	>5-20 lb	AML	Shelf (<200 m)	B3
			Slope (>200 m)	B4
Standard Blasting	>20-80 lb	BML	Shelf (<200 m)	C1
			Slope (>200 m)	C2
	>20-80 lb	AML	Shelf (<200 m)	C3
			Slope (>200 m)	C4
Large Blasting	>80-200 lb	BML	Shelf (<200 m)	D1
			Slope (>200 m)	D2
	>80-200 lb	AML	Shelf (<200 m)	D3
			Slope (>200 m)	D4
Specialty Blasting	>200-500 lb	BML	Shelf (<200 m)	E1
			Slope (>200 m)	E2
	>200-500 lb	AML	Shelf (<200 m)	E3
			Slope (>200 m)	E4

There are currently over 4,000 bottom-founded, "platform" structures (e.g., jacketed platforms, caissons, and well protectors) and 29,500 well-related structures in the area of the proposed action. Several complicated and often unpredictable factors need to be considered when projecting their decommissioning needs. In order to best integrate these factors to determine impending removals (i.e., within 1-5 years) and their related severance methodologies, MMS reviewed (1) historical trends, (2) industry projections, and (3) forecasting models. Ultimately, since past and current regulations limit most of the proposed action's explosive-severance activities, the scenario projections presented in this appendix were made with the assumption that permissive MMPA/ESA conditions would be established.

Historical Trends

During the past 10 years (1994-2003), there has been an average of 156 platform removals per year, with over 60 percent using explosive-severing tools (Table A-2). In addition, many of the older, nominally-producing structures in the mature GOM fields are beginning to near decommissioning age; subsequently lending to an increase in removal operations. Despite advancements in nonexplosive-severance methods and increased public concern for MPS protection, MMS expects explosive-severance activities to continue being used in at least 63 percent of all platform removals for the foreseeable future.

Table A-2

Platform Removals from 1994 to 2003 (Source: MMS Data)

Severing Method	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Average / Year
Nonexplosive	44	42	101	79	48	67	52	48	42	55	58 (37%)
Explosive	120	120	55	113	42	80	102	69	165	118	98 (63%)
Total / Year	164	162	156	192	90	147	154	117	207	173	156 (100%)

Well removal activities are much more difficult to quantify. Unlike platform removals, which are permitted and strenuously tracked under MMS's data management system, well removals often occur as secondary projects under permanent well plugging and abandonment (P&A) activities or left after P&A work to be ancillary targets during associated platform-removal operations. Even though limited severance method information exists, MMS's database indicates that an average of 534 permanent P&A activities have occurred annually since 1994 (Table A-3).

Table A-3

Permanent Well Abandonments from 1994 to 2003 (Source: MMS Data)

Well Type	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Average / Year
Exploratory	308	232	330	406	240	341	386	317	338	363	326 (61%)
Development	197	165	240	278	215	191	239	223	134	192	207 (39%)
Total / Year	505	397	570	684	455	532	625	540	472	555	533 (100%)

Though presently infrequent due to current limitations and mitigation, a number of exploratory well severances were once performed with explosives in instances where the drilling unit moved off-site immediately after encountering a "dry hole" and/or accomplishing initial P&A work – a practice often conducted during periods of peak drilling rig demand. To avoid the mobilization costs required for a second "workover rig" to reenter and sever the well using a mechanical cutter, explosive contractors utilized divers or remotely operated vehicles (ROV's) to place the charge into the subsea well (i.e., terminating in the water column) for the required BML severance. During the years when this practice was most common, contractor records indicated that approximately 17 percent of well severances may have been conducted with explosive cutters. Applying this percentage to the permanent P&A activity rates (with standard deviation applied for ranges), MMS estimates that 72-105 explosive well severances could occur annually requisite to new MMPA/ESA conditions.

Industry Projections

To attain the operators' perspective on potential targets and scenario projections, MMS queried GOM explosive-severance contractors and industry representatives for details concerning the blasting categories outlined under the proposed action. Most of the information was presented to MMS in the *Explosive Technology Report for Structure Removals in the Gulf of Mexico* (DEMEX, 2003). Individual companies provided follow-up information such as current/past activity rates, mitigation suggestions, and severance projections via workshops, subject-matter-expert meetings, and or activity-specific reports. In addition to information related to platform and well severances, explosive contractors indicated the potential need for approximately 4-8 mooring (i.e., chains, cables, tendons, lines, etc.) and pipeline-related (i.e., lines, valves, unions, manifold assemblies, etc.) explosive severances – primarily for, though not limited to, emergency operations. As noted earlier, the scenario estimates reviewed by MMS were provided by the contractors/industry representatives presuming that permissive regulations would be promulgated.

Forecasting Models

In 2002, MMS contracted Louisiana State University's Center for Energy Studies (CES) to prepare a modeling report, *Modeling Structure Removal Processes in the Gulf of Mexico*, addressing platform-removal forecasting needs (Kaiser et al., in preparation). The framework for most of the modeling was difficult to develop because most of the important factors involved with decommissionings are not observable and often impossible to incorporate. These unquantifiable variables include the direct/indirect costs, human safety concerns, environmental issues, the potential "cost of failure," operator/contractor experiences and preferences, scheduling, and the configuration and reliability of the cutter itself. Despite caveats, several effective methodology and economic-based models were developed and analyzed in the report. The primary projections from the report's "pessimistic" and "optimistic" forecasting models (Section 1.3.4; Kaiser et al., in preparation) were reviewed to determine annual averages and ranges for each of the five-year periods, and the results for the two most concurrent/applicable periods are presented in Table A-4.

Table A-4

Projected Number of Platform-Removal Operations Using Explosive Severing Tools

Forecasting Model I ("Pessimistic")					
Forecast Period	Caissons	Well Protectors	Jacketed Platforms	Period Total	Annual Period Average
2002-2006	111	73	288	472	94
2007-2011	152	63	386	601	120
Forecasting Model II ("Optimistic")					
Forecast Period	Caissons	Well Protectors	Jacketed Platforms	Period Total	Annual Period Average
2002-2006	199	105	494	798	160
2007-2011	232	106	502	840	168
Annual Range for Forecast Period					
2002-2006 94—160					
2007-2011 120—168					

From *Modeling Structure Removal Processes in the Gulf of Mexico* (Kaiser et al., in preparation).

Conclusions

Based upon a review of the historical trends, industry projections, and recent forecast modeling, MMS estimates that between 170 and 273 explosive-severance activities would occur annually. Table A-5 lists the estimated ranges of each explosive-severance scenario as a total of either platform (i.e., caisson, well protector, and jacketed platform), well (i.e., well-, pipeline-, and mooring-related targets), or combined (i.e., platform/well) annual averages.

Table A-5

Explosive-Severance Projections for the Proposed Action

Explosive-Severance Scenario	Annual "Platform" Severance Projections		Annual "Well*" Severance Projections		Annual "Combined" Projection Totals	
	(low)	(high)	(low)	(high)	(low)	(high)
A1	13	18	9	13	22	31
A2	2	5	1	2	3	7
A3	8	12	3	5	11	17
A4	3	6	1	2	4	8
B1	14	20	19	24	33	44
B2	4	8	3	4	7	12
B3	5	9	4	7	9	16
B4	2	6	1	2	3	8
C1	22	35	20	26	42	61
C2	4	9	2	4	6	13
C3	8	13	4	6	12	19
C4	2	5	3	5	5	10
D1	5	8	4	8	9	16
D2	0	1	1	3	1	4
D3	1	2	1	2	2	4
D4	0	1	0	0	0	1
E1	1	2	0	0	1	2
E2	0	0	0	0	0	0
E3	0	0	0	0	0	0
E4	0	0	0	0	0	0
Total	**94**	**160**	**76**	**113**	**170**	**273**

* Well projections include pipeline and mooring severances.

Ultimately, several unquantifiable decision factors and the lack of pertinent, well-related data make the accurate projection of explosive-severance scenarios difficult and somewhat speculative. The reporting requirements recommended under Appendix F, *Programmatic Mitigation for the Proposed Action*, would ensure that future data collection is afforded; concurrently providing MMS with an indicator as to the accuracy of the projections. Future data collection and review of the actual scenario trends would also give MMS decisionmakers the opportunity to readdress affected analyses and dependent rulemaking/consultation efforts.

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Appendix B

Shock Wave/Sound Propagation Modeling Results for Calculating Marine Protected Species Impact Zones During Explosive Removal of Offshore Structures

Synopsis:

This appendix comprises a study prepared for the Minerals Management Service (MMS) on modeling the detonation pressure and energy released during explosive-severance activities conducted during structure decommissionings. The propagation model developed under this study was used by MMS to calculate impact zones critical to protected species analyses and mitigation planning found in this programmatic environmental assessment (PEA). This information is also necessary for subsequent Marine Mammal Protection Act (MMPA) take-authorization rulemaking and Endangered Species Act consultation assessment.

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A copy of this report and Excel®-based propagation model can be attained from the Public Information Office of MMS's Gulf of Mexico OCS Region at the following address:

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
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1.0 INTRODUCTION

The explosive removals of offshore structures (EROS) impact marine life. In order to assess that impact adequately, a methodology is needed that accurately models the shock effects caused by the detonation of an explosive charge below the mud line (typically 15 feet) inside a pile, leg, conduit or other structural element. Current methodologies do not take the effects of an explosive detonating below the mud line and the pile leg confinement into consideration in determining shock characteristics in the water at distances. This effort investigated the reduction of energy transmitted to the water resulting from the below-the-mud-line detonation inside a pile or leg. A method was developed that calculates the effectiveness of the explosive as a function of the pile diameter and wall thickness, and the weight of explosive used.

In the sections below, the approach is given (2.0), the literature review is summarized (3.0), the range of parameters is defined (4.0), the calculational matrix is presented (5.0), the results of the baseline and parametric numerical simulations are given (6.0 and 7.0, respectively), the analysis and model development are described (8.0), underwater shock calculational methods are discussed (9.0), the use of the model is demonstrated (10.0), this research work is summarized (11.0) and, lastly, recommendations are given (12.0).

2.0 APPROACH

The approach was to simulate the various pile, explosive, clay, and water conditions numerically with the CTH shock propagation code (McGlaun et al., 1990) to understand the phenomenology of explosive detonations below the sea floor and in offshore structural elements such as piles. From these studies, the effects of explosive burial and pile attributes on the coupling of explosive energy to the water were determined. The end result was that an explosive efficiency factor was defined for each case. For example, if a 50-lb. explosive below the mud line inside of the pile coupled 40% of the energy as a 50-lb. explosive in free water, then the explosive efficiency factor would be 40%. Using the explosive efficiency factor, the user would use 40% of the explosive weight, in this case 20 lb., in calculating the peak pressure, impulse, and energy flux density using free-water equations or other methods.

The steps defined for this approach were:

- Conduct a literature review to obtain relevant experimental data and studies.
- Determine the range of parameters that were varied in the numerical simulations.
- Develop the calculational matrix.
- Perform the numerical simulations.
- Analyze the results and develop the models that describe the shock environment (peak pressure, impulse, and energy flux density) in the water.

Each of these steps will be discussed below.

3.0 LITERATURE REVIEW SUMMARY

A literature review was conducted to develop an understanding of the problem, to see what has and is being done in this field, and to help plan the project. The bibliography that was developed is presented in Appendix A.

Underwater blasting is a practice that is well documented in available literature and scientific journals. The mechanical and physical effects of explosive detonation are well known for both the air and water. Shock wave propagation is accurately described by theory and can be understood through the use of shock propagation computer simulation codes such as CTH, as described by McGlaun et al. (1990). In this journal article, the authors describe the intended purpose of computer code and the types of problems that have been examined with this Sandia National Laboratories software tool. A thorough monograph on numerical modeling of explosive detonation can be found in Mader (1979). Mader describes the results of numerical modeling of the detonation process for condensed explosives. Mader's work was performed at Los Alamos National Laboratories over the last three decades. A more conventional and complete treatment of underwater explosions may be found in Cole (1948). Cole provides the fundamentals of underwater shock physics and documents the assumptions and their respective limitations.

Ward et al. (1998) concentrated on sound propagation and attenuation, in particular the modeling of continuous wave and pulse propagation characteristics for different types of sound sources in a range of environments that are typical of the northeast Atlantic. The studies of Ward used techniques from Yelverton et al. (1973) and Swisdak (1978). Yelverton conducted a number of tests to determine the far-field underwater blast effects on mammals and birds using Pentolite-TNT explosive charges up to 8 lbs. at 10 foot depths. Swisdak compiled a large amount of experimental information into one report for the use of creating similitude equations for peak pressure, impulse, time constants, and energy flux density as a function of scaled range for a number of different explosive sources. Range is scaled relative to the weight of the explosive charge. Swisdak's work used the same methodologies as Cole (1948).

Young (1991) conducted experiments that applied shock pressures on various types of fish for developing injury prediction models. These studies showed that cube-root scaling was valid for close-in distances from a charge, but at greater distances the effects of surface rarefaction waves and seabed reflections may play a more dominant role and should be considered when making predictions at large distances.

Goertner (1982) conducted a study to determine the ranges at which sea mammals would be injured by underwater explosions. The purpose was to provide guidance for explosive removal and testing. A computer program was developed under his study that is similar to the type of predictive tool this report describes. The driving equations were based on the scaling of data developed by Yelverton et al. (1973).

This literature review shows the abundance of underwater shock studies for free-water explosions. Much important information was gleaned from this literature review. However, this review shows little work reported on underwater explosions, which included the influence of explosive detonation below the mud line and pile confinement of explosives. The Connor (1990) study did show a reduction in explosive effectiveness in developing water shock. The measured pressure, impulse, and energy flux density were less than would be expected for a free-water explosion for half-scale experiments and full-scale offshore structure removal operations. The lack of a robust method to account for the actual conditions encountered in off-shore structure removal led us to select a range of parameters for a numerical study that would allow the determination of an effective explosive weight based on the operational environment of the explosive.

4.0 RANGE OF PARAMETERS

Important underwater blasting considerations include, but are not limited to, types of explosives and their properties; energy releases from underwater explosions - amplitude, duration, frequency, pressure, impulse, energy flux density; charge weight and configuration, scaling laws of underwater blasting; details and properties of the structural element to be removed; wave propagation mechanisms - spherical, cylindrical and planar wave propagation; and, measuring equipment and its calibration.

The range of parameters for this study was developed based on the literature and input from MMS staff, as well as Mr. Russell W. Wilcox of DEMEX Explosive Products & Services. These parameters were used as input for the numerical simulations of the near-field explosive effects and subsequent energy coupling to the water.

The major parameters for this study are:

Soil:	Soft clay and stiff Beaumont clay
Explosive Weight:	25, 50, and 100 lbs.
Explosive Type:	C-4 / Cyclotol
Explosive Shape:	Bulk and toroid
Detonation Point:	15 feet below mud line
Pile Material:	Steel
Pile Diameter:	24", 36", 48", and 72"
Pile Wall Thickness:	¾", 1½" and 2½"

5.0 CALCULATIONAL MATRIX

A total of eighteen numeric simulations were performed to quantify the effects of the pile/mud/explosive configuration on the water shock. This selected set of runs was chosen to cover a wide range of typical conditions to facilitate the model development while limiting the number of calculations because of the relatively short duration of this project. A high fidelity numeric simulation is costly in time of setup and execution. Therefore, we chose a select group of simulations that would sufficiently answer our questions. All simulations were computed using a C-4 explosive, which has nearly the same explosive performance as Cyclotol (their explosive release energies are within 2½% of each other). A 15-foot explosive burial depth was used for all numerical simulations.

All the numeric simulations were performed with the CTH Eulerian hydrocode, which was developed at Sandia National Laboratories. This code handles complex one-, two-, and three-dimensional geometries for shock propagation problems, and non-linear material properties. It is a first principle finite difference code that uses conservation of mass, momentum, and energy along with equations-of-state and strength models for the various materials. The geometry and materials are modeled in a discretized grid. For these calculations, the two-dimensional cylindrical (i.e., axisymmetric) grid contained approximately 130,000 cells. The code uses an explicit solver, meaning that it solves the problem for a single time step (that is automatically determined based on shock properties of the simulation to ensure numeric stability) and marches forward in time until the specified end time is reached. The time step ranged from 3 to 8 microseconds, and the typical CTH numerical simulation took 3 to 8 hours on a 1-GHz Linux workstation.

Five numeric simulations were performed for free water or mud (i.e., no pile) as listed in Table 1. These simulations basically show the variation of shock characteristics caused by a bulk charge weight within water at a selected location for measurement. The single soil-only numerical simulation was performed to isolate the effect of the soil on the shock propagation into water.

Table 1. Free-water and Soil Numerical Simulations.

Medium	Explosive Weight, lbs.			
	12.5	25	50	100
Free water	X	X	X	X
Soil			X	

Table 2 shows the thirteen calculations that were done for the pile cases. This set of simulations was run to understand the effects of pile geometry and properties for the various charge weights.

Table 2. Pile Numerical Simulations

Pile Wall Thickness (inches)	Pile Diameter (inches)			
	24	36	48	72
¾	25 lb.			
1½ 1½ 1½ 1½	50 lb.	50, 100 lb. 50 lb (soft clay) 50 lb. (water) 50 lb. (toroid)	100 lb.	100 lb.
2½		50, 100 lb.	100 lb.	100 lb.

To separate the effects of the soil and the pile, one calculation was done without a pile (50 lbs, Table 1) and another calculation was done with a pile but without soil (50 lb., 36" diameter, 1½" wall thickness, Table 2). One calculation was done with a toroidal charge instead of a bulk charge to investigate any differences in energy coupling to the water caused by the explosive charge shape (50 lb., 36" diameter, 1½" wall thickness, Table 2). One calculation was done with the pile in soft clay while the others were done in stiff clay.

6.0 BASELINE NUMERICAL SIMULATIONS

The first four simulations were designated as baseline simulations whose objectives were to gain an understanding of the phenomena and isolate the factors that affect the amount of energy coupled into the water.

The four baseline calculations were:

1. 50-lb. explosive – free water
2. 50-lb. explosive – stiff clay (no pile)
3. 50-lb. explosive – pile and water (no clay)
4. 50-lb. explosive – pile in clay, and water

These near-field calculations extended from the explosive charge to approximately 30 m in each direction. The 30 m distance was chosen to be more than twice (2.3 X) the extent of the strong shock or nonlinear region as cited in Richardson et al. (1995) and Ward et al. (1998). Each calculation was run out to a simulation time of 20 to 25 ms, which is the time it takes for the shock wave to propagate 30 to 37 m through water. The energy coupled to the water was monitored, as well as the pressure, impulse, density, particle velocity, temperature, and other thermodynamic variables at various points in the calculational grid.

The material plots (left) and the pressure fields (right) at a time of 15 ms are shown for the free-water calculation in Figure 1, the clay calculation in Figure 2, the pile in water calculation in Figure 3, and lastly, the pile in clay calculation in Figure 4. The general appearance of the pressure fields for the four baseline calculations is similar, in that the pressure field shows a spherical divergent wave propagating from the detonation point and an explosive cavity forming. The free water case has higher pressures at the shock front than the other cases. The kinetic energy coupled to the water is compared in Figure 5. Here the differences in the four numerical simulations are clearly shown. Note the decrease of the kinetic energy at a time around 20 ms is caused by water passing out of the calculational grid as the boundaries were set as transmitting. The free-water case has the highest energy, while the case with the explosive detonating in clay (no pile) shows about a 20% decrease. The case with the pile in water reveals the kinetic energy to be approximately 50% below that of the free-water case. This demonstrates that the pile has a stronger influence on the water coupling than just the clay. Lastly, kinetic energy for the pile in clay is reduced by approximately 60%.

The explosive coupling efficiencies that were defined by dividing the kinetic energy coupled into the water for each simulation by the kinetic energy for the free water case for the four baseline calculations are shown in Table 3. Interestingly enough, if the efficiency for the clay only case (79%) is multiplied by the efficiency of the pile in water only case (49%), one obtains the efficiency for this combined case of the pile in the clay (39%). The implication is that the effects can be identified, isolated, and quantified.

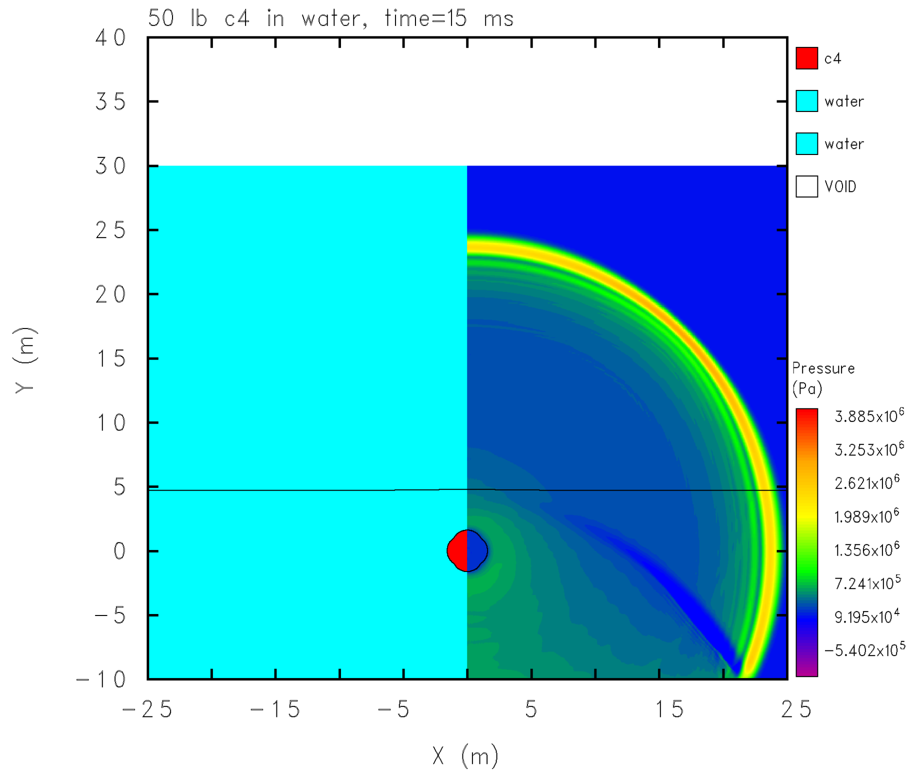

Figure 1. Material and Pressure Field for 50-lb C-4 Free-water Calculation at 15 ms.

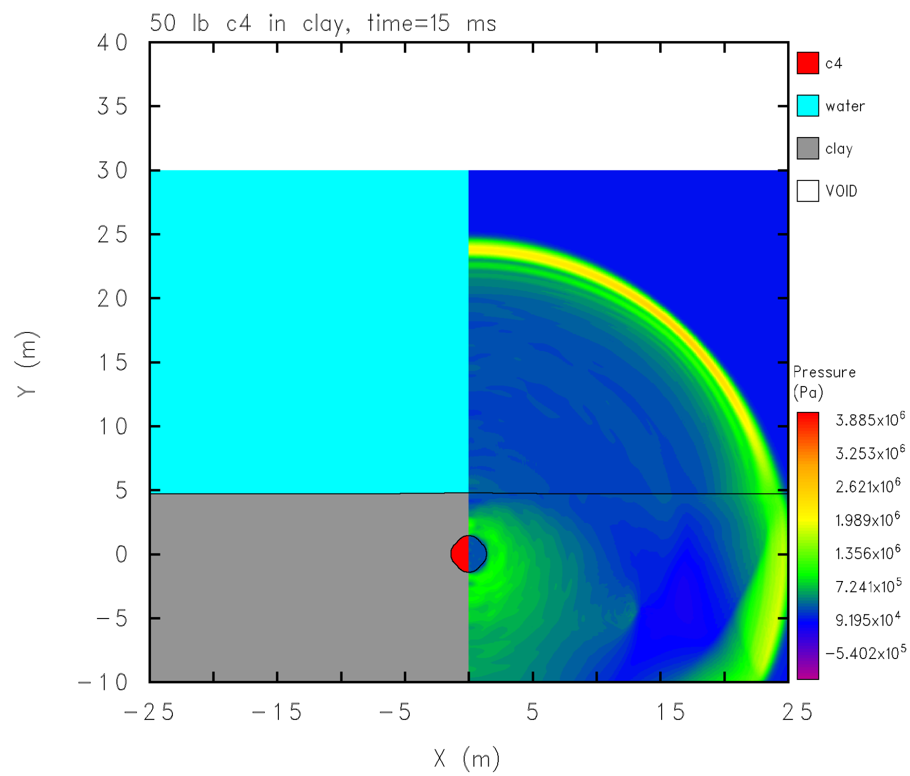

Figure 2. Material and Pressure Field for 50-lb C-4 Free-water Clay Only Calculation at 15 ms.

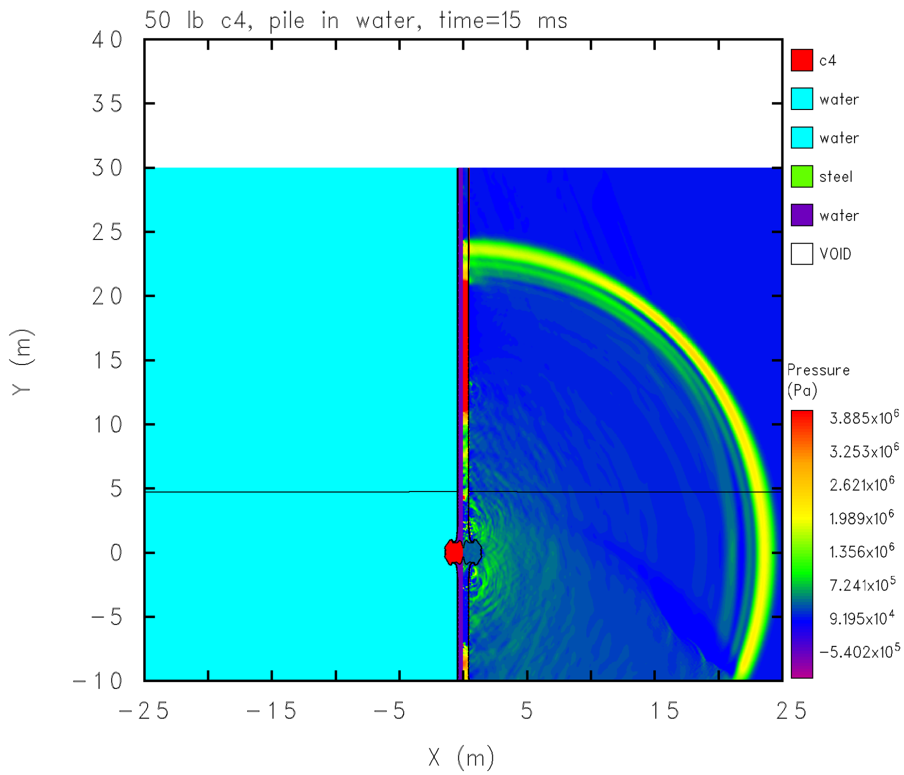

Figure 3. Material and Pressure Field for 50-lb C-4 Pile in Water Calculation at 15 ms.

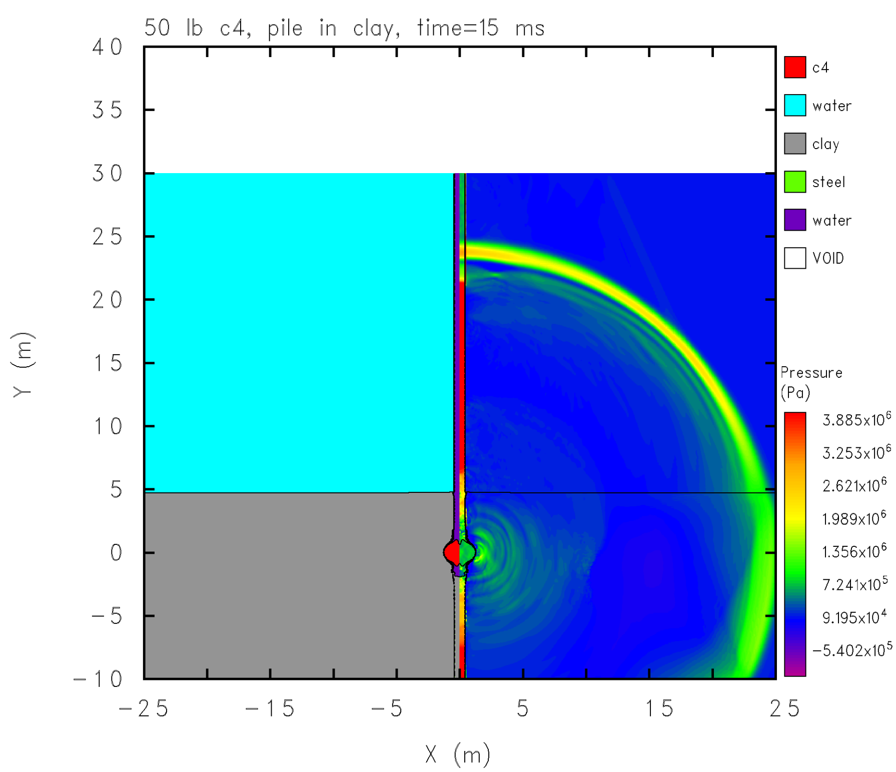

Figure 4. Material and Pressure Field for 50-lb C-4 Pile in Clay Calculation at 15 ms.

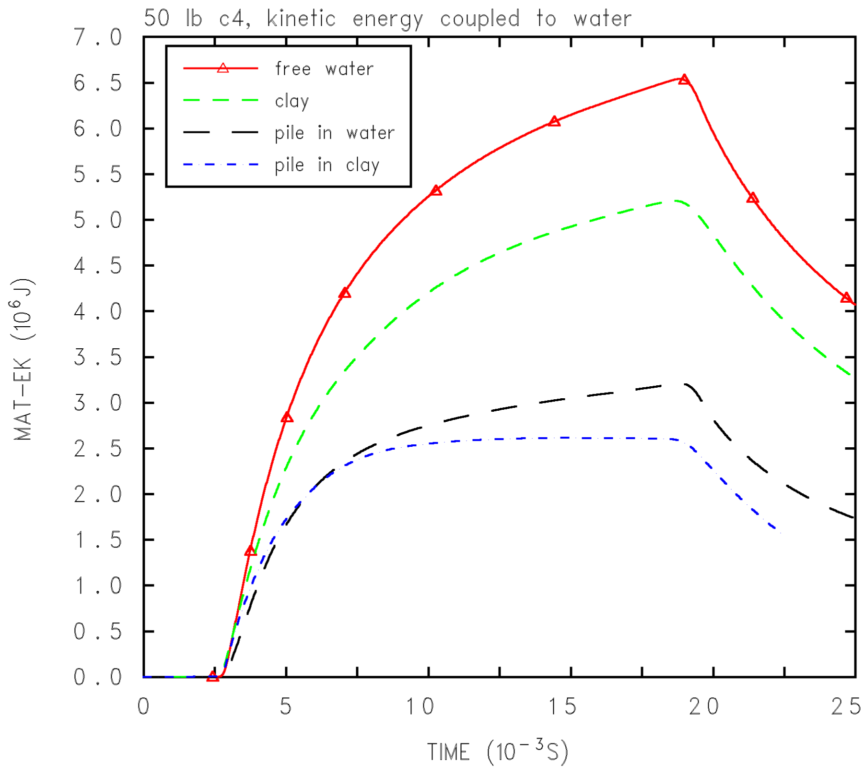

Figure 5. Comparison of Kinetic Energy Coupled into the Water for Baseline Numerical Simulations.

Table 3. Explosive Coupling Efficiencies for the Four Baseline Numerical Simulations – 50-lb. Explosive Weight.

Numerical Simulation	Explosive Coupling Efficiency
Free water	100%
Stiff Clay (no pile)	79%
36” diameter, 1½” wall thickness in water (no clay)	49%
36” diameter, 1½” wall thickness in clay	39%

The pressure and impulse time histories at a range of 20 m are compared with the baseline calculations in Figure 6 and Figure 7, respectively. The pressure waveforms in Figure 6 show that these calculations with confinement caused by clay and/or pile have lower peak pressures than the free water case. More significantly, the pressure drops off faster, as can be more dramatically seen in the impulse comparisons in Figure 7. The clay only calculation shows some reduction in impulse, while the pile in water and pile in clay cases show a very significant reduction in impulse. This drop in impulse is another indication of reduced energy coupling and lower effective explosive weight.

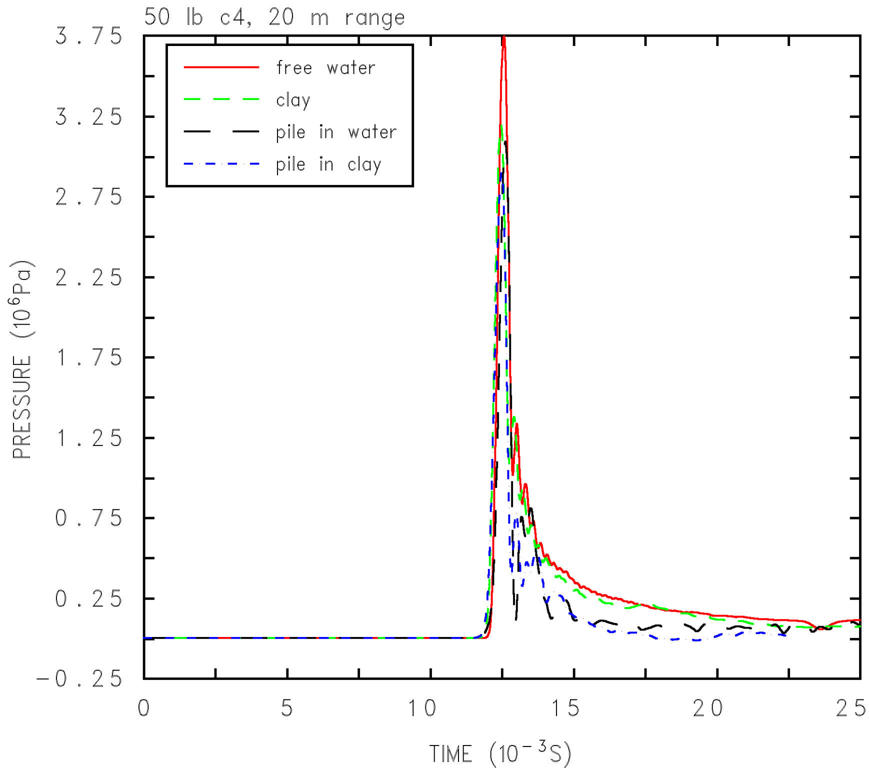

Figure 6. Comparison of Pressure Time Histories at the 20-Meter Range.

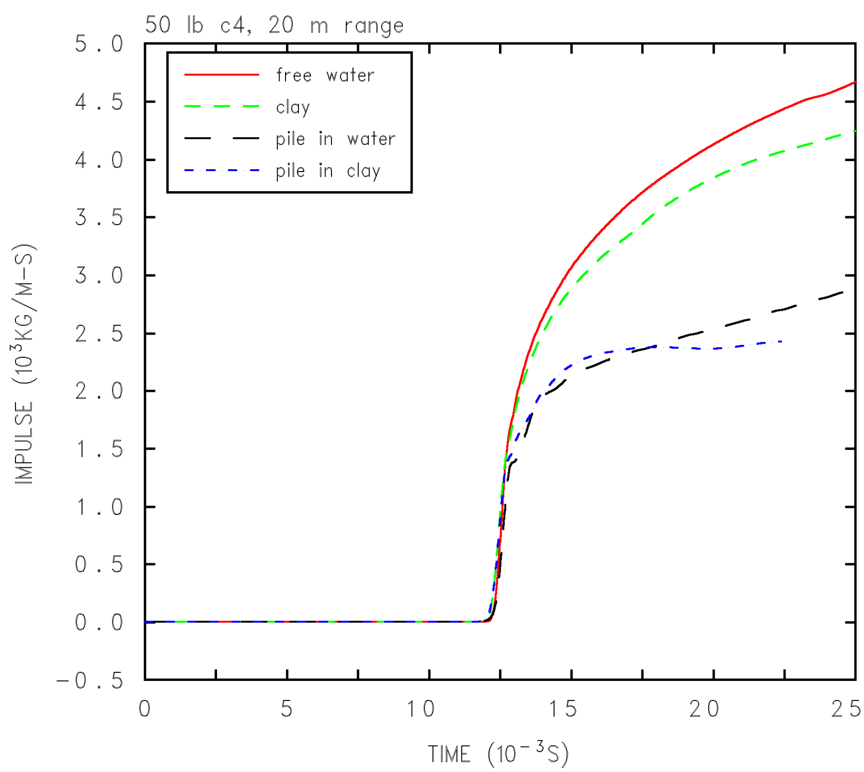

Figure 7. Comparison of Impulse Time Histories at the 20-Meter Range.

From Table 3, the pile in clay case has a 40% explosive coupling efficiency, or 60% less energy than the free water case. In order to investigate this finding more, comparisons of this pile in clay simulation were made to 12.5-, 25-, and 50-lb C4 free water calculations. The kinetic energy comparisons are presented in Figure 8, while the pressure and impulse time histories are compared in Figure 9 and Figure 10, respectively. These comparisons support the idea that a pile in clay scenario couples less energy to the water continuum than a free-water explosion and that the reduction in coupled energy is 50% or greater, in this case, being approximately 60%. Put another way, the pile in clay case coupled 40% of the free-water explosion case.

These simulations showed that a reduction of coupled energy into the water was dominated by the pile influence and soil confinement. Both pile and soil confinement offer inertial and strength effects which need to be overcome by the explosive prior to explosive energy deposition into the water. The pile confinement has a greater effect than the soil due to the higher strength and density of the pile material. The numerical simulations also indicate that some energy loss is due to explosive energy propagating in the water inside the pile (typically less than 5%).

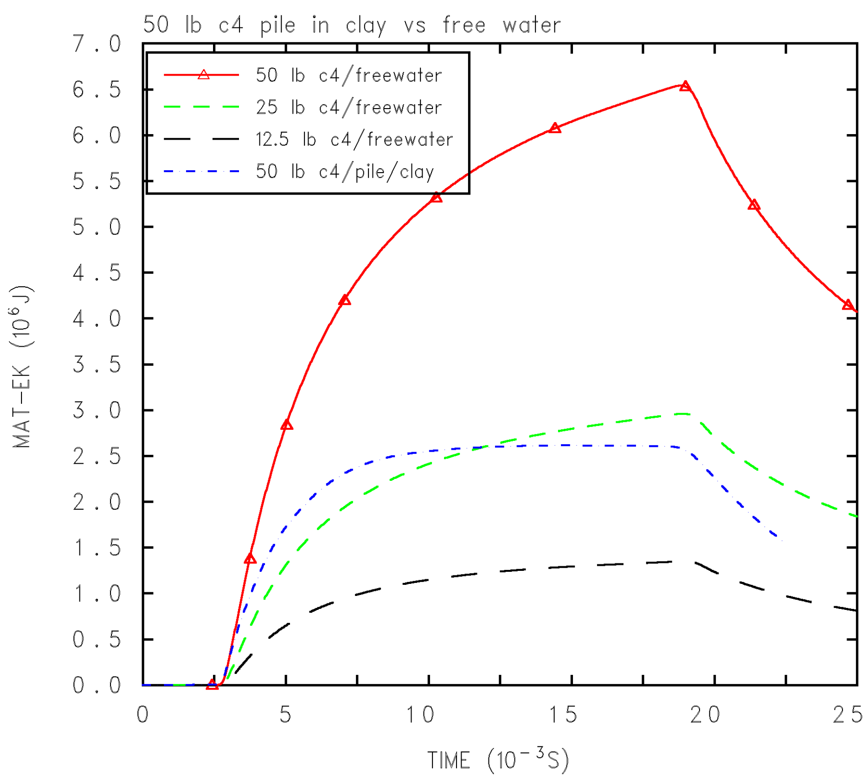

Figure 8. Kinetic Energy Coupled into the Water for Pile in Clay and Free-water Numerical Simulations.

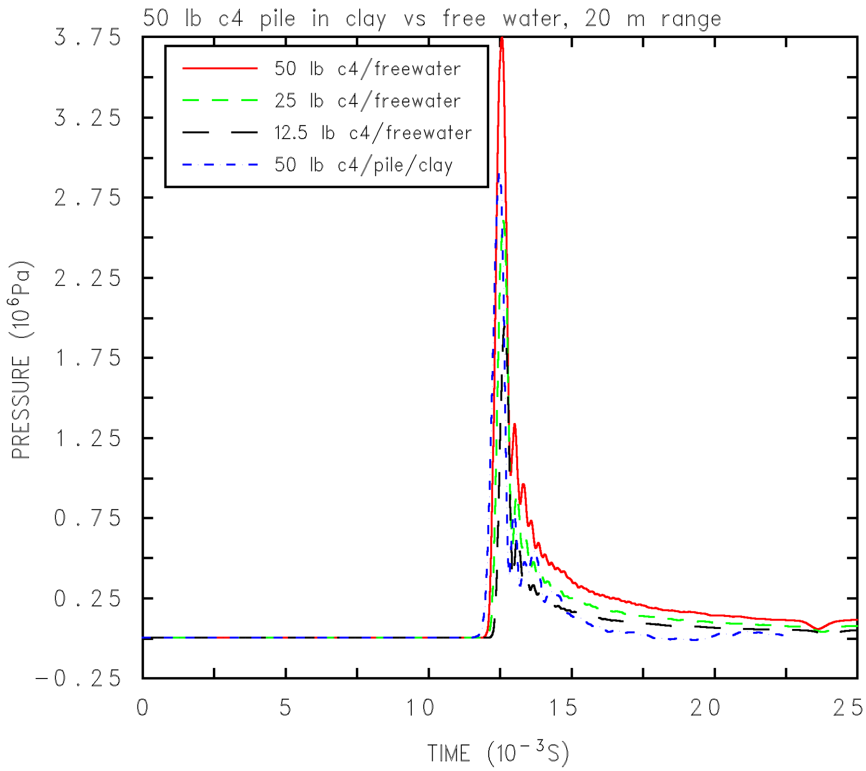

Figure 9. Pressure Time Histories for Pile in Clay and Free-water Numerical Simulations.

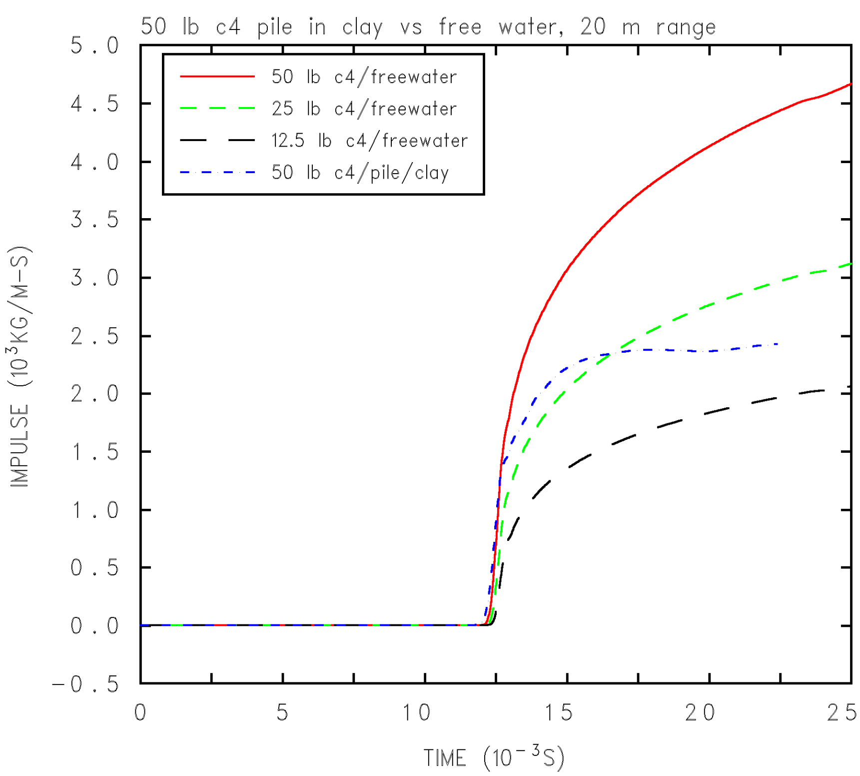

Figure 10. Impulse Time Histories for Pile in Clay and Free-water Simulations.

7.0 PARAMETRIC NUMERICAL SIMULATIONS

To further define the explosive coupling efficiency over a broader range of pile diameter, wall thickness, clay strength, and explosive weight, numerical simulations were performed for the conditions previously given in Table 2. Note this was a parameter study and the explosive amount for a particular pile presented here is not necessarily the optimum or recommended value.

The results of these numerical simulations were analyzed in a similar way to the baseline calculations presented in the previous section. The energy coupling efficiency was calculated by dividing the coupled energy to the water by the appropriate free water value. The resulting energy coupling efficiencies are presented in the parametric variations in Table 4. A 3% difference between the coupling efficiencies of a bulk charge to that of a toroidal charge for the same pile geometry is shown in Table 4. This small difference is caused by the toroidal charge being closer to the pile wall and thus is able to deliver more energy into the surrounding water. Also, the use of a soft clay model which is less dense, more compressible, and had about one-third of the strength of the stiff clay caused a 4% increase in the energy coupling to the water.

Table 4. Explosive Coupling Efficiencies for Pile Geometry in Clay Numerical Simulations.

Pile Wall Thickness (Inches)	Explosive Weight (lb.)	Pile Diameter (Inches)			
		24	36	48	72
¾	25	45%			
1½	50	44%	39%		
	50 (soft clay)		43%		
	50 (toroid)		41%		
	100		48%	51%	62%
2½	50		26%		
	100		35%	36%	53%

The trend that is shown in Table 4 is that more energy is coupled into water for thinner pile walls, larger pile diameters, and higher explosive weights. These findings will be quantified more fully in the analysis and modeling section, which follows.

8.0 ANALYSIS AND MODEL DEVELOPMENT

The main result of the parametric numerical simulations was the determination of the amount of energy coupled to the water and, hence, the explosive coupling efficiency for the various pile scenarios (Table 4). The next step was to develop a model for the explosive coupling efficiency as a function of the pile attributes and the amount of explosive.

On the basis of thin-walled pressure vessel theory, in which the hoop stress is directly proportional to the internal pressure and radius (or diameter) and inversely proportional to wall thickness, we developed the pile parameter, p, as follows:

$$\text{Pile parameter, } p = \frac{w \cdot d}{t} \qquad [1]$$

where: w = explosive weight, lbs.
d = pile diameter, inches
t = wall thickness, inches

We then plotted the explosive coupling efficiency versus the pile parameter, p, as shown in Figure 11. The data show that there is approximately a linear relationship to the three pile wall thicknesses that were studied. We fit a line to the points and came up with the following equation:

$$\text{Explosive coupling efficiency } (\%) = 34.37 + 0.005 \cdot p \text{, with } R^2 = 0.664 \qquad [2]$$

There is some scatter in the results shown in Figure 11. This scatter is also indicated by the coefficient of determination (R^2) indicating that 66.4% of the uncertainty has been explained by the linear fit. The reason for this scatter is caused by the fact the piles were not severed to the same degree. Some walls were easily breached by the explosive while others did not fail as catastrophically. The pile parameter that we chose was just one of many possible. However, the form makes sense physically. More energy is coupled with increasing charge weight (the strength of the pile is over matched), increasing pile diameter (increased forces that the pile must resist), and decreasing wall thickness (higher stresses). As a side note, when the 1½-inch pile wall thickness results are plotted alone, a much better linear fit is obtained (R^2 = 0.9134) than when all the results are plotted together. The 1½-inch wall thickness data is banded more tightly and is more linear than the results for 2½-inch wall thickness numerical simulations. The lower coupling efficiencies for the 2½-inch wall thickness and lower explosive weight cases are caused by the increased pile confinement, which results in less catastrophic breaching.

The upper bound for the explosive coupling efficiency for 50 lbs of explosive buried 15 feet below the mud line should be approximately 80%, as that is the value for the clay only, no pile case (Table 3).

Having established the energy coupling factor for a particular pile configuration, the next step is to multiply the actual explosive charge weight by the explosive coupling efficiency and use the resulting reduced explosive weight to calculate the water shock using free-water methods. These methods are discussed in the next section and a spreadsheet calculator that we developed is described.

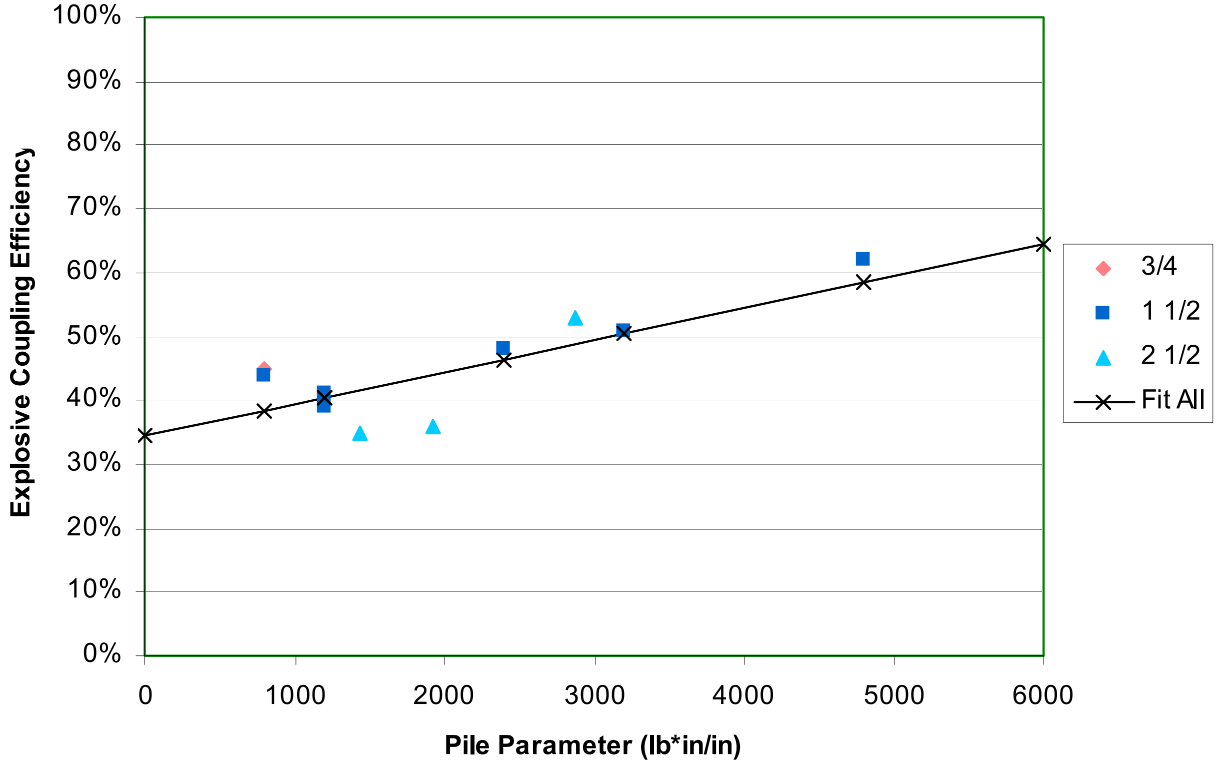

Figure 11. Relationship between the Explosive Coupling Efficiency and the Pile Parameter $\left(w \cdot \dfrac{d}{t}\right)$.

9.0 METHODS OF UNDERWATER SHOCK CALCULATION

This section describes the various ways the underwater shock event can be modeled for determining peak pressure, impulse, and energy flux density at range for an underwater explosion. Exploring these methodologies helped us better understand the limitations of each method. It is our goal to create a simple tool that offers accuracy and flexibility. However, "simple" means assumptions have been made and are applied to reduce the complexity and simplify use. The simplified tool is based on well-documented similitude equations and has been compared against other, more sophisticated methodologies, the most sophisticated of which is the computational continuum mechanics methodology. "Hydrocodes" such as CTH are numerical computational continuum mechanics tools that simulate the response of both solid and fluid material under such highly dynamic conditions (e.g., detonation and impact) that shock wave propagation is the dominant feature. The hydrocode approach to solving shock wave related problems makes few simplifying assumptions and thus offers the greatest complexity and greatest challenge to easy use. The other numerical method is the analytical wavecode. Analytical wavecodes such as REFMS (Britt et al., 1991) employ empirically derived relations and robust mathematical approximations to simulate the shock propagation environment. The analytical wavecode offers much less complexity than the hydrocode approach. Codes such as REFMS have been validated on a wide variety of underwater shock problems and used with much success. However, a significant level of sophistication to this method exists and limits the ease of use.

The comparison of the above described methods ensures that the simple tool is adequate for calculation purposes. The various methodologies will be further explained in the following sub-sections after discussion of some simplifying assumptions for all methods. The assumptions will allow all the methods to correlate.

9.1 Simplifying Assumptions for All Methods

Figure 12 shows the major wave types considered that affect pressure at a point in the water. The first wave in the water caused by a blast is the direct pressure wave or shock. The upper wave in Figure 12 shows its rapid rise and exponential-like decay. After some additional time there will be a rarefaction wave from the water-air interface. The reflection off the water-air interface is negative, caused by displacement of the surface. The air-water surface reflection is of nearly the same amplitude as the shock wave, because of the shock impedance mismatch with air. As shown in Figure 12, the air-surface reflection arrives later than the direct shock arrival because of the added distance traveled in reflection. The arrival time of the surface reflection depends upon geometric relationship of the explosive source, water-air interface, and the receiver.

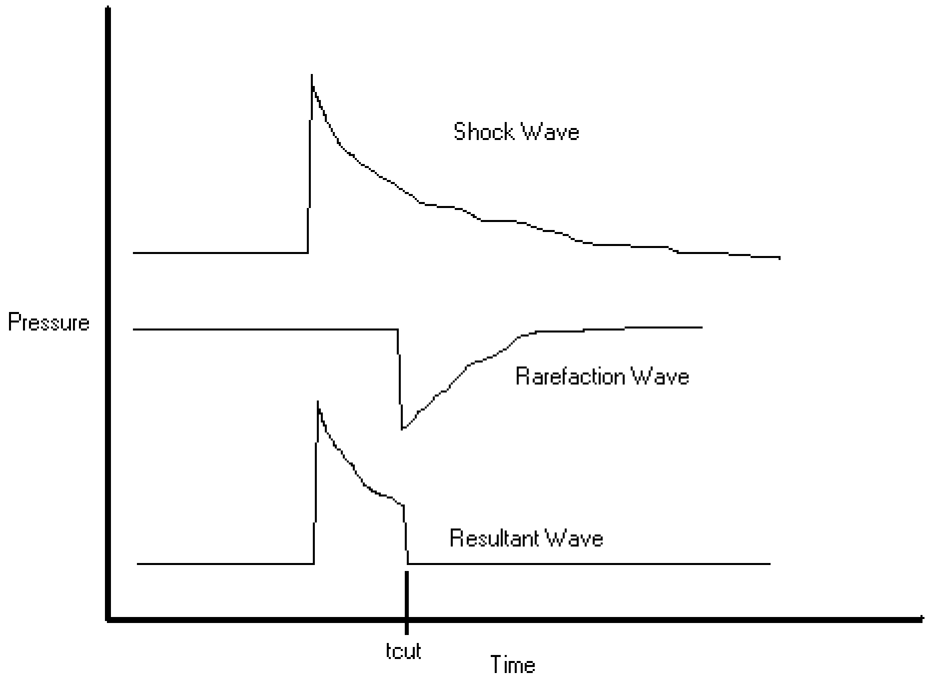

Figure 12. Superposition of Shock Waves.

The effects of the bottom surface, other structures, and other phenomena in and around the explosive source are not considered in this investigation. The bottom surface, however, is not a perfect reflector. The bottom surface absorbs shock energy. Typically, the amplitude of the wave reflected from the bottom surface is less than the direct shock wave. We are considering the amplitude of this wave to be in the same positive sense as the direct shock but much lower in value. Therefore, we are considering the bottom reflections as negligible for this study. The other shock interactions caused by the explosive event are much later in time. This study does not show possible multiple reflections between the air surface and the bottom, nor arriving bubble sphere peaks. We are only considering the shock interactions within the five or so time constants of the direct shock pulse.

9.2 Numerical – CTH Hydrocode

CTH is a first principle finite difference code that uses conservation of mass, momentum, and energy, along with equations-of-state and strength models to solve a defined explosive problem. This code was briefly described above in the Calculational Matrix Section (5.0). CTH is used to model the detonation and mechanical confinement of the explosive detonation products for an underwater pile configuration. The user has the ability to place sensors within the calculation to record pressures, impulse, and energy, as well as other parameters as a function of time at various ranges. The CTH is best suited to model the near field phenomena, i.e., the details of the explosive pile, clay, and water interaction. CTH was used in this study to understand the coupling of explosive energy into the water. On the basis of the results from CTH, we were able to develop an effective explosive yield for underwater pile explosions.

9.3 Similitude Equations - Spreadsheet Calculator

The pressure from an explosive detonation takes on a decreasing exponential form with respect to time. Depending on the distance from the blast, the pressure outside the explosive rises to a maximum pressure, Pm, in a very short time frame, usually that of several microseconds. The work of Cole (1948) and Swisdak et al. (1978) have demonstrated that the pressure as a function of time at some location from the explosive event will have the following form

$$P(t) = P_m e^{-(t/\theta)} \qquad [3]$$

P_m is the initial maximum pressure and θ is the time constant. The time constant is the time over which the pressure-time history can be approximated with an exponential decay. Over practical ranges of interest, it has been empirically established that shock wave pressures decay at later times more slowly than that of an exponential decay (Swisdak et al., 1978). The pressure decline is closer to a linear decrease. The spreadsheet uses an exponential decay for the first 1.5 time constants of the pressure pulse, then a linear decay out to a calculated end time.

Swisdak et al. (1978) provide the equations for the parameters of the above pressure history equation [which are in metric units].

$$P_m = K \cdot (W^{1/3} / R)^{\alpha} \quad \text{(MPa)} \qquad [4]$$

$$\theta = K_2 \cdot W^{1/3} (W^{1/3} / R)^{\alpha_2} \quad \text{(ms)} \qquad [5]$$

The above equations use the slant distance, *R*, in meters, pressure in MPa, time in milliseconds (ms), and explosive weight in kilograms. The coefficients shown (K, K_2, α, and α_2) are specific to a given explosive. The inverse scaled range ($W^{1/3}/R$), the explosive weight divided by the slant range, is an important term. It allows the comparison of differing explosive weights. It provides the means to "scale" the pressure, energy, and effects on marine life from an underwater explosion. Equation [4] gives a good estimate of the pressure at distances from approximately 10 to 100 charge radii (Cole, 1948). The actual pressure in a given location can be affected by local conditions, such as water depth and bottom conditions. However, the bottom conditions are not considered in this study.

The effect of an underwater shock on marine life also depends on the time-integral of pressure (impulse), rather than the detailed form of the pressure-time history. The energy flux density is another significant measure of underwater shock. The energy flux density represents the energy flux across a unit area of a fixed surface normal to the direction of propagation of the wave (Cole, 1948). The impulse and energy flux density have the following forms:

$$I(t) = \int_0^{\tau} P(t)dt \qquad [6]$$

$$E_f(t) = \frac{1}{\rho_o c_o} \cdot \int_0^{\tau} P^2(t)dt \qquad [7]$$

The integration interval τ is usually some multiplier of θ (typically 5*θ, Swisdak, et al., 1978) for ***I*** and ***E$_f$***. The integration period should be determined by the purpose and intent of the explosive event. Others have documented that the integration period should be something on the order of 6.7*θ (Cole, 1948). The multiplier on the time constant is a matter of choice based on the explosive event geometry. The integrals of equations [6] and [7] accurately resolve the strength and intensity of the shock wave at any point in the water continuum.

Often, the energy flux density is given in terms of decibels (dB) referenced to 1 μPa^2-s. The following two equations are the conversion relationships between the energy flux density in SI units and dB.

$$E_{dB} = 10 \cdot \log_{10}\left(\frac{E_f \cdot \rho_o c_o}{1 \cdot 10^{-12}}\right) \qquad [8]$$

Where: $\rho_o c_o$ = water impedance = 1.54 x 10^6 kg/(m^2 - s)

$$E_f = \frac{1 \cdot 10^{-12}}{\rho_o c_o} \cdot 10^{\frac{E_{dB}}{10}} \qquad [9]$$

All of the above relationships are for total energy flux density. Often the thresholds for affecting marine life are based on the value of energy flux density in any 1/3-octave band. Explosions are impulsive noise sources and are typically characterized by having a transient output signal. These transient signals contain a broadband of frequencies. To obtain the 1/3-octave band energy flux densities from a particular pressure time history requires a sophisticated analysis package. In lieu of this, we took the results from REFMS calculations for 50 lbs. of explosives and plotted the maximum 1/3-octave band energy flux density versus the total energy flux density (see Figure 13). The result was an approximate linear relationship between the two quantities that can be used to convert from one to the other. The coefficient of determination (R^2) was quite good (R^2 =0.94) for this relation. For example, a total EFD value of 192 dB yields a maximum 1/3-octave EFD of 181.6 dB. This is a reasonable result as for a broad band waveform, the 1/3-octave value is 10 dB lower than the total value.

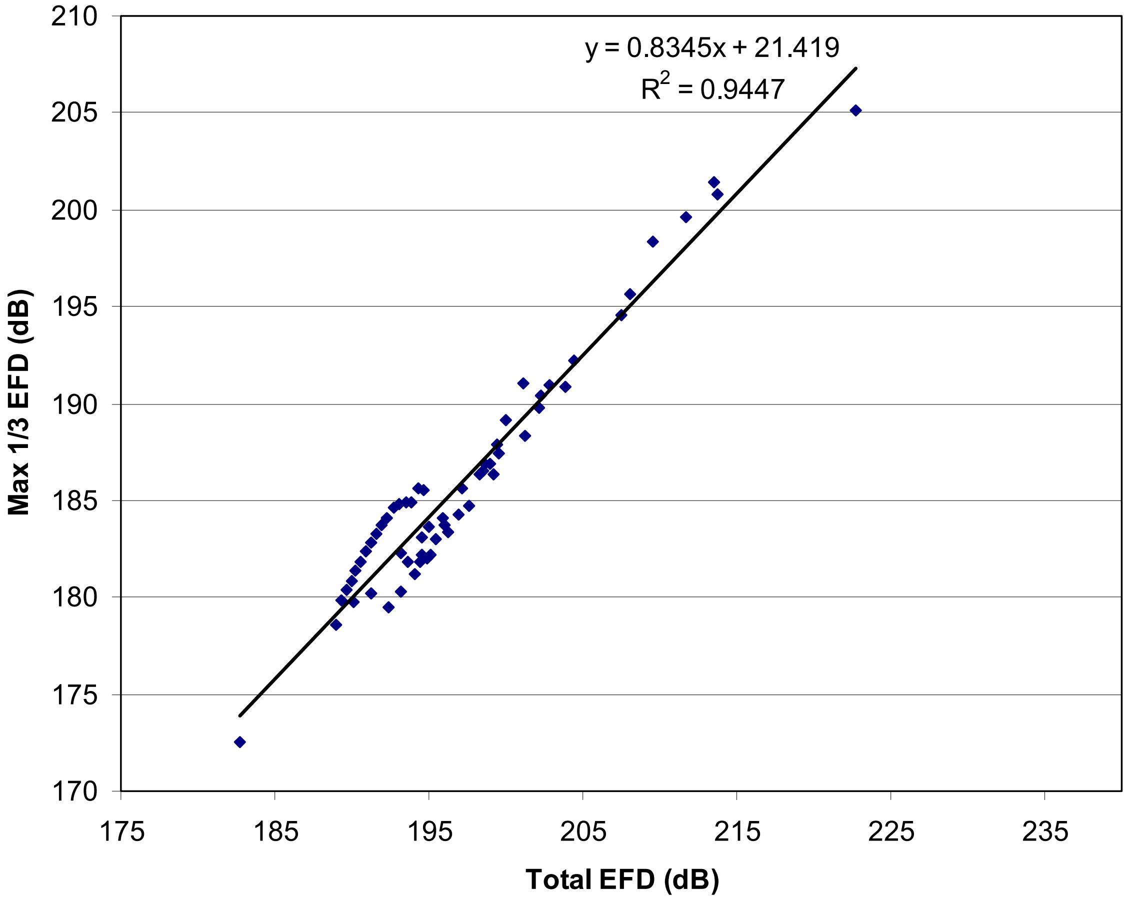

Figure 13. Relationship Between Maximum EFD in any 1/3-Octave Band and Total EFD.

The UnderWater Calculator (UWC) spreadsheet (Excel) performs both a forward calculation (input: slant range, output: pressure, impulse, EFD) and a backward calculation (input: peak pressure or EFD, output: slant range). The forward calculation includes the free surface effects while the backward calculation does not.

For the forward calculation, the spreadsheet takes into account surface rarefaction waves, which reduce the duration of the explosive shock pulse. The rarefaction wave interaction is based on where the explosive charge and receptor are located in relation to the water surface. Equation [10] provides the cut-off time. *R'* is the radial distance from the charge to the receptor the wave travels after being reflected from the surface. *R* is the slant range from the explosive to the receptor and c_o is the sound speed of the water.

$$t_{cut} = \left(R' - R\right) / c_o \qquad [10]$$

R' can be calculated from straightforward geometric relations resulting in Equation [11]. *Sd* is the source depth and *Rd* is the receptor depth from the water line. *H* is the horizontal range of the receptor from the explosive charge. Figure 14 illustrates the geometry for determining the cut-off time due to a surface rarefaction wave.

$$R' = \sqrt{(Sd + Rd)^2 + H^2} \qquad [11]$$

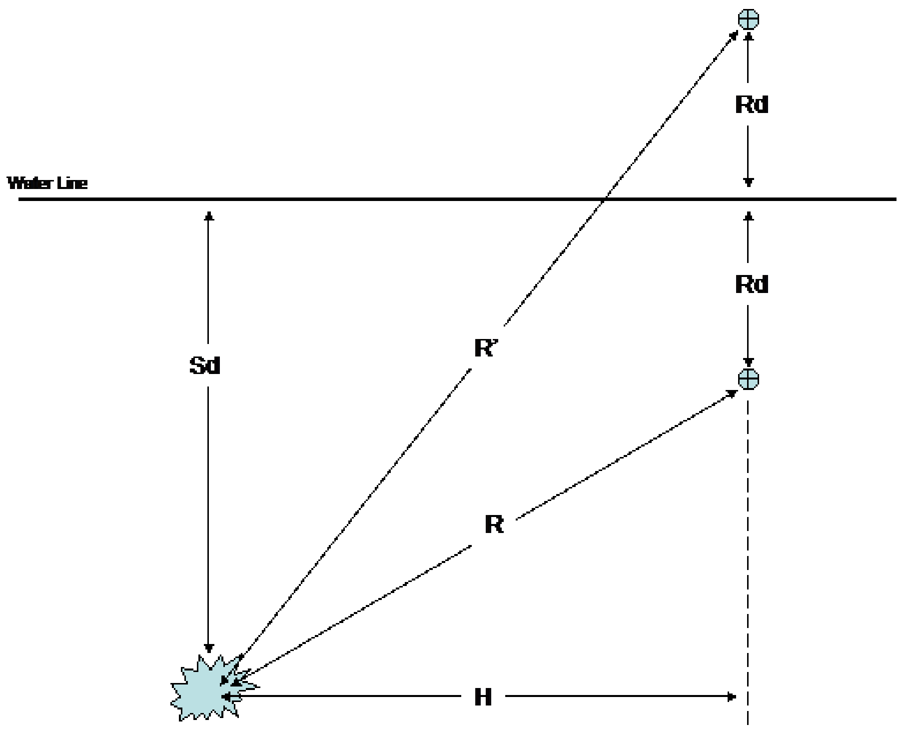

Figure 14. Geometry for Time Cut-Off of the Shock Pulse.

Figure 12 in the Simplifying Assumptions sub-section shows the end results of a shock pulse and rarefaction wave interaction. The cut-off time is calculated to determine the integration end time of the pressure time history. This allows for a more accurate computation of shock impulse and energy flux density.

9.4 Numerical – REFMS

REFMS v5.07 (Britt et al., 1991) is a computer program for predicting shock wave characteristics for explosions in water. It includes the aspects of near-source shock wave propagation caused by direct shock and water shock refraction from bottom and surface reflections. This code is designed to handle multi-layered ocean/bottom configurations with a variety of explosives sources available. The REFMS code has been extensively tested and validated against numerous high explosive experiments. It was used in the FEIS for the shock trials of the *Winston S. Churchill* (U.S. Dept. of the Navy, 2001). REFMS was used in that study to produce the pressure-time waveforms of shock wave transmission.

REFMS can be used to calculate peak pressures, pressure histories, impulse, and energy flux densities at a specified range. REFMS incorporates the Swisdak et al. (1978) shock formulations and closed-form ray-tracing analytical solutions to solve for the explosive shock environment.

However, the limiting factor of the REFMS code may be that it is quite sophisticated, allows very complex conditions, and the untrained user may have difficulty choosing the correct parameters for a particular calculation.

10.0 UNDERWATER CALCULATOR (UWC) SPREADSHEET EXAMPLES

This section presents examples using the UnderWater Calculator (UWC) spreadsheet, which is based upon the information given in Section 9.3. One free water calculation will be presented and compared with REFMS results. Then UWC results will be given to demonstrate the differences in range to effect for peak pressure and energy flux density between the free water and pile cases.

The free-water case is an open-water 22.68 kg (50 lb) H-6 explosive charge. The receiver is 400 meters from the surface and at a slant range of 403.11 meters. Given this geometry, the receptor is 50 meters horizontally from the source. The geometry of the free-water case is shown in Figure 15. The spreadsheet for this case is shown in Figure 16. Table 5 compares the UWC and REFMS results. The peak pressure, impulse and energy flux density are nearly the same for both methods.

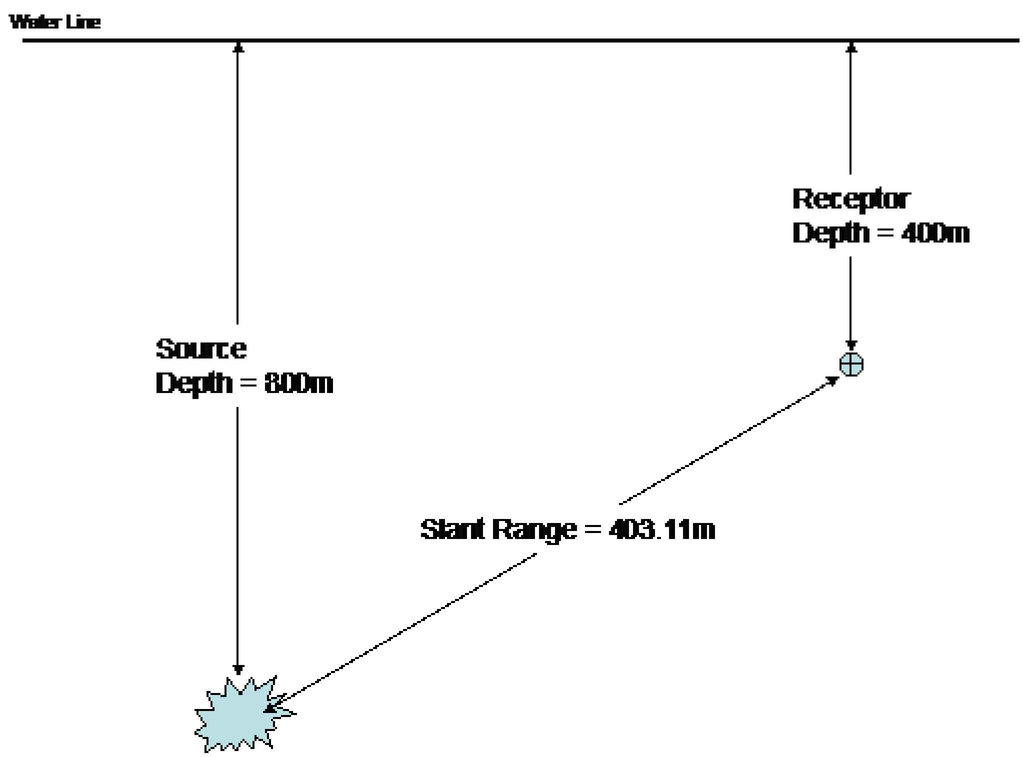

Figure 15. Free-water Configuration Used for Comparison.

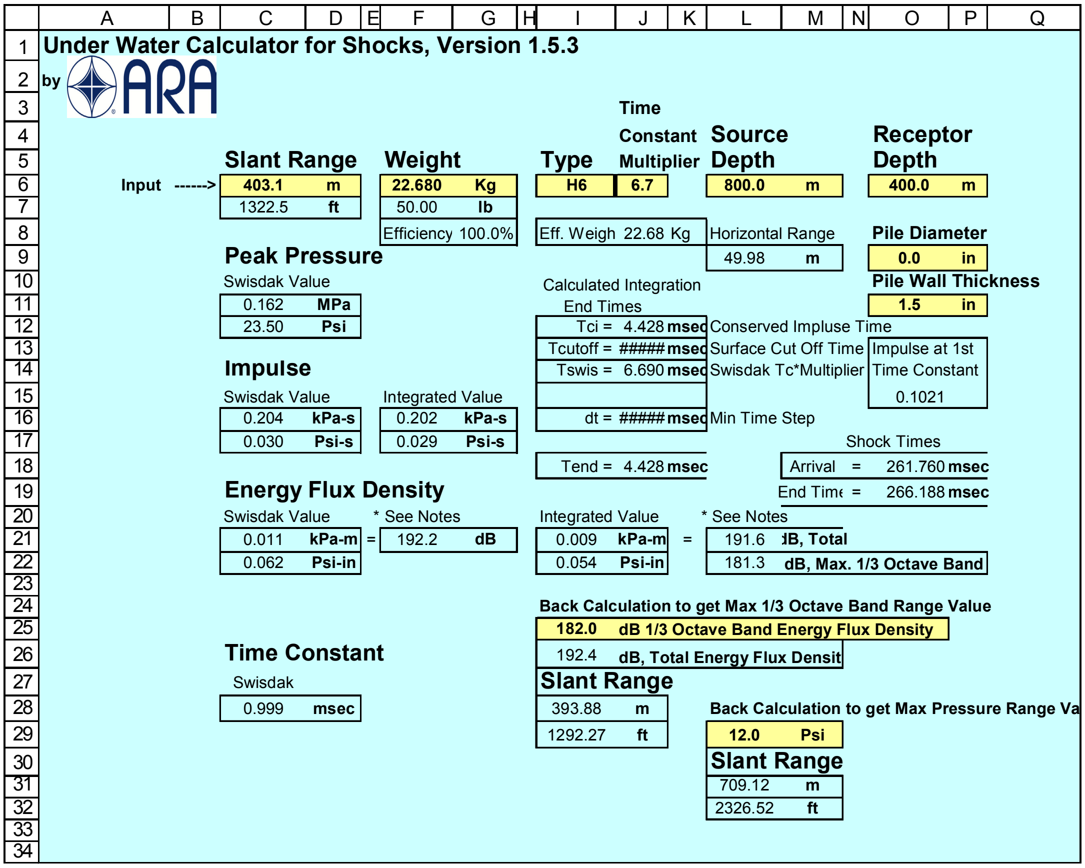

Figure 16. UnderWater Calculator Spreadsheet for the Configuration in Figure 15.

Table 5. Results of the Free-water Case for the Two Methods.

Method	Peak Pressure (MPa)	Impulse (kPa-s)	Energy Flux Density re 1 $\mu Pa^2 s$ (dB)
REFMS	0.167	0.205	191.6
UWC	0.162	0.202	191.6

To demonstrate the difference in the shock propagation into the water between a free-water and a pile case, the UWC spreadsheet was exercised. The pile case is similar to the free-water case with the exception of the 36-inch diameter pile with a 1.5 inch wall thickness. The water depth was 200 meters and the receiver depth was 100 meters. We performed a series of calculations to determine the range for a given energy flux density (182 dB for any 1/3-octave band) and for a given peak pressure (12 psi). The results for the free-water charge and the buried pile charge are shown in Tables 6 and 7. As can be seen from these two tables, the range to effect for the pile case is less than the free-water case. This is an expected result because of the reduced energy coupling to the water for the pile configuration.

Table 6. 50-lb H-6 Charge, Range to 182-dB Energy Flux Density.

Explosive Configuration	Range (m)	Peak Pressure (psi)	Total Energy Flux Density re 1 $\mu Pa^2 s$ (dB)	Max 1/3 Octave Band Energy Flux Density re 1 $\mu Pa^2 s$ (dB)
Free-Water Charge	394	24.2	191.8	181.5
Buried Pile Charge	252	28.7	191.8	181.5

Table 7. 50-lb H-6 Charge, Range to 12-psi Peak Pressure.

Explosive Configuration	Range (m)	Peak Pressure (psi)	Total Energy Flux Density re 1 $\mu Pa^2 s$ (dB)	Max 1/3 Octave Band Energy Flux Density re 1 $\mu Pa^2 s$ (dB)
Free-Water Charge	710	11.98	186.5	177.0
Buried Pile Charge	525	11.98	185.1	175.9

In order to minimize the effect on marine mammals and other aquatic life, the dual criteria of 12 psi (acceptable peak pressure level) and 182 dB re 1 $\mu Pa^2 s$ (acceptable received energy density level in any 1/3-octave band) to define the impact zone radius are cited by the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service. Tables 6 and 7 illustrate the difference of range to effect between the two criteria. As indicated by the UWC tool in the above tables, the energy criteria provides approximately a 50% smaller slant range than the peak pressure criteria. The Churchill shock trials FEIS (U.S. Dept. of the Navy, 2001) indicates that the 182-dB energy criterion was more frequently the determining factor in defining the impact zone radius (10,000 lb explosive charge). The determining factor as to which criterion governs is based on the explosive charge weight. For smaller charge weights, the pressure criterion will govern (Tables 6 and 7), while for larger charges, the energy flux density criterion will govern (Churchill shock trials). The crossover point is approximately 2,000 lbs; i.e., below 2,000 lbs, the pressure criterion will yield the greater impact zone radius, while above 2,000 lbs, the energy flux density criterion will determine the impact zone radius.

11.0 SUMMARY

The objective of this work was to develop a method to determine the shock wave propagation into water caused by the removal of offshore structures by explosive methods. This was accomplished by performing numerical simulations of various explosive, pile, clay, water systems and determining the amount of energy coupled to the water. The numerical simulations showed that less energy is coupled to the water for the pile cases than would be coupled for free water explosions. These simulations showed that a reduction of coupled energy into the water was dominated by pile confinement followed by soil confinement. Parametric numerical simulations were performed that covered a range of typical pile diameters, wall thicknesses, and explosive weight. From these results, a model was developed to predict the explosive efficiency factors for various pile scenarios. Lastly, the UnderWater Calculator spreadsheet was developed to predict peak pressure, impulse, and energy flux density for both the free-water and pile cases.

12.0 RECOMMENDATIONS

The model development and the UnderWater Calculator are based on the numerical simulations for a fairly wide range of parameters (Section 4.0). A natural extension for the model would be to extend the explosive coupling efficiency/pile parameter relation to include the pile steel yield strength, explosive depth of burial, and more complex structures (e.g., the inclusion of grout). The UnderWater Calculator should be evaluated for shallow water conditions and modified if necessary. Lastly, the model results should continually be compared to existing data from EROS operations.

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Appendix C

Conner – ARA UWC – *In Situ* Comparisons

Synopsis:

This appendix comprises an "annex" (appendix) to a separate study, *Oil Platform Removal Using Engineered Explosive Charges: In Situ Comparison of Engineered and Bulk Explosive Charges*, prepared for the Technology Assessment and Research (TAR) Program Office of the Minerals Management Service (MMS). The study was prepared to complement the development and testing of small, linear-shaped charges that could be used during decommissioning activities. Since the testing phase of the study included *in situ* shock wave and acoustic property measurements, Annex B was prepared to compare actual measurements with calculated results from the UnderWater Calculator (UWC) discussed in Appendix B. The comparison data was critical in establishing the UWC as a viable model for marine mammal and sea turtle analyses of this programmatic environmental assessment (PEA) and related take-estimate calculations and mitigation development (Appendixes E and F).

Report Citation and Availability:

Saint-Arnaud, D., P. Pelletier, W. Poe, and J. Fowler. 2004. Oil platform removal using engineered explosive charges: In-situ comparison of engineered and bulk explosive charges – final report. U.S. Dept. of the Interior, Minerals Management Service, Technology Assessment and Research Program, Herndon, VA.

A copy of the complete report can be attained by emailing your request, project number (No. 429), and report citation to TAR at MMS.TAR.Information@mms.gov, or by providing the information to the following address:

U.S. Department of the Interior
Minerals Management Service
Technology Assessment and Research Program (MS 4021)
381 Elden Street
Herndon, Virginia 20170-4817

Attention: Kurt Stein

Introduction

This document is a modified version of the document "Conner-ARA UWC-In-Situ Comparisons" prepared by Mr. T.J. Broussard from the New Orleans office taking into consideration some differences between the reported and actual values for the charge weight and set-up distances as well as some differences in the equations used for the impulse and energy flux density.

Calculation methods and differences

Physical differences

The engineered charge weight had been reported in the past as being 4.6 pounds and it was planned to mention it in SNC TEC Corp. final report that the actual weight is 4.05 pounds. The difference comes from that the linear shape charge (LSC) used to produce the engineered charge was originally planned to 4400 grains/foot but it was eventually changed to 4000 grains/foot by Accurate Energetics, the charge supplier. While this change has been done prior to the tests performed at DRDC Suffield, we kept using the old number.

We found a small mistake in the calculation of the slant range coming from the calculation of the distance in the horizontal plane. Figure 1 below illustrates the situation. In the calculation of the slant range the horizontal plane distance used by Broussard was obtained by adding 37.7 feet to the distance between transducer of interest and pile 1 to which the transducer array was tied. According to the drawing received at SNC TEC describing the set-up, the 37.7 feet distance represents the distance shown in Figure B.1. Therefore , in order to obtain the actual distance in the horizontal plane ("y"), we have to obtain the distance "a". We considered the platform arrangement to be a equilateral triangle and from trigonometry, the value of distance was computed as being 21.67 feet. From this we computed the distance "y" for all the transducers and eventually the modified slant distance by considering the distance in the vertical plane. The modified values are presented in the tables presented in this document. The difference between those values and the values computed by Broussard are about 2 feet.

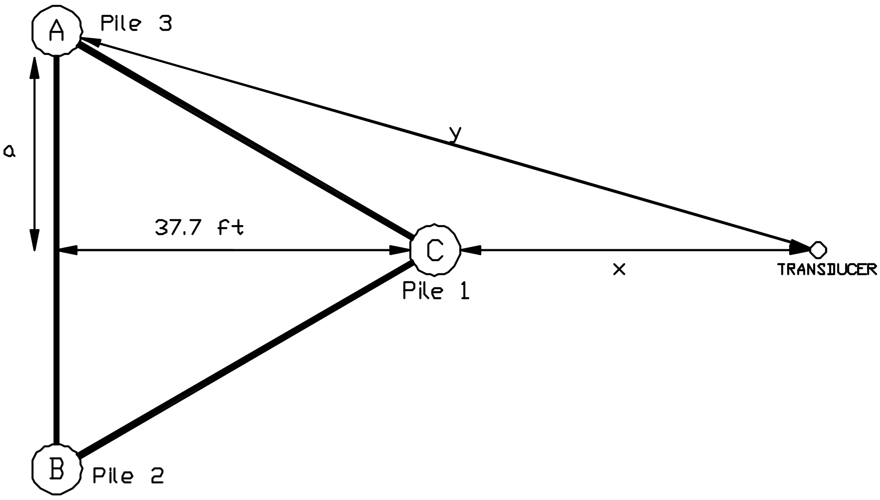

Figure B.1 – Platform and transducers considered arrangement

Connor similitude equations differences
In his calculations of impulse and energy flux density, Broussard used the equations for reduced impulse and reduced energy flux given in page 6-3 of from Connor study[11] and presented below:

$$I/W^{1/3} = 15.35\left(R/W^{1/3}\right)^{-1.79} \quad (1)$$

$$E/W^{1/3} = 11900\left(R/W^{1/3}\right)^{-3.13} \quad (2)$$

The computed results reported in his tables for the "Connor Main Pile SimEQ" are found to be the reduced values of impulse and energy flux density divided by the cube root of the charge weight rather than the actual values of impulse and energy flux density. These latter values are used for the ARA model and the measured values.

ARA model calculations
The bulk charges used in this program were made of composition C4 explosive. The calculations were performed using the calculator (EXCEL® version) supplied by MMS based on ARA report[12] considering the modified distances discussed above and C4 explosive for the bulk charge. In the case of the engineered charge, the RDX explosive was not available and we could not find acceptable details on the "user explosive" neither a way to adjust the parameters used for a user defined one. We looked at the other explosives but we were surprised to see that explosives which are known to have lower detonation pressure than C4

[11] Connor, J.G., *Underwater Blast Effects from Explosive Severance for Offshore Platform Legs and Well conductors*, Naval Surface Warfare Center, NAVSWC TR 90-532, 15 December 1990.
[12] Dzwilewski, P.T. and Fenton, G., *Shock Wave /Sound Propagation Modeling Results for Calculating Marine Protected Species Impact Zones During Explosive Removal of Offshore Structures,* Applied Research Associates Inc report for MMS contract 0302P057572, September 2003.

produced higher peak overpressure based on the ARA model. Since a review of the ARA model is out of the scope of our research project, it was decided to use C4 explosive for the engineered charge. The value to be used for the time constant multiplier and the method to select it was not clear to us so we used the default value of 6.7.

Results

Peak overpressure

Table B.1 – Peak overpressure data

Peak Overpressure (psi)					
Transducer	Slant range (ft)	Charge weight (lb)	ARA UWC	Connor Main Pile SimEQ	Field measure
Charge A (4.05lbs RDX engineered charge) – Pile 3					
A	77.2	4.05	155.7	42.0	139.2
B	80.9	4.05	147.0	38.4	140.3
C	85.1	4.05	138.2	34.8	78.8
D	98.6	4.05	115.5	26.2	86.7
F	104.5	4.05	107.6	23.4	74.4
G	127.7	4.05	84.3	15.9	45.5
H	129.6	4.05	82.8	15.5	93.2
I	132.3	4.05	80.7	14.9	119
L	251.6	4.05	36.8	4.3	10.1
Charge B (50lbs C4 bulk charge) – Pile 2					
A	77.2	50	465.7	205.1	137.9
B	80.9	50	439.9	190.3	167.1
C	85.1	50	413.5	172.7	98.2
D	98.6	50	345.5	130.5	90.9
F	104.5	50	321.9	116.8	134.2
G	127.7	50	252	79.6	64.1
H	129.6	50	247.5	77.3	82.7
I	132.3	50	241.4	74.4	118.8
L	251.6	50	110.2	21.6	26.8
Charge C (50lbs C4 bulk charge) – Pile 1					
A	40.3	50	1029.6	742.6	244.1
B	46	50	873.5	575.3	281.6
C	53.1	50	733.5	436.1	279
D	60.6	50	628.2	337.9	192.5
F	69.7	50	528.5	258.0	211.6
G	89.3	50	389.9	159.9	151.4
H	92.1	50	376	150.7	137.7
I	95.8	50	357.9	139.6	83.3
L	214.7	50	134.4	29.4	41.2

The peak overpressure data were put in graphs the same way as Broussard but it was found that presentation of the data as a function of the factor "$R/W^{1/3}$" and using log-log graph was giving a better view of the data. In the case of the bulk charges, the data was combined on one chart because the only difference came from the slant range from the transducers.

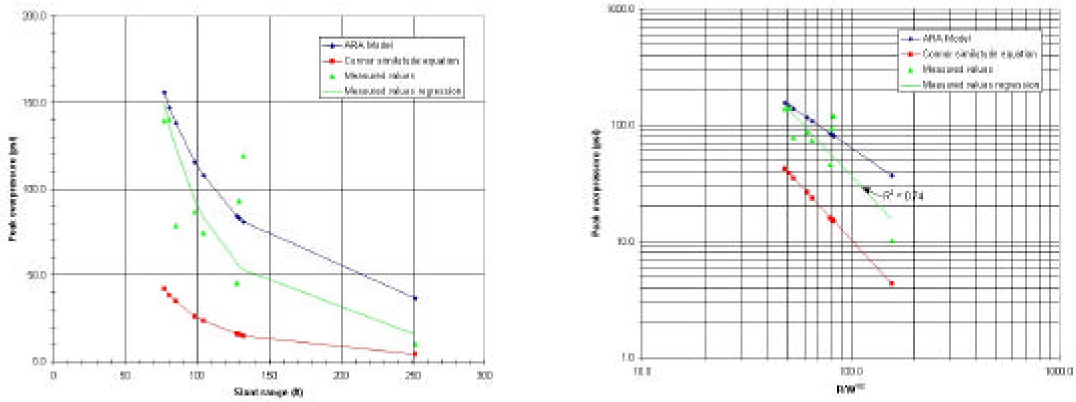

Figure B.2 – Peak overpressure – 4.05 lbs engineered charge

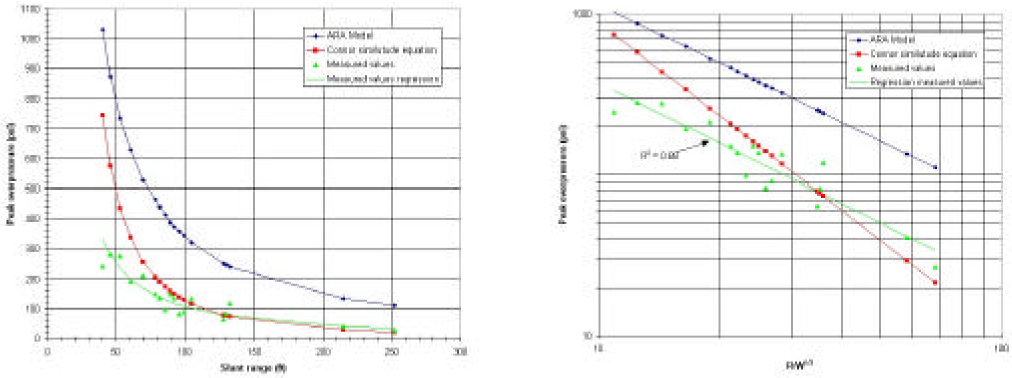

Figure B.3 – Peak overpressure – Combined 50 lbs bulk charges data

Using linear regression, we computed the equations for the measured data from both types of charge with the least square method in an EXCEL® spreadsheet. The equation obtained for the 4.05 lbs engineered charge was:

$$P = 260581 \left(R/W^{1/3}\right)^{-1.923} \tag{3}$$

with a regression coefficient (R^2) of 0.74. This value of regression coefficient is considered low and can be easily explained when looking at the dispersion of the data around the line in the right side of Figure B.2. Using the data from both bulk 50 lbs bulk charges tested, the following equation was obtained:

$$P = 6473.06 \left(R / W^{1/3} \right)^{-1.241} \quad (4)$$

with a regression coefficient (R^2) of 0.88. This value of regression coefficient is much better and while there is still some dispersion of the data, the fact that we have more data covering a larger range of distance helps in reducing the regression coefficient. This also indicates that having more experimental data should be useful to define more exactly the actual equation.

Both charges experimental data as well as the Connor similitude equations and ARA model are illustrated in Figure B.4 below. Only the log-log graph of the data as a function of "$R/W^{1/3}$" was used.

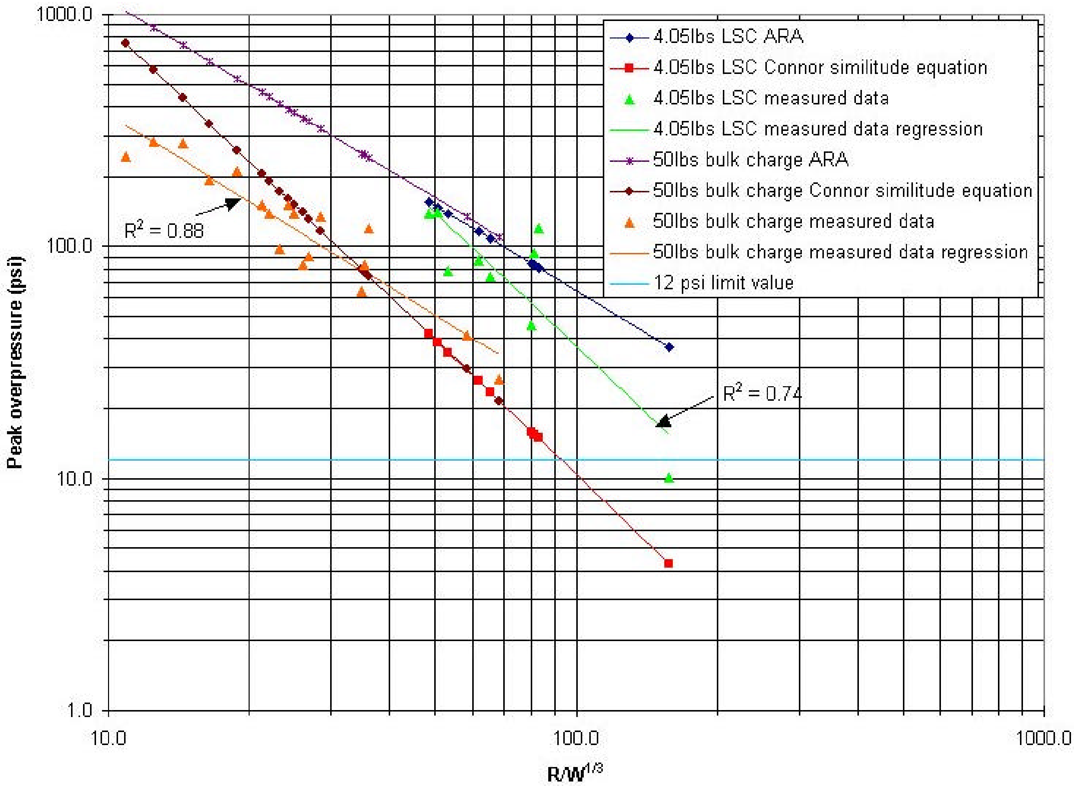

Figure B.4 – Peak overpressure – data from both types of charges

The figure also presents the 12 psi peak overpressure criteria for marine mammal harassment as per NOAA 50 CFR Part 216. From equations (3) and (4), the range distance corresponding to this 12 psi limit value was computed for both charges. A value of 286.5 feet for the engineered charge and 585.1 feet for the bulk charge so a reduction factor of 2.04 is obtained when going from the bulk charge to the engineered charge.

Impulse

The impulse values computed by Sonalysts were compared to the values obtained from the ARA model and the Connor similitude equation presented as equation (1). The data obtained are given in Table B.2.

Table B.2 – Impulse data

Impulse (psi-s)					
Transducer	Slant range (ft)	Charge weight (lb)	ARA UWC	Connor Main Pile SimEQ	Field measure
Charge A (4.05lbs RDX engineered charge) – Pile 3					
A	77.2	4.05	0.041	0.025	0.016
B	80.9	4.05	0.039	0.023	0.012
C	85.1	4.05	0.037	0.021	0.012
D	98.6	4.05	0.033	0.016	0.010
F	104.5	4.05	0.031	0.014	0.012
G	127.7	4.05	0.026	0.010	0.006
H	129.6	4.05	0.025	0.010	0.010
I	132.3	4.05	0.025	0.009	0.008
L	251.6	4.05	0.014	0.003	0.004
Charge B (50lbs C4 bulk charge) – Pile 2					
A	77.2	50	0.226	0.237	0.069
B	80.9	50	0.216	0.221	0.017
C	85.1	50	0.207	0.202	0.013
D	98.6	50	0.181	0.156	0.054
F	104.5	50	0.171	0.140	0.019
G	127.7	50	0.143	0.098	0.054
H	129.6	50	0.141	0.096	0.013
I	132.3	50	0.138	0.093	0.016
L	251.6	50	0.077	0.029	0.022
Charge C (50lbs C4 bulk charge) – Pile 1					
A	40.3	50	0.781	0.140	0.146
B	46	50	0.616	0.193	0.126
C	53.1	50	0.477	0.183	0.108
D	60.6	50	0.376	0.108	0.093
F	69.7	50	0.293	0.018	0.080
G	89.3	50	0.188	0.081	0.061
H	92.1	50	0.178	0.066	0.059
I	95.8	50	0.166	0.044	0.056
L	214.7	50	0.039	0.030	0.023

The impulse data for Connor similitude equation was obtained using equation (1) above and the ARA model data was obtained using the EXCEL® spreadsheet calculator. As in the case of the peak overpressure, we prepared two types of graphs for each charge, one of the impulse as a function of the slant range using linear axis like Broussard and one with the data as a function of $R/W^{1/3}$ with log-log axis.

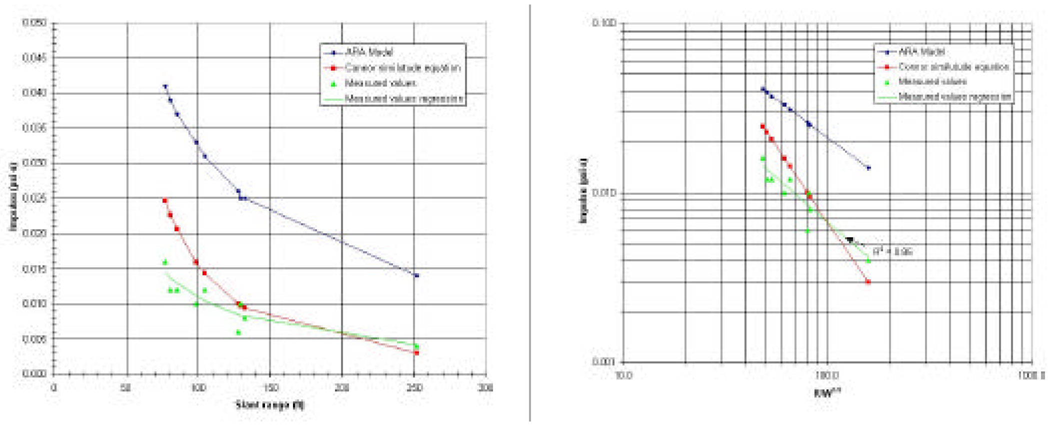

Figure B.5 – Impulse – 4.05 lbs engineered charge

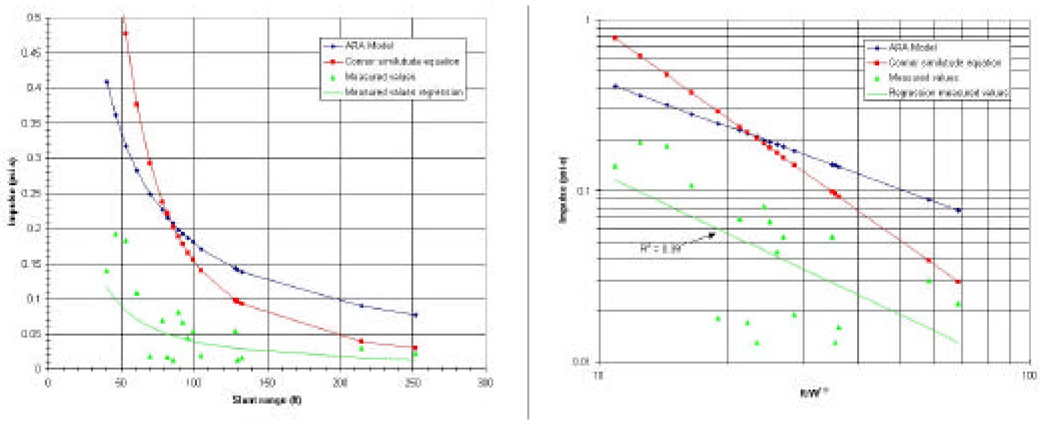

Figure B.6 – Impulse – Combined 50 lbs bulk charges data

Using linear regression, we computed the equations for the measured data from both types of charge with the least square method in an EXCEL® spreadsheet. The equation obtained for the 4.05 lbs engineered charge was:

$$I = 0.8952\left(R/W^{1/3}\right)^{-1.0535} \quad \text{or} \quad I/W^{1/3} = 0.5383\left(R/W^{1/3}\right)^{-1.0535} \qquad (5)$$

with a regression coefficient (R^2) of 0.85. This value of regression coefficient is better than what was obtained with the peak overpressure which can be explained by the smaller dispersion of the data as shown in the right side of Figure B.5. Using the data from both bulk 50 lbs bulk charges tested, the following equation was obtained:

$$I = 1.9908\left(R/W^{1/3}\right)^{-1.191} \quad \text{or} \quad I/W^{1/3} = 0.5404\left(R/W^{1/3}\right)^{-1.191} \qquad (6)$$

with a regression coefficient (R^2) of 0.39. Contrary to the peak overpressure, in this case the dispersion of the data obtained with the bulk charge for the impulse data about the regression curve is very large hence the small regression coefficient. Care should therefore be used to make conclusions based on this data.

Both charges experimental data as well as the Connor similitude equations and ARA model are illustrated in Figure B.7 below. Only the log-log graph of the data as a function of "$R/W^{1/3}$" was used.

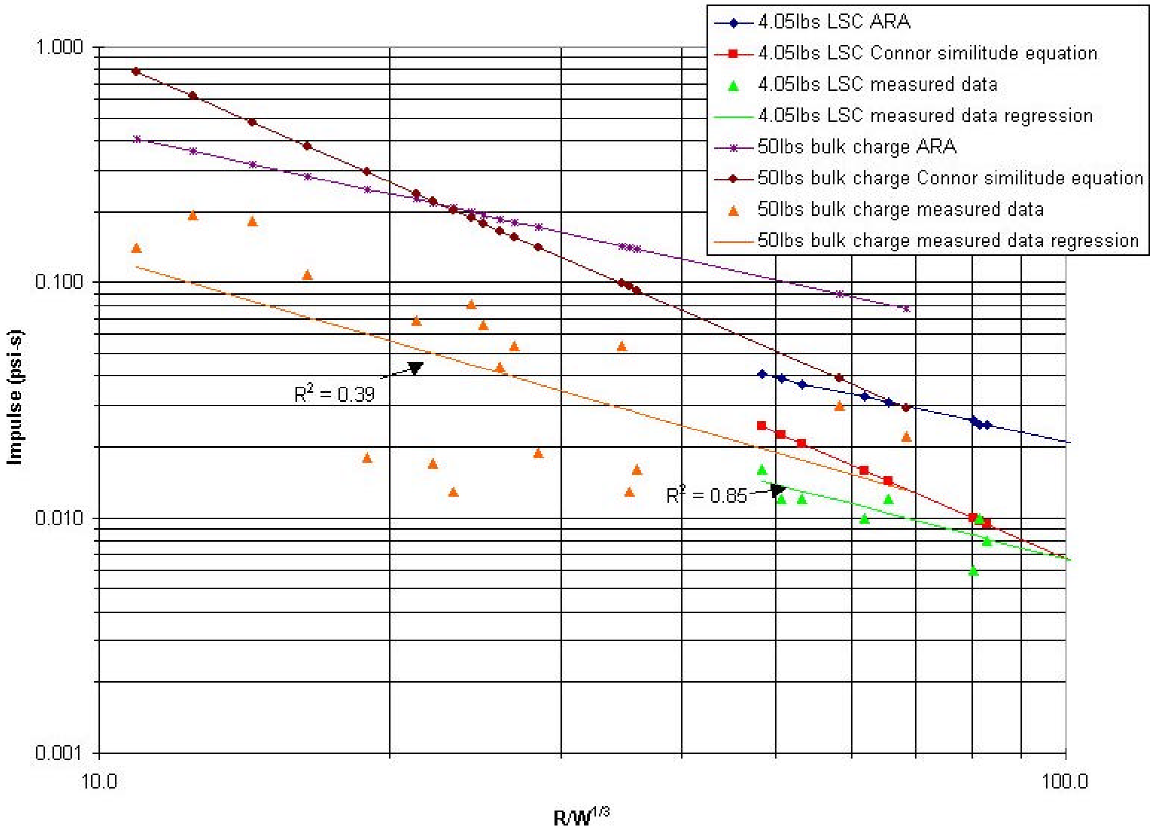

Figure B.7 - Impulse – data from both types of charges

It is interesting to note that for this value, the ARA model and the Connor similitude equations seem to match well for the bulk charges. The Connor similitude equation data were along the same line for the peak overpressure but this time this is not the case because of the $W^{1/3}$ factor.

<u>Energy flux density</u>

The energy flux density values computed by Sonalysts were compared to the values obtained from the ARA model and the Connor similitude equation presented as equation (2) above. The data obtained are given in Table B.3.

Table B.3 – Energy flux density data

Energy Flux Density (psi-in)					
Transducer	Slant range (ft)	Charge weight (lb)	ARA UWC	Connor Main Pile SimEQ	Field measure
Charge A (4.05lbs RDX engineered charge) – Pile 3					
A	77.2	4.05	0.586	0.101	0.132
B	80.9	4.05	0.531	0.087	0.097
C	85.1	4.05	0.478	0.074	0.055
D	98.6	4.05	0.352	0.047	0.038
F	104.5	4.05	0.312	0.039	0.054
G	127.7	4.05	0.206	0.021	0.013
H	129.6	4.05	0.199	0.020	0.057
I	132.3	4.05	0.191	0.019	0.054
L	251.6	4.05	0.050	0.002	0.004
Charge B (50lbs C4 bulk charge) – Pile 2					
A	77.2	50	9.314	3.045	0.813
B	80.9	50	8.449	2.697	0.138
C	85.1	50	7.605	2.305	0.078
D	98.6	50	5.599	1.463	0.419
F	104.5	50	4.961	1.221	0.105
G	127.7	50	3.269	0.656	0.280
H	129.6	50	3.170	0.626	0.047
I	132.3	50	3.037	0.589	0.082
L	251.6	50	0.798	0.079	0.051
Charge C (50lbs C4 bulk charge) – Pile 1					
A	40.3	50	24.539	3.589	4.168
B	46	50	16.219	5.526	2.996
C	53.1	50	10.349	4.353	2.094
D	60.6	50	6.844	1.756	1.506
F	69.7	50	4.417	0.162	1.062
G	89.3	50	2.034	1.009	0.573
H	92.1	50	1.846	0.678	0.530
I	95.8	50	1.632	0.259	0.480
L	214.7	50	0.131	0.090	0.064

The energy flux density data for Connor similitude equation was obtained using equation (2) above and the ARA model data was obtained using the EXCEL® spreadsheet calculator. As in the case of the peak overpressure and impulse, we prepared two types of graphs for each charge, one of the energy flux density as a function of the slant range using linear axis like Broussard and one with the data as a function of $R/W^{1/3}$ with log-log axis.

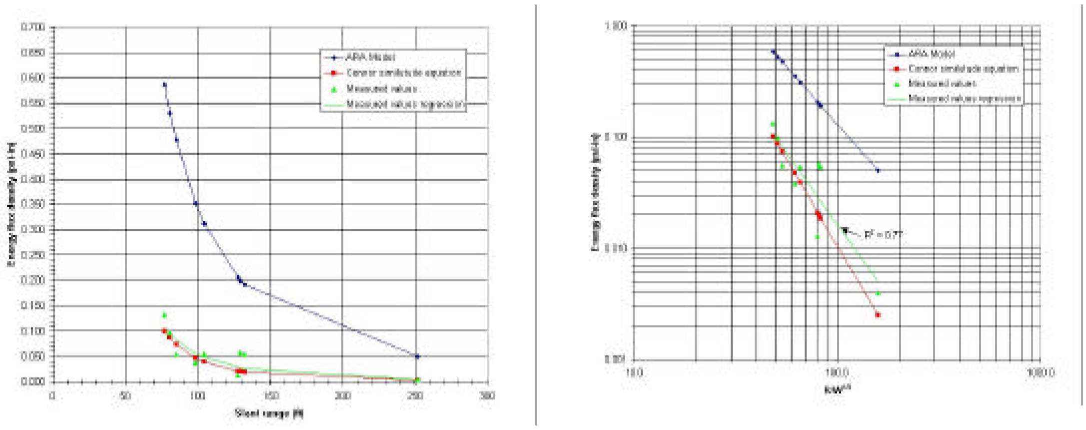

Figure B.8 – Energy flux density – 4.05 lbs engineered charge

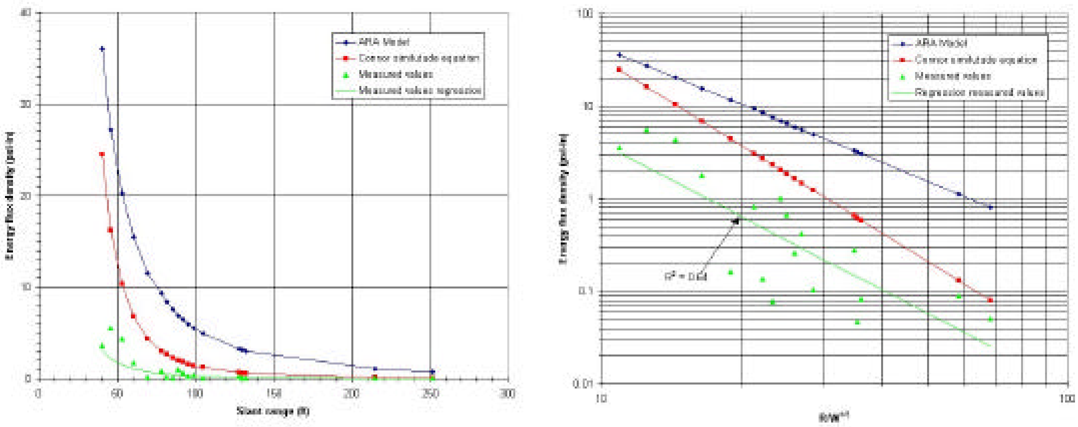

Figure B.9 – Energy flux density – Combined 50 lbs bulk charges data

Using linear regression, we computed the equations for the measured data from both types of charge with the least square method in an EXCEL® spreadsheet. The equation obtained for the 4.05 lbs engineered charge was:

$$E = 2390.6\left(R/W^{1/3}\right)^{-2.5840} \quad \text{or} \quad E/W^{1/3} = 1499.8\left(R/W^{1/3}\right)^{-2.5840} \qquad (7)$$

with a regression coefficient (R^2) of 0.77. This value of regression coefficient is close to what was obtained with the peak overpressure which can be explained by the dispersion of the data as shown in the right side of Figure B.8. Using the data from both bulk 50 lbs bulk charges tested, the following equation was obtained:

$$E = 1640.7\left(R/W^{1/3}\right)^{-2.6215} \quad \text{or} \quad E/W^{1/3} = 445.36\left(R/W^{1/3}\right)^{-2.6215} \qquad (8)$$

with a regression coefficient (R^2) of 0.64. Although better than the value obtained for the impulse data, this regression coefficient is still small. Care should therefore be used to make conclusions based on this data.

Both charges experimental data as well as the Connor similitude equations and ARA model are illustrated in Figure B.10 below. Only the log-log graph of the data as a function of "$R/W^{1/3}$" was used.

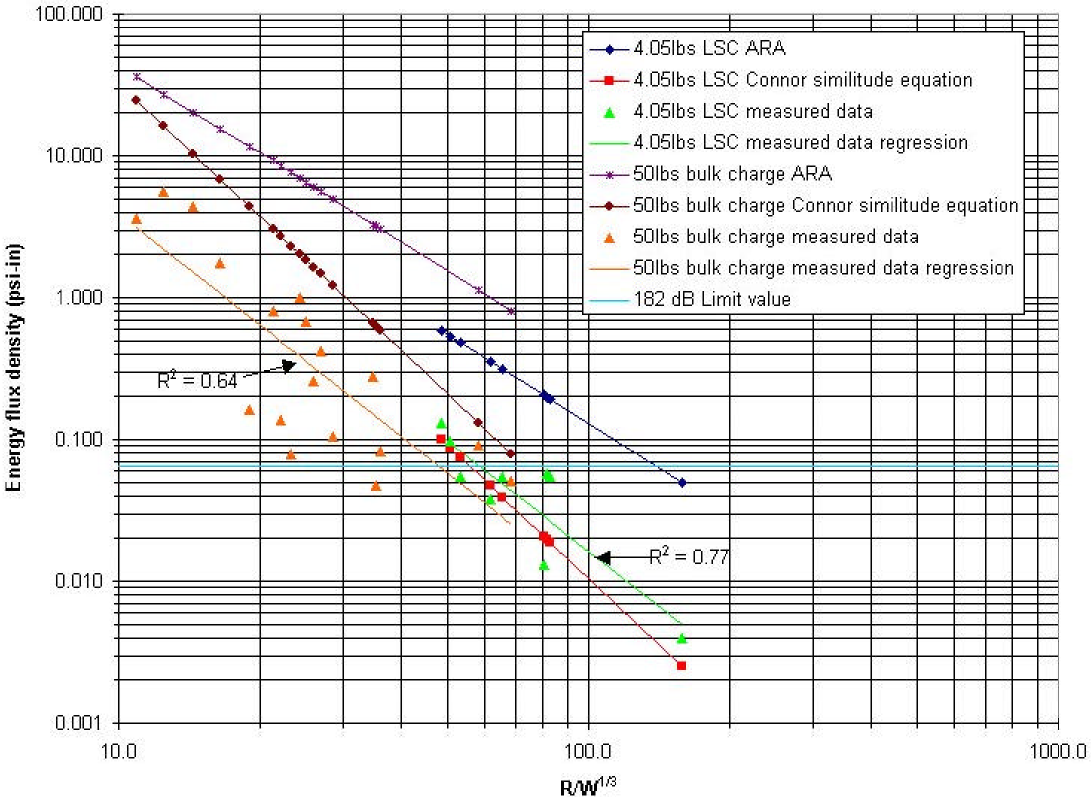

Figure B.10 – Energy flux density – data from both types of charges

The figure also presents the 182 dB (re 1 µPa^{2}sec) energy flux density criteria for marine mammal harassment as per NOAA 50 CFR Part 216. This value was converted in psi-in by using some assumptions of the ARA study that 182 dB (re 1 µPa^{2}sec) for any 1/3 octave band corresponds to 192.4 dB (re 1 µPa^{2}sec) of total energy flux density, which in turns corresponds to 0.06489 psi-in. From equations (7) and (8), the range distance corresponding to this value was computed for both charges. A value of 93.2 feet for the engineered charge and 176.1 feet for the bulk charge so a reduction factor of 1.89 is obtained when going from the bulk charge to the engineered charge.

Appendix D

Explosive Removal Scenario Simulation Results

Synopsis:

This appendix comprises a report prepared for the Minerals Management Service (MMS) on projecting the numbers and types of marine mammals that could be "taken" incidental to explosive-severance activities on the Gulf of Mexico (GOM) Outer Continental Shelf (OCS). The simulation results were used by MMS to calculate potential take estimates critical to this programmatic environmental assessment (PEA) and a subsequent Marine Mammal Protection Act (MMPA) take-authorization rulemaking and Endangered Species Act consultation assessment.

Report Citation and Availability:

Frankel, A. and W. Ellison. 2004. Explosive removal model simulation report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-064.

A copy of this report can be attained from the Public Information Office of MMS's Gulf of Mexico Region at the following address:

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
Public Information Office (MS 5034)
1201 Elmwood Park Boulevard
New Orleans, Louisiana 70123-2394

Telephone: (504) 736-2519 or
1-800-200-GULF

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Introduction

The Minerals Management Service (MMS) is petitioning the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service for incidental take of marine mammals in the Gulf of Mexico. There is concern about the potential effects of seismic exploration using airgun arrays and the explosive removal of offshore structures (EROS). Therefore it is desirable to predict the degree of impact of operation of these sources.

For a given scenario, the Acoustic Integration Model © (AIM) can make predictions of received sound levels for an animal. AIM is a Monte Carlo model that operates by considering the acoustic source characteristics, and then calculates the sound field of the particular physical environment. Within that environment, numerous virtual animals ("animats") are moved in three dimensions and time, thereby simulating the real movement patterns of real animals. AIM then convolves the model-predicted sound field with the animal movements to predict the exposure of each animat. This exposure history can be compared to regulatory thresholds to determine the number of animals that will be affected or "taken" by the proposed activity.

The accurate modeling of movement behavior is important because it affects the exposure levels that the animal is likely to receive. For example, in estimating the effects from explosions on or below the bottom of the ocean, deep diving species are more likely to receive high exposure levels than shallow diving species. AIM uses a set of behavioral parameters derived from a wide number of scientific papers to reproduce animal movements (Appendix A, Frankel et al. 2002).

In addition to the movement patterns of the animals being properly simulated, the propagation of the sound from the explosion to the animals needs to be accurately modeled. The analysis of explosive propagation is a complex undertaking with multiple variables. MMS supported Applied Research Associates (ARA) in the development of a model to predict the effective source level and propagation of an explosion taking place below the mudline, as well as when contained within pipes of varying diameters and wall thicknesses (Dzwilewski and Fenton 2003). The ARA model was therefore chosen for this application, and was interfaced to AIM. The result was the capability to perform comprehensive integrated three-dimensional modeling of the effect of explosive removals upon marine mammals.

The work reported here is for 24 EROS simulations occurring over ten sites selected to represent existing offshore structure locations and areas of likely cetacean concentration. The take criteria were established in consultation with MMS and are based on the criteria developed for the U.S. Navy *Seawolf* shock trials, i.e. exceeding 182 dB re 1 μPa^2-secec in the loudest third octave band and/or 12-psi peak pressure.

Methods

Criteria Used

Impulsive sources are, by their nature, broadband (*i.e.*, they simultaneously produce a wide spectrum of frequencies, ranging from tens to thousands of Hertz). However, the energy produced across this frequency band is not uniform. The energy density from impulsive sources generally peaks at a relatively low frequency and then decreases rapidly as frequency increases. This document uses the exposure criteria developed for the *Seawolf* Final Environmental Impact Statement (FEIS) (Department of the Navy 1998) to determine the potential impacts of impulsive sources on marine mammals.

The *Seawolf* FEIS established that an animal would be considered 'taken' if its exposure exceeded either of two criteria. The first criterion is a received level of 182 dB re 1 μPa^2-sec in the appropriate 1/3-octave band. The appropriate 1/3 octave band is above 10 Hz for mysticetes, and above 100 Hz for odontocetes. The second is the 12-psi peak pressure criterion. The ARA model that was incorporated into AIM calculated the received levels for both of these criteria.

Simulation Locations and Parameters

A set of 10 sites was chosen to encompass the shelf, slope and abyssal regions in the three MMS Gulf of Mexico Region planning areas. Sites were selected to represent existing structure locations and areas of likely cetacean concentration, such as areas with high primary productivity or predominant cyclonic activity.

The final set of 24 explosive removal scenarios was developed in cooperation with MMS. The scenarios were developed to encompass the range of possible activities in different planning areas and species regimes (*i.e.*, coastal, slope and abyssal).

Table 1

Location of the Runs and Their Environmental Regimes are Presented

Site Number	Lat Deg	Lat Min	Long Deg	Long Min	Planning Area	In/Off Shore	Species Density Province
1	27	52.7	96	16	W	In	Coastal
2	26	20.4	96	3.8	W	Off	Slope
3	28	51.0	93	56	W	In	Coastal
4	27	27.3	93	52	W	Off	Slope
5	28	40.7	91	34	C	In	Coastal
6	28	26.1	88	55	C	Off	Slope
7	27	27.3	88	29	C	Off	Abyssal
8	25	52.7	89	43	C	Off	Abyssal
9	27	55.5	87	40	E	Off	Abyssal
10	28	20.7	87	43	E	Off	Abyssal

C – Central, E – Eastern, and W – Western.

Multiple explosive removal scenarios were envisioned for some of the sites. At these sites a variety of different types of offshore structures exist which would require different removal methods. Each scenario was simulated with an individual model run. Each explosive removal was considered an explosive event, and each model run predicted the exposure from a single event. The specific characteristics of each run are presented in Table 2. The characteristics include the water depth, charge weight, charge location, pile diameter and pile wall thickness. Due to the required time delay between charges to prevent the summation of energy, scenarios involving multiple charges were modeled with a single charge. The ranges to the 182 dB re $1\mu Pa^2$-sec and 12 psi isopleths are also presented. These are the ranges for which mitigation efforts would be needed, if this scenario where to be enacted. Figure 1 depicts the input and setup screens in the AIM program, illustrating how these parameters were input into AIM.

Propagation Modeling

The Underwater Shockwave/sound Propagation model developed by ARA (Dzwilewski and Fenton 2003) was incorporated into AIM. It was used to estimate the received pressure level at an animal, both in the 1/3 octave band of maximal energy of the source (dB re 1 μPa^2-sec) as well as the total peak pressure (psi). The original model was developed for a range of charge weights between 25 and 100 lbs. Several of the scenarios identified by MMS specified charge weights in excess of the range of explosive weights considered in the original model (25-100 lbs). However, the implementation of the ARA model interfaced to the AIM model accepts and accounts for these larger charge weights. This implementation is based on the observation that the processes are mathematically linear as suggested in the original ARA modeling report (Dzwilewski and Fenton 2003). Thus, a linear extrapolation approach was used to modify the original ARA model to accommodate the larger charge weights shown in Table 2. The particular 200-lb scenarios modeled where both open water, and a single scenario with a charge inside a pile. The calculated explosive efficiency for this simulation falls within the range of values included in the original ARA model and is therefore a valid prediction (Dzwilewski, pers. comm.). However, all of the parameters for the 500-lb charge scenarios exceed the original ARA modeling parameter ranges in charge weight, pile diameter and wall thickness. The calculated explosive efficiencies for these scenarios exceed 90%, thereby approaching the level of an open-water explosion. These estimates are based upon the best available science. Additional modeling for the larger (500 lbs) parameters would refine these estimates. The take estimates might decrease, but they could only increase by a maximum of 10% (Dzwilewski, pers. comm.).

Table 2

Specific Characteristics of Each Scenario Simulation
(The values indicate the site and run numbers, where it is located, the depth of ocean and the explosive parameters. Open Water Modeling indicates that the charge was simulated as being exploded outside of a pile, rather than inside one. The ranges to the 182 dB re 1µPa2-s and 12 psi peak pressure levels are indicated as well.)

Site #	**Plan-ning Area**	**Run #**	**Water Depth (m)**	**Charge Wt (lb)**	**Above or Below Mudline**	**Open Water Model-ing?**	**Num-ber of Piles**	**Pile Dia-meter (in)**	**Wall Thick-ness (in)**	**182 dB iso-pleth (m)**	**12 psi iso-pleth (m)**
1	W	1	57	20	BML	No	1	48	1.5	154	377
1	W	2	57	80	BML	No	4	48	1.5	343	646
1	W	3	57	80	AML	Yes				470	830
2	W	4	806	80	BML	Yes				470	830
2	W	5	806	200	BML	Yes				781	1126
3	W	6	24	20	AML	Yes				250	522
3	W	7	24	80	AML	No	6	36	0.75	365	674
3	W	8	24	80	BML	No	1	64	2	343	646
3	W	9	24	200	BML	No	8	36	1.25	622	966
3	W	10	24	500	BML	No	1	96	3.5	1269	1564
4	W	11	893	80	BML	No	1	24	0.75	343	646
4	W	12	893	200	AML	Yes				781	1126
5	C	13	28	20	BML	No	3	30	1.5	152	373
5	C	14	28	20	AML	Yes				250	522
5	C	15	28	80	BML	No	6	36	1.75	326	624
5	C	16	28	200	BML	No		76	3	599	941
5	C	17	28	500	BML	No	4	68	3	1172	1481
6	C	18	1196	20	AML	Yes				250	522
6	C	19	1196	80	BML	Yes				470	830
7	C	20	2201	200	BML	Yes				781	1126
8	C	21	3226	80	BML	Yes				470	830
9	E	22	2794	20	AML	Yes				250	522
9	E	23	2794	80	BML	Yes				470	830
10	E	24	2446	20	AML	Yes				250	522

C- Central, E – Eastern, W – Western, AML – Above Mudline, BML – Below Mudline

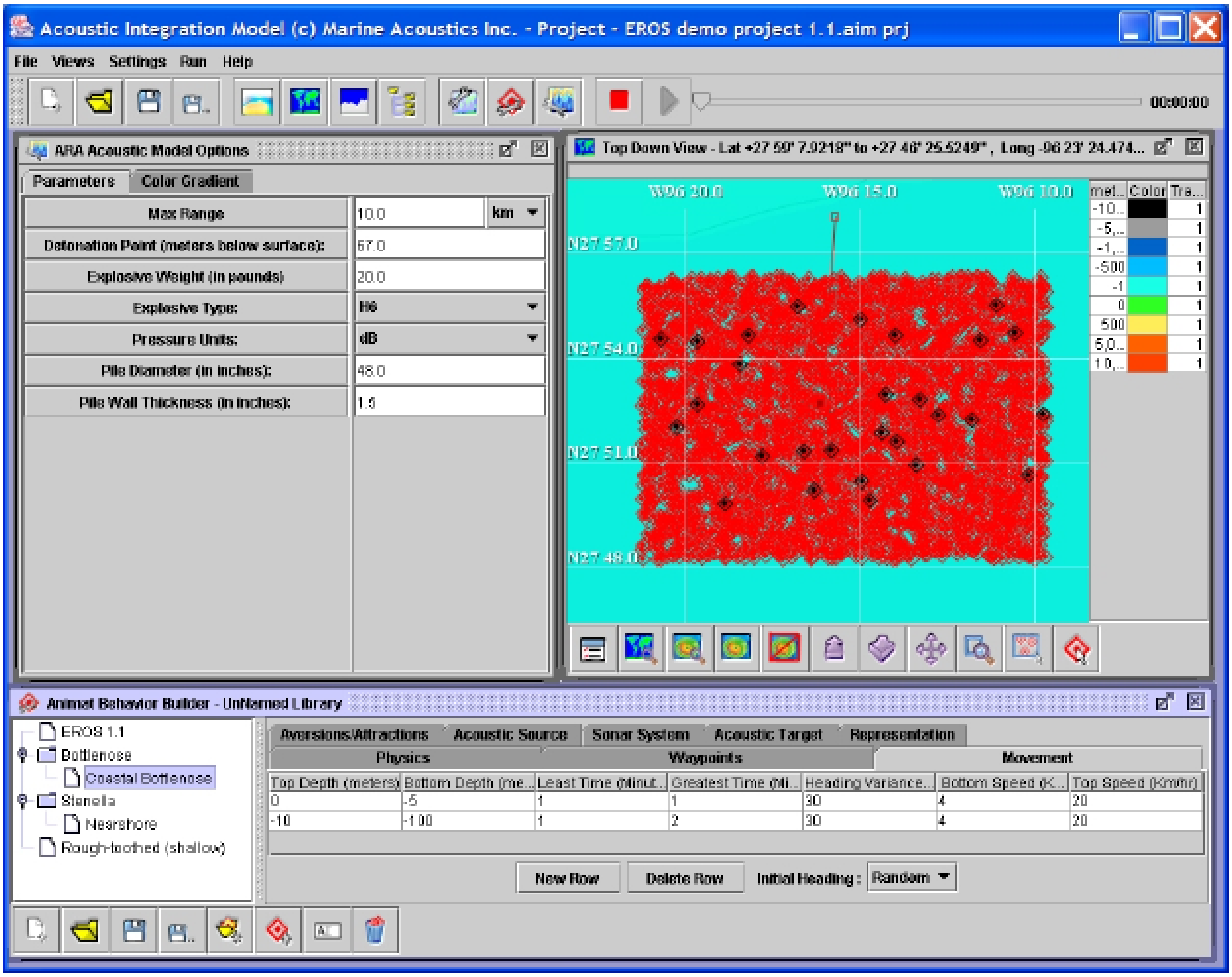

Figure 1. AIM model screen showing input of run parameters. (The upper left hand panel is where EROS source parameters are input for the ARA model. The upper right panel shows the geographic location of the simulation; the red and black icons represent different marine mammal species. The Red icons represent the “overpopulated” number of animals present in the simulation. The Black icons represent a random distribution based on real-world densities. The lower panel shows how the animal movement parameters are input into AIM.)

Species Modeled

Densities

Species densities are based upon two recent reports specified as the preferred data sources by MMS for describing cetacean distribution and abundance in the Gulf of Mexico. Fulling et al. (2003) analyzed data collected between 1998 and 2001 to determine the distribution and density of different species in the 20-200 m water depth range. Mullin and Fulling (in press) analyzed ship survey data from 1996 to 2001. They reported densities for all species in slope region (200-2,000 m water depth) the NW (Western and Central Planning Areas), the NE (Eastern Planning

Areas) as well as the abyssal region (depth > 2,000 m). The density estimates presented here were taken from these papers and are summarized in Tables 3-5.

Dive Behavior

Parameters describing species' diving behavior were taken from the existing MAI database. Documentation for this database is provided in Appendix A.

Table 3

Western and Central Shelf (20-200 m) Species Density
(data from Fulling et al. 2003)

Species	Density (animals/km^2)
bottlenose dolphin	0.095
Atlantic spotted dolphin	0.026
rough-toothed dolphin	0.006

Table 4

Western and Central Slope Area (200-2,000 m) Species Densities
(data from Fulling et al. 2003 and Mullin and Fulling in press)

Species	Density (animals/km^2)	Species	Density (animals/km^2)
Bryde's whale	0.00003	Fraser's dolphin	0.00067
sperm Whale	0.0043	Risso's dolphin	0.0063
Kogia spp.	0.0020	bottlenose dolphin	0.0025
Cuvier's beaked whale	0.0050	rough-toothed dolphin	0.0014
Mesoplodon spp.	0.0005	Atlantic spotted dolphin	0.0014
killer whale	0.0004	pantropical spotted dolphin	0.1351
Globicephala spp.	0.0185	Clymene dolphin	0.0482
Melon-headed wh	0.0267	striped dolphin	0.0251
false killer whale	0.00011	spinner dolphin	0.0010
pygmy killer whale	0.00037		

Table 5

Abyssal (>2,000 m) Species List and Densities
(data from Mullin and Fulling in press)

Species	Density (animals/km^2)	Species	Density (animals/km^2)
sperm whale	0.0037	Risso's dolphin	0.0043
Kogia spp.	0.0021	spinner dolphin	0.0042
Cuvier's beaked whale	0.0001	rough-toothed dolphin	0.0014
Mesoplodon spp.	0.0008	pantropical spotted	0.2983
pygmy killer whale	0.0022	Clymene dolphin	0.0583
false killer whale	0.0037	striped dolphin	0.0147
killer whale	0.0005		

Definition of "Take" within the Model Context

The exposures of simulated animals within each simulation were calculated every minute during a one hour simulation, in which the simulated animals were moving according to their programmed behavioral parameters. This ensured that each animal moved through its entire dive cycle. Therefore, 60 exposure levels were calculated for each animal. The reported exposure value for each animal was the highest of the 60 estimates calculated for each animal. A simulated animal was considered to have been "taken" if the exposure exceeded either the 182 dB re 1µPa^2-sec (within the appropriate 1/3 octave band) or the 12 psi peak criteria. The number of takes in each model run was scaled with the ratio of modeled and real-world animal densities to produce the Take Estimate per Event (TEPE).

Simulation Construction and Take Estimation

Each simulation was initiated with an "over-populated" model density of 10 animals/km^2. This density exceeds the actual value of number per km^2 of any species, but the linear "overpopulation" method helps to ensure that a reasonable distribution density of values will be obtained, i.e. a smoother and more continuous distribution curve with well-defined tails. This model density is corrected to the actual density when calculating takes, as explained below. The simulated animals were distributed in a 5 km square box around the source of the explosion. The ARA model was set to run out to 10 km, to insure that each animal received the signal. The model was set to run at 60-second intervals and each simulation lasted one hour. This was done in order to insure that each animal moved through a least one full dive cycle during the simulation.

Once the simulation was run, the maximum received level was calculated for each animal. The resulting distribution of received levels was plotted as a histogram. The number of animals exposed to received levels exceeding the criteria was determined. These were the "model" take numbers for each species and simulation. Both the 182 dB re $1\mu Pa^2$-sec and 12 psi 'take' numbers were reported. The larger of the two values was used as the modeled take for each species. These modeled 'take' values were then scaled to reflect the real-world density of the animals. This was calculated with the following formula:

Take Estimate per Event = number of "model" takes * (real / modeled density)

The simulation of an EROS event might produce 19 "modeled" takes for a given species. In this example, the density of animals was $0.095/km^2$ (Table 6, Column 3), and the take value of 19 is scaled with the ratio of 0.095 / 10 (real / modeled densities) to produce a Take Estimate per Event (TEPE) of 0.18 animals for this simulation (Table 6, Column 7). Because this calculation is based upon animal densities, and those densities are not exact, we used the reported variation in the density numbers to calculate upper and lower bounds of the TEPE. These bounds were determined by multiplying the TEPE by the coefficient of variation (CV) (Table 6, Column 4) for each animal's density estimate. The product was then added or subtracted from the TEPE to produce the upper and lower bounds (Table 6, Columns 8 and 9). To illustrate, the TEPE for this example was 0.18 and the CV was 0.30. Therefore, the upper and lower bounds of the take probability are 0.13 and 0.23, respectively.

Finally, the number of EROS events needed to produce a take was calculated by taking the inverse of the upper bound of the Take Estimate per Event (Table 6, Column 11). In this example, 1/0.23 = 4.3333, indicating that if four removals of this type took place, a single take would probably have occurred. A five year forecast of the number of predicted removals by planning areas and depth regime has been produced (Kaiser et al. 2002) and may be applicable to generate total number of takes.

Table 6

Example of Take Estimation Calculations

Run	Species	Density (animals/ sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
0	bottlenose dolphin	0.095	0.30	0.10	0.18	0.18	0.13	0.23	10.0	4

Results

Table 8 displays those examples of scenarios and species where the upper bound of the Take Estimate per Event exceeded 1.00. These examples were summarized here to illustrate the combinations of location, charge weight, and species that are most likely to generate takes. Four nearshore (shelf) examples involving bottlenose dolphins produced TEPE greater than one with small (20 lb) charges. All of the remaining 22 (out of 26) high-take scenarios resulted from the use of charges greater than 50 pounds. The TEPE are listed for all species and scenarios in Tables 9-22.

These tables list the Take Estimates per Event. In order to determine the total number of animals predicted to be taken for a year, or five year period, the total number of explosive removals that correspond to each scenario needs to be determined. Consider if there were 120 removals scheduled to be conducted in a five-year period that correspond to Scenario 3. The total five-year take would then be calculated as follows.

Number of Takes = Take Estimate per Event * Number of Events

In addition, the coefficient of variation for each species density can be used to estimate the upper and lower bounds of the total take estimate. This is achieved by multiplying the number of events by upper and lower bounds of the Take Estimate per Event, respectively. For this example, the take estimate for bottlenose dolphins would be 103 (C.I. 72-133), Atlantic spotted dolphins would be 25 (C.I. 15-36) and rough-toothed dolphins would be 6 (C.I. 0-11). The details of these calculations are shown in Table 7.

Table 7

Example Take Calculation for a Five-Year Period

Species	Density (animals/ sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Number of Events	Total Takes	Lower Bound	Upper Bound
bottlenose dolphin	0.095	0.30	0.39	0.86	0.86	0.60	1.11	120	103	72	133
Atlantic spotted dolphin	0.026	0.42	0.13	0.21	0.21	0.12	0.30	120	25	15	36
rough-toothed dolphin	0.006	0.98	0.02	0.05	0.05	0.00	0.09	120	6	0	11

Table 8

Scenarios that Produced Takes with a Single Explosive Removal
(Note that all examples are with charge weights greater than 50 lbs, with the exception of some nearshore cases with bottlenose dolphins.)

Loc-ation	Run	Charge Wt	Species	Density (animalsper sq. km)	C.V. of Den-sity	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
4	11	80	pantropical spotted dolphin	0.1351	0.84	3.28	0.53	6.04	41.7	1
5	17	500	bottlenose dolphin	0.095	0.30	2.63	1.84	3.42	10.0	1
3	10	500	bottlenose dolphin	0.095	0.30	2.34	1.64	3.04	10.0	1
2	5	200	pantropical spotted dolphin	0.1351	0.84	2.24	0.36	4.13	41.7	1
4	12	200	pantropical spotted dolphin	0.1351	0.84	2.01	0.32	3.70	41.7	1
5	16	200	bottlenose dolphin	0.095	0.30	1.70	1.19	2.21	10.0	1
3	9	200	bottlenose dolphin	0.095	0.30	1.43	1.00	1.86	10.0	1
1	3	80	bottlenose dolphin	0.095	0.30	1.35	0.94	1.75	10.0	1
4	11	80	Clymene dolphin	0.0482	0.73	1.17	0.32	2.03	64.3	1
5	15	80	bottlenose dolphin	0.095	0.30	1.17	0.82	1.52	10.0	1
3	7	80	bottlenose dolphin	0.095	0.30	1.02	0.71	1.32	10.0	1
2	4	80	pantropical spotted dolphin	0.1351	0.84	1.01	0.16	1.86	41.7	1
1	2	80	bottlenose dolphin	0.095	0.30	1.00	0.70	1.30	10.0	1
3	8	80	bottlenose dolphin	0.095	0.30	0.98	0.68	1.27	10.0	1
5	14	20	bottlenose dolphin	0.095	0.30	0.98	0.68	1.27	10.0	1
1	1	20	bottlenose dolphin	0.095	0.30	0.86	0.60	1.11	10.0	1

Table 8 (continued)

Scenarios that Produced Takes with a Single Explosive Removal
(Note that all examples are with charge weights greater than 50 lbs, with the exception of some nearshore cases with bottlenose dolphins.)

Loc-ation	Run	Charge Wt	Species	Density (animalsper sq. km)	C.V. of Den-sity	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
2	5	200	Clymene dolphin	0.0482	0.73	0.80	0.22	1.38	64.3	1
3	6	20	bottlenose dolphin	0.095	0.30	0.78	0.55	1.01	10.0	1
5	17	500	Atlantic spotted dolphin	0.026	0.42	0.72	0.42	1.03	15.6	1
4	12	200	Clymene dolphin	0.0482	0.73	0.72	0.19	1.24	64.3	1
3	10	500	Atlantic spotted dolphin	0.026	0.42	0.71	0.41	1.01	15.6	1
5	13	20	bottlenose dolphin	0.095	0.30	0.68	0.48	0.89	10.0	1
4	11	80	melon-headed whale	0.0267	0.55	0.63	0.28	0.98	65.0	1
4	12	200	melon-headed whale	0.0267	0.55	0.63	0.28	0.98	65.0	1
4	11	80	striped dolphin	0.0251	0.67	0.61	0.20	1.02	53.6	1
2	5	200	melon-headed whale	0.0267	0.55	0.44	0.20	0.69	65.0	1

Table 9

Take Estimates for Location 1 and Scenarios 1-3

Run	Species	Density (animals per sq. km)	C.V. of Density	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
1	bottlenose dolphin	0.095	0.30	0.39	0.86	0.86	0.60	1.11	10.0	1
1	Atlantic spotted dolphin	0.026	0.42	0.13	0.21	0.21	0.12	0.30	15.6	3
1	rough-toothed dolphin	0.006	0.98	0.02	0.05	0.05	0.00	0.09	14.0	11
2	bottlenose dolphin	0.095	0.30	0.54	1.00	1.00	0.70	1.30	10.0	1
2	Atlantic spotted dolphin	0.026	0.42	0.17	0.25	0.25	0.15	0.36	15.6	3
2	rough-toothed dolphin	0.006	0.98	0.03	0.05	0.05	0.00	0.11	14.0	9
3	bottlenose dolphin	0.095	0.30	0.85	1.35	1.35	0.94	1.75	10.0	1
3	Atlantic spotted dolphin	0.026	0.42	0.27	0.34	0.34	0.20	0.48	15.6	2
3	rough-toothed dolphin	0.006	0.98	0.05	0.08	0.08	0.00	0.16	14.0	6

Table 10

Take Estimates for Location 2 and Scenario 4

Run	Species	Density (animals per sq. km)	C.V. of den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produced a Take
4	Bryde's whale	0.00003	0.61	0.00	0.00	0.00	0.00	0.00	2.0	3,106
4	sperm whale	0.0043	0.37	0.00	0.03	0.03	0.02	0.05	1.8	21
4	*Kogia* spp.	0.002	0.49	0.00	0.01	0.01	0.01	0.02	2.2	60
4	Beaked Whale	0.0005		0.00	0.00	0.00				
4	Cuvier's beaked whale	0.0003	0.82	0.00	0.00	0.00	0.00	0.01	4.0	137
4	*Mesoplodon* spp.	0.0005	0.54	0.00	0.00	0.00	0.00	0.01	1.2	162
4	killer whale	0.0004	0.67	0.00	0.00	0.00	0.00	0.00	2.0	272
4	blackfish	0.0267		0.00	0.26	0.26				
4	*Globicephala* spp.	0.0185	0.48	0.00	0.18	0.18	0.09	0.27	34.2	4
4	melon-headed whale	0.0267	0.55	0.00	0.26	0.26	0.12	0.40	65.0	2
4	false killer whale	0.00011	0.71	0.00	0.00	0.00	0.00	0.00	28.5	548
4	pygmy killer whale	0.00037	0.60	0.00	0.00	0.00	0.00	0.01	9.5	174
4	Fraser's dolphin	0.00067	0.70	0.00	0.00	0.00	0.00	0.01	117.0	128
4	Risso's dolphin	0.0063	0.47	0.00	0.06	0.06	0.03	0.09	8.1	11
4	bottlenose dolphin	0.0025	0.95	0.00	0.02	0.02	0.00	0.04	5.6	25
4	rough-toothed dolphin	0.0014	1.00	0.00	0.02	0.02	0.00	0.04	15.0	27
4	*Stenella*	0.1351		0.00	1.01	1.01				
4	Atlantic spotted dolphin	0.0014	1.04	0.00	0.01	0.01	-0.04	2.07	15.0	1
4	pantropical spotted dolphin	0.1351	0.84	0.00	1.01	1.01	0.16	1.86	41.7	1
4	Clymene dolphin	0.0482	0.73	0.00	0.36	0.36	0.10	0.63	64.3	2
4	striped dolphin	0.0251	0.67	0.00	0.19	0.19	0.06	0.31	53.6	3
4	spinner dolphin	0.0085	0.71	0.00	0.06	0.06	0.02	0.11	164.0	9

Table 11

Take Estimates for Location 2 and Scenario 5

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produced a Take
5	Bryde's whale	0.00003	0.61	0.00	0.00	0.00	0.00	0.00	2.0	1,553
5	sperm whale	0.0043	0.37	0.00	0.05	0.05	0.03	0.07	1.8	14
5	*Kogia* spp.	0.002	0.49	0.00	0.02	0.02	0.01	0.03	2.2	34
5	beaked whale	0.0005		0.00	0.01	0.01				
5	Cuvier's beaked whale	0.0003	0.82	0.00	0.00	0.00	0.00	0.01	4.0	161
5	*Mesoplodon* spp.	0.0005	0.54	0.00	0.01	0.01	0.00	0.01	1.2	114
5	killer whale	0.0004	0.67	0.00	0.00	0.00	0.00	0.01	2.0	136
5	blackfish	0.0267		0.03	0.44	0.44				
5	*Globicephala* spp.	0.0185	0.48	0.02	0.31	0.31	0.16	0.45	34.2	2
5	melon-headed whale	0.0267	0.55	0.03	0.44	0.44	0.20	0.69	65.0	1
5	false killer whale	0.00011	0.71	0.00	0.00	0.00	0.00	0.00	28.5	320
5	pygmy killer whale	0.00037	0.60	0.00	0.01	0.01	0.00	0.01	9.5	102
5	Fraser's dolphin	0.00067	0.70	0.00	0.01	0.01	0.00	0.01	117.0	83
5	Risso's dolphin	0.0063	0.47	0.02	0.10	0.10	0.05	0.15	8.1	7
5	bottlenose dolphin	0.0025	0.95	0.01	0.04	0.04	0.00	0.07	5.6	14
5	rough-toothed dolphin	0.0014	1.00	0.00	0.03	0.03	0.00	0.05	15.0	19
5	*Stenella*	0.1351		0.50	2.24	2.24				
5	Atlantic spotted dolphin	0.0014	1.04	0.01	0.02	0.02	-0.09	4.57	15.0	1
5	pantropical spotted dolphin	0.1351	0.84	0.50	2.24	2.24	0.36	4.13	41.7	1
5	Clymene dolphin	0.0482	0.73	0.18	0.80	0.80	0.22	1.38	64.3	1
5	striped dolphin	0.0251	0.67	0.09	0.42	0.42	0.14	0.70	53.6	1
5	spinner dolphin	0.0085	0.71	0.03	0.14	0.14	0.04	0.24	164.0	4

Table 12

Take Estimates for Location 3 and Scenarios 6-10

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
6	bottlenose dolphin	0.095	0.30	0.22	0.78	0.78	0.55	1.01	10.0	1
6	rough-toothed dolphin	0.006	0.98	0.02	0.05	0.05	0.00	0.10	14.0	10
6	Atlantic spotted dolphin	0.026	0.42	0.12	0.24	0.24	0.14	0.34	15.6	3
7	bottlenose dolphin	0.095	0.30	0.46	1.02	1.02	0.71	1.32	10.0	1
7	rough-toothed dolphin	0.006	0.98	0.04	0.07	0.07	0.00	0.14	14.0	7
7	Atlantic spotted dolphin	0.026	0.42	0.17	0.29	0.29	0.17	0.41	15.6	2
8	bottlenose dolphin	0.095	0.30	0.43	0.98	0.98	0.68	1.27	10.0	1
8	rough-toothed dolphin	0.006	0.98	0.04	0.06	0.06	0.00	0.13	14.0	8
8	Atlantic spotted dolphin	0.026	0.42	0.15	0.28	0.28	0.16	0.40	15.6	3
9	bottlenose dolphin	0.095	0.30	0.85	1.43	1.43	1.00	1.86	10.0	1
9	rough-toothed dolphin	0.006	0.98	0.06	0.10	0.10	0.00	0.21	14.0	5
9	Atlantic spotted dolphin	0.026	0.42	0.30	0.41	0.41	0.24	0.59	15.6	2
10	bottlenose dolphin	0.095	0.30	1.95	2.34	2.34	1.64	3.04	10.0	1
10	rough-toothed dolphin	0.006	0.98	0.14	0.16	0.16	0.00	0.32	14.0	3
10	Atlantic spotted dolphin	0.026	0.42	0.58	0.71	0.71	0.41	1.01	15.6	1

Table 13

Take Estimates for Location 4 and Scenario 11

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
11	Bryde's whale	0.00003	0.61	0.00	0.00	0.00	0.00	0.00	2.0	N/A
11	sperm whale	0.0043	0.37	0.06	0.07	0.07	0.05	0.10	1.8	10
11	*Kogia* spp.	0.002	0.49	0.02	0.03	0.03	0.02	0.05	2.2	22
11	beaked whale	0.0005		0.01	0.01	0.01				
11	Cuvier's beaked whale	0.0003	0.82	0.00	0.00	0.00	0.00	0.01	4.0	116
11	*Mesoplodon* spp.	0.0005	0.54	0.01	0.01	0.01	0.00	0.01	1.2	82
11	killer whale	0.0004	0.67	0.01	0.01	0.01	0.00	0.01	2.0	86
11	Blackfish	0.0267		0.00	0.63	0.63				
11	*Globicephala* spp.	0.0185	0.48	0.00	0.44	0.44	0.23	0.65	34.2	2
11	melon-headed whale	0.0267	0.55	0.00	0.63	0.63	0.28	0.98	65.0	1
11	false killer whale	0.00011	0.71	0.00	0.00	0.00	0.00	0.00	28.5	225
11	pygmy killer whale	0.00037	0.60	0.00	0.01	0.01	0.00	0.01	9.5	72
11	Fraser's dolphin	0.00067	0.70	0.00	0.01	0.01	0.00	0.02	117.0	54
11	Risso's dolphin	0.0063	0.47	0.00	0.14	0.14	0.08	0.21	8.1	5
11	bottlenose dolphin	0.0025	0.95	0.00	0.06	0.06	0.00	0.12	5.6	8
11	rough-toothed dolphin	0.0014	1.00	0.00	0.03	0.03	0.00	0.07	15.0	15
11	*Stenella*	0.1351		2.59	3.28	3.28				
11	Atlantic spotted dolphin	0.0014	1.04	0.03	0.03	0.03	-0.13	6.70	15.0	1
11	pantropical spotted dolphin	0.1351	0.84	2.59	3.28	3.28	0.53	6.04	41.7	1
11	Clymene dolphin	0.0482	0.73	0.93	1.17	1.17	0.32	2.03	64.3	1
11	striped dolphin	0.0251	0.67	0.48	0.61	0.61	0.20	1.02	53.6	1
11	spinner dolphin	0.0085	0.71	0.16	0.21	0.21	0.06	0.35	164.0	3

Table 14

Take Estimates for Location 4 and Scenario 12

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
12	Bryde's whale	0.00003	0.61	0.00	0.00	0.00	0.00	0.00	2.0	1,553
12	sperm whale	0.0043	0.37	0.04	0.05	0.05	0.03	0.07	1.8	15
12	*Kogia* spp.	0.002	0.49	0.01	0.02	0.02	0.01	0.03	2.2	36
12	beaked whale	0.0005		0.00	0.01	0.01				
12	Cuvier's beaked whale	0.0003	0.82	0.00	0.00	0.00	0.00	0.01	4.0	173
12	*Mesoplodon* spp.	0.0005	0.54	0.00	0.01	0.01	0.00	0.01	1.2	123
12	killer whale	0.0004	0.67	0.00	0.00	0.00	0.00	0.01	2.0	146
12	blackfish	0.0267		0.25	0.44	0.44				
12	*Globicephala* spp.	0.0185	0.48	0.00	0.44	0.44	0.23	0.65	34.2	2
12	melon-headed whale	0.0267	0.55	0.00	0.63	0.63	0.28	0.98	65.0	1
12	false killer whale	0.00011	0.71	0.00	0.00	0.00	0.00	0.00	28.5	225
12	pygmy killer whale	0.00037	0.60	0.00	0.01	0.01	0.00	0.01	9.5	72
12	Fraser's dolphin	0.00067	0.70	0.00	0.01	0.01	0.00	0.01	117.0	85
12	Risso's dolphin	0.0063	0.47	0.06	0.10	0.10	0.05	0.15	8.1	7
12	bottlenose dolphin	0.0025	0.95	0.03	0.04	0.04	0.00	0.08	5.6	13
12	rough-toothed dolphin	0.0014	1.00	0.01	0.02	0.02	0.00	0.04	15.0	26
12	*Stenella*	0.1351		1.08	2.01	2.01				
12	Atlantic spotted dolphin	0.0014	1.04	0.01	0.02	0.02	-0.08	4.11	15.0	1
12	pantropical spotted dolphin	0.1351	0.84	1.08	2.01	2.01	0.32	3.70	41.7	1
12	Clymene dolphin	0.0482	0.73	0.39	0.72	0.72	0.19	1.24	64.3	1
12	striped dolphin	0.0251	0.67	0.20	0.37	0.37	0.12	0.62	53.6	2
12	spinner dolphin	0.0085	0.71	0.07	0.13	0.13	0.04	0.22	164.0	5

Table 15

Take Estimates for Location 5 and Scenarios 13-17

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
13	bottlenose dolphin	0.095	0.30	0.18	0.68	0.68	0.48	0.89	10.0	1
13	Atlantic Spotted dolphin	0.026	0.42	0.06	0.15	0.15	0.09	0.21	15.6	5
13	rough-toothed dolphin	0.006	0.98	0.01	0.03	0.03	0.00	0.07	14.0	15
14	bottlenose dolphin	0.095	0.30	0.41	0.98	0.98	0.68	1.27	10.0	1
14	Atlantic spotted dolphin	0.026	0.42	0.07	0.21	0.21	0.12	0.30	15.6	3
14	rough-toothed dolphin	0.006	0.98	0.02	0.05	0.05	0.00	0.10	14.0	10
15	bottlenose dolphin	0.095	0.30	0.56	1.17	1.17	0.82	1.52	10.0	1
15	Atlantic spotted dolphin	0.026	0.42	0.11	0.27	0.27	0.16	0.38	15.6	3
15	rough-toothed dolphin	0.006	0.98	0.03	0.06	0.06	0.00	0.12	14.0	9
16	bottlenose dolphin	0.095	0.30	1.15	1.70	1.70	1.19	2.21	10.0	1
16	Atlantic spotted dolphin	0.026	0.42	0.22	0.43	0.43	0.25	0.61	15.6	2
16	rough-toothed dolphin	0.006	0.98	0.06	0.09	0.09	0.00	0.17	14.0	6
17	bottlenose dolphin	0.095	0.30	2.10	2.63	2.63	1.84	3.42	10.0	1
17	Atlantic spotted dolphin	0.026	0.42	0.54	0.72	0.72	0.42	1.03	15.6	1
17	rough-toothed dolphin	0.006	0.98	0.12	0.14	0.14	0.00	0.29	14.0	3

Table 16

Take Estimates for Location 6 and Scenario 18

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
18	Bryde's whale	0.00003	0.61	0.00	0.00	0.00	0.00	0.00	2.0	N/A
18	sperm whale	0.0043	0.37	0.00	0.01	0.01	0.01	0.02	1.8	61
18	*Kogia* spp.	0.002	0.49	0.00	0.00	0.00	0.00	0.00	2.2	559
18	Beaked Whale	0.0005		0.00	0.00	0.00				
18	Cuvier's beaked whale	0.0003	0.82	0.00	0.00	0.00	0.00	0.00	4.0	366
18	*Mesoplodon* spp.	0.0005	0.54	0.00	0.00	0.00	0.00	0.00	1.2	433
18	killer whale	0.0004	0.67	0.00	0.00	0.00	0.00	0.00	2.0	N/A
18	Blackfish	0.0267		0.00	0.00	0.00				
18	*Globicephala* spp.	0.0185	0.48	0.00	0.00	0.00	0.00	0.00	34.2	N/A
18	melon-headed whale	0.0267	0.55	0.00	0.00	0.00	0.00	0.00	65.0	N/A
18	false killer whale	0.00011	0.71	0.00	0.00	0.00	0.00	0.00	28.5	N/A
18	pygmy killer whale	0.00037	0.60	0.00	0.00	0.00	0.00	0.00	9.5	N/A
18	Fraser's dolphin	0.00067	0.70	0.00	0.00	0.00	0.00	0.00	117.0	1176
18	Risso's dolphin	0.0063	0.47	0.00	0.00	0.00	0.00	0.00	8.1	N/A
18	bottlenose dolphin	0.0025	0.95	0.00	0.00	0.00	0.00	0.00	5.6	N/A
18	rough-toothed dolphin	0.0014	1.00	0.00	0.00	0.00	0.00	0.01	15.0	139
18	*Stenella*	0.1351		0.00	0.04	0.04				
18	Atlantic spotted dolphin	0.0014	1.04	0.00	0.00	0.00	0.00	0.08	15.0	12
18	pantropical spotted dolphin	0.1351	0.84	0.00	0.04	0.04	0.01	0.07	41.7	13
18	Clymene dolphin	0.0482	0.73	0.00	0.01	0.01	0.00	0.03	64.3	40
18	striped dolphin	0.0251	0.67	0.00	0.01	0.01	0.00	0.01	53.6	79
18	spinner dolphin	0.0085	0.71	0.00	0.00	0.00	0.00	0.00	164.0	229

Table 17

Take Estimates for Location 6 and Scenario 19

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
19	Bryde's whale	0.00003	0.61	0.00	0.00	0.00	0.00	0.00	2.0	N/A
19	sperm whale	0.0043	0.37	0.00	0.00	0.00	0.00	0.00	1.8	N/A
19	*Kogia* spp.	0.002	0.49	0.00	0.00	0.00	0.00	0.00	2.2	N/A
19	beaked whale	0.0005		0.00	0.00	0.00				
19	Cuvier's beaked whale	0.0003	0.82	0.00	0.00	0.00	0.00	0.00	4.0	N/A
19	*Mesoplodon* spp.	0.0005	0.54	0.00	0.00	0.00	0.00	0.00	1.2	N/A
19	killer whale	0.0004	0.67	0.00	0.00	0.00	0.00	0.00	2.0	N/A
19	blackfish	0.0267		0.00	0.00	0.00				
19	*Globicephala* spp.	0.0185	0.48	0.00	0.00	0.00	0.00	0.00	34.2	N/A
19	melon-headed whale	0.0267	0.55	0.00	0.00	0.00	0.00	0.00	65.0	N/A
19	false killer whale	0.00011	0.71	0.00	0.00	0.00	0.00	0.00	28.5	N/A
19	pygmy killer whale	0.00037	0.60	0.00	0.00	0.00	0.00	0.00	9.5	N/A
19	Fraser's dolphin	0.00067	0.70	0.00	0.00	0.00	0.00	0.00	117.0	N/A
19	Risso's dolphin	0.0063	0.47	0.00	0.00	0.00	0.00	0.00	8.1	N/A
19	bottlenose dolphin	0.0025	0.95	0.00	0.00	0.00	0.00	0.00	5.6	N/A
19	rough-toothed dolphin	0.0014	1.00	0.00	0.00	0.00	0.00	0.00	15.0	N/A
19	*Stenella*	0.2482		0.00	0.00	0.00				
19	Atlantic spotted dolphin	0.0014	1.04	0.00	0.00	0.00	0.00	0.00	15.0	N/A
19	pantropical spotted dolphin	0.1351	0.84	0.00	0.00	0.00	0.00	0.00	41.7	N/A
19	Clymene dolphin	0.0482	0.73	0.00	0.00	0.00	0.00	0.00	64.3	N/A
19	striped dolphin	0.0251	0.67	0.00	0.00	0.00	0.00	0.00	53.6	N/A
19	spinner dolphin	0.0085	0.71	0.00	0.00	0.00	0.00	0.00	164.0	N/A

Table 18

Take Estimates for Location 7 and Scenario 20

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
20	sperm whale	0.0037	0.32	0.02	0.03	0.03	0.02	0.04	2.3	25
20	*Kogia* spp.	0.0021	0.44	0.01	0.02	0.02	0.01	0.03	1.7	34
20	beaked whale	0.0008		0.00	0.01	0.01				
20	Cuvier's beaked whale	0.0001	0.75	0.00	0.00	0.00	0.00	0.00	1.0	749
20	*Mesoplodon* spp.	0.0008	0.58	0.00	0.01	0.01	0.00	0.01	1.0	104
20	blackfish	0.0037		0.03	0.05	0.05				
20	false killer whale	0.0022	1.00	0.02	0.03	0.03	0.00	0.06	65.0	16
20	pygmy killer whale	0.0037	0.60	0.03	0.05	0.05	0.02	0.09	9.5	12
20	killer whale	0.0005	0.66	0.01	0.01	0.01	0.00	0.01	2.7	71
20	Risso's dolphin	0.0043	0.66	0.00	0.00	0.00	0.00	0.01	7.8	126
20	rough-toothed dolphin	0.0014	0.84	0.00	0.00	0.00	0.00	0.01	25.0	113
20	*Stenella*	0.2983		0.00	0.00	0.00				
20	spinner dolphin	0.0042	0.64	0.00	0.00	0.00	0.00	0.01	70.0	127
20	pantropical spotted dolphin	0.2983	0.21	0.00	0.00	0.00	0.00	0.01	62.8	172
20	Clymene dolphin	0.0583	0.94	0.00	0.00	0.00	0.00	0.01	121.9	107
20	striped dolphin	0.0147	0.62	0.00	0.00	0.00	0.00	0.01	81.7	129

Table 19

Take Estimates for Location 8 and Scenario 21

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
21	sperm whale	0.0037	0.32	0.00	0.00	0.00	0.00	0.00	2.3	N/A
21	*Kogia* spp.	0.0021	0.44	0.00	0.00	0.00	0.00	0.00	1.7	N/A
21	beaked whale	0.0008		0.00	0.00	0.00				
21	Cuvier's beaked whale	0.0001	0.75	0.00	0.00	0.00	0.00	0.00	1.0	N/A
21	*Mesoplodon* spp.	0.0008	0.58	0.00	0.00	0.00	0.00	0.00	1.0	N/A
21	blackfish	0.0037		0.00	0.00	0.00				
21	false killer whale	0.0022	1.00	0.00	0.00	0.00	0.00	0.00	65.0	N/A
21	pygmy killer whale	0.0037	0.60	0.00	0.00	0.00	0.00	0.00	9.5	N/A
21	killer whale	0.0005	0.66	0.00	0.00	0.00	0.00	0.00	2.7	N/A
21	Risso's dolphin	0.0043	0.66	0.00	0.00	0.00	0.00	0.00	7.8	N/A
21	rough-toothed dolphin	0.0014	0.84	0.00	0.00	0.00	0.00	0.00	25.0	N/A
21	*Stenella*	0.2983		0.00	0.00	0.00				
21	spinner dolphin	0.0042	0.64	0.00	0.00	0.00	0.00	0.00	70.0	N/A
21	pantropical spotted dolphin	0.2983	0.21	0.00	0.00	0.00	0.00	0.00	62.8	N/A
21	Clymene dolphin	0.0583	0.94	0.00	0.00	0.00	0.00	0.00	121.9	N/A
21	striped dolphin	0.0147	0.62	0.00	0.00	0.00	0.00	0.00	81.7	N/A

Table 20

Take Estimates for Location 9 and Scenario 22

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
22	sperm whale	0.0037	0.32	0.00	0.00	0.00	0.00	0.00	2.3	N/A
22	*Kogia* spp.	0.0021	0.44	0.00	0.00	0.00	0.00	0.00	1.7	N/A
22	beaked whale	0.0008		0.00	0.00	0.00				
22	Cuvier's beaked whale	0.0001	0.75	0.00	0.00	0.00	0.00	0.00	1.0	N/A
22	*Mesoplodon* spp.	0.0008	0.58	0.00	0.00	0.00	0.00	0.00	1.0	N/A
22	blackfish	0.0037		0.00	0.00	0.00				
22	false killer whale	0.0022	1.00	0.00	0.00	0.00	0.00	0.00	65.0	N/A
22	pygmy killer whale	0.0037	0.60	0.00	0.00	0.00	0.00	0.00	9.5	N/A
22	killer whale	0.0005	0.66	0.00	0.00	0.00	0.00	0.00	2.7	N/A
22	Risso's dolphin	0.0043	0.66	0.00	0.00	0.00	0.00	0.00	7.8	N/A
22	rough-toothed dolphin	0.0014	0.84	0.00	0.00	0.00	0.00	0.00	25.0	N/A
22	*Stenella*	0.2983		0.00	0.00	0.00				
22	spinner dolphin	0.0042	0.64	0.00	0.00	0.00	0.00	0.00	70.0	N/A
22	pantropical spotted dolphin	0.2983	0.21	0.00	0.00	0.00	0.00	0.00	62.8	N/A
22	Clymene dolphin	0.0583	0.94	0.00	0.00	0.00	0.00	0.00	121.9	N/A
22	striped dolphin	0.0147	0.62	0.00	0.00	0.00	0.00	0.00	81.7	N/A

Table 21

Take Estimates for Location 9 and Scenario 23

Run	Species	Density (animals per sq. km)	C.V. of Density	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
23	sperm whale	0.0037	0.32	0.00	0.00	0.00	0.00	0.00	2.3	N/A
23	*Kogia* spp.	0.0021	0.44	0.00	0.00	0.00	0.00	0.00	1.7	N/A
23	beaked whale	0.0008		0.00	0.00	0.00				
23	Cuvier's beaked whale	0.0001	0.75	0.00	0.00	0.00	0.00	0.00	1.0	N/A
23	*Mesoplodon* spp.	0.0008	0.58	0.00	0.00	0.00	0.00	0.00	1.0	N/A
23	blackfish	0.0037		0.00	0.00	0.00				
23	false killer whale	0.0022	1.00	0.00	0.00	0.00	0.00	0.00	65.0	N/A
23	pygmy killer whale	0.0037	0.60	0.00	0.00	0.00	0.00	0.00	9.5	N/A
23	killer whale	0.0005	0.66	0.00	0.00	0.00	0.00	0.00	2.7	N/A
23	Risso's dolphin	0.0043	0.66	0.00	0.00	0.00	0.00	0.00	7.8	N/A
23	rough-toothed dolphin	0.0014	0.84	0.00	0.00	0.00	0.00	0.00	25.0	N/A
23	*Stenella*	0.2983		0.00	0.00	0.00				
23	spinner dolphin	0.0042	0.64	0.00	0.00	0.00	0.00	0.00	70.0	N/A
23	pantropical spotted dolphin	0.2983	0.21	0.00	0.00	0.00	0.00	0.00	62.8	N/A
23	Clymene dolphin	0.0583	0.94	0.00	0.00	0.00	0.00	0.00	121.9	N/A
23	striped dolphin	0.0147	0.62	0.00	0.00	0.00	0.00	0.00	81.7	N/A

Table 22

Take Estimates for Location 10 and Scenario 24

Run	Species	Density (animals per sq. km)	C.V. of Den-sity	182 dB Takes	12 psi Takes	Take Est. per Event	Lower Bound	Upper Bound	Pod Size	Number of Events Needed to Produce a Take
24	sperm whale	0.0037	0.32	0.00	0.00	0.00	0.00	0.00	2.3	N/A
24	*Kogia* spp.	0.0021	0.44	0.00	0.00	0.00	0.00	0.00	1.7	N/A
24	beaked whale	0.0008		0.00	0.00	0.00				
24	Cuvier's beaked whale	0.0001	0.75	0.00	0.00	0.00	0.00	0.00	1.0	N/A
24	*Mesoplodon* spp.	0.0008	0.58	0.00	0.00	0.00	0.00	0.00	1.0	N/A
24	blackfish	0.0037		0.00	0.00	0.00				
24	false killer whale	0.0022	1.00	0.00	0.00	0.00	0.00	0.00	65.0	N/A
24	pygmy killer whale	0.0037	0.60	0.00	0.00	0.00	0.00	0.00	9.5	N/A
24	killer whale	0.0005	0.66	0.00	0.00	0.00	0.00	0.00	2.7	N/A
24	Risso's dolphin	0.0043	0.66	0.00	0.00	0.00	0.00	0.00	7.8	N/A
24	rough-toothed dolphin	0.0014	0.84	0.00	0.00	0.00	0.00	0.00	25.0	N/A
24	*Stenella*	0.2983		0.00	0.00	0.00				
24	spinner dolphin	0.0042	0.64	0.00	0.00	0.00	0.00	0.00	70.0	N/A
24	pantropical spotted dolphin	0.2983	0.21	0.00	0.00	0.00	0.00	0.00	62.8	N/A
24	Clymene dolphin	0.0583	0.94	0.00	0.00	0.00	0.00	0.00	121.9	N/A
24	striped dolphin	0.0147	0.62	0.00	0.00	0.00	0.00	0.00	81.7	N/A

Discussion

The take predictions presented here are based upon the current dual criteria of 182 dB re 1 μPa^2-sec in a 1/3 octave band or the 12 psi peak pressure limit. These values are intended to correspond to the approximate onset of temporary threshold shift. It should be noted that there are indications that smaller, behavioral reactions may occur at larger ranges (Finneran et al. 2000). Nevertheless, these results indicate a low take number for each of these activities when considered independently. Most of the simulations that produced a Take Estimate per Event estimate greater than or equal to 1.0 were based upon charge weights greater than 50 pounds. The only small charge weight simulations that produced a take estimate per event equal to or greater than one were the shallow water runs, with the numerous bottlenose dolphin.

The Take Estimates per Event are statistical predictions and are valid for large numbers of events. The actual number of takes is a product of the take probabilities and the number of explosive removals forecast to be performed over a year or five-year period. It is important to understand the differences between these statistical predictions and the actual results of a single EROS event. The actual take of any single given event is likely to be either zero (no animals within range of the explosion) or greater than the statistical prediction, because the animals naturally occur in groups. Nevertheless the statistical predictions are valid for a large number of events.

To illustrate, the statistical prediction might be 1.0 animal taken per removal. If twenty such removals were conducted then the predicted take would be twenty animals. However, the density values used in these calculations are in terms of single animals per square kilometer. In reality, most of the species occur in groups of varying size. For our example animals, the pod size is 10. Therefore the probability of a pod being present during a single event is given by the Take Estimate per Event divided by the pod size. Therefore the Take Estimate per Event FOR A GROUP is 0.1. Over the course of twenty events, the probable take is 2.0, or 2 pods (multiply by 10 animals/pod), or twenty animals. The number of takes is the same given either method over the total number of events.

Other Potential Effects

Turtles are known to be attracted to offshore platforms, which apparently function as artificial reefs (Gitschlag and Herczeg 1994). It is suspected that these platforms may function to attract marine mammals. This is based upon observations of biologists working from oil and gas platforms (Weller, pers. comm.). However, there are no published data documenting such an effect. A survey in the northwestern Atlantic found no differences in cetacean abundance before and after oil structures were installed (Sorensen et al. 1984). If there was such an aggregative effect, it would probably be due to the structures acting as fish aggregating devices (FADs). Such stationary structures are known to support localized ecosystems that may serve as sources of prey for marine mammals (Fréon and Dagorn 2000; Castro et al. 2001). Should any attractive effect of the structures be found, then the take estimates should be adjusted upward.

Effect of Mitigation

All of these results are calculated without consideration of the potential effect of mitigation. Table 2 listed the site scenario ranges to the 182 dB re 1µPa^2-sec and 12 psi isopleths around the charges. These isopleths range between 152 and 1,564 meters. Only those simulations using 500 lb charges produced 'take' ranges greater than the current standard (941 meters) for aerial visual surveys (Kaiser et al. 2002). The existing mitigation procedures are likely to reduce the take numbers for some species. This is further reinforced by noting that most of the "high take" scenarios listed in Table 8 include dolphin species that are relatively easy to detect visually.

There are three basic mitigation procedures that can be used. The first is visual monitoring of the area. The effectiveness of visual monitoring is dependent upon the sightability of the animals, which varies between species (Clarke 1982). Some species, such as bottlenose dolphins are relatively easy to visually detect, occurring in medium sized groups and surfacing often. Sperm whales have long submergence times (Papastavrou et al. 1989), making them less likely to be detected visually. However, sperm whales produce frequent clicks that can be detected and tracked over long distances (Watkins and Moore 1982; Whitehead and Weilgart 1990). Passive acoustic monitoring is an extremely effective technique for vocal species such as sperm whales. There are some cryptic species, such as most beaked whales, that are difficult to detect visually and do not vocalize often. The most effective approach for mitigating the effects of EROS activities on these species would be the use of an active 'whale-finding' sonar.

Conclusion

These results indicate that the majority of EROS activities have a very low probability of actually taking an animal. Effective mitigation techniques can probably reduce the actual takes and may be able to reduce this activity to a "no effects" status. This is especially likely when charge size is limited to 50 pounds or less.

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Attachment

Marine Mammal Behavioral Analysis for Minerals Management Service Analyses

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24 March 2004

Table of Contents

Introduction

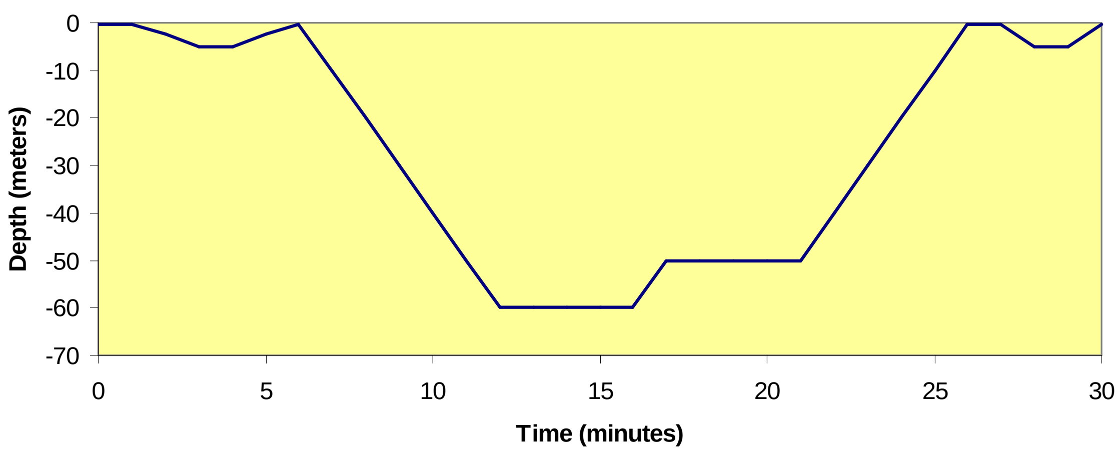
It is a general characteristic of any model that the quality of the results is dependent upon the quality of the inputs to the model. The Acoustic Integration Model © (AIM) is built around the realistic modeling of 1) acoustic sources and propagation and 2) the accurate modeling of animal behavior. Both of these are necessary in order to realistically predict the exposure of marine mammals to an acoustic source, because the complicated nature of acoustic propagation makes the depth of an animal as important as its range from the source.

The AIM model has been used to predict exposures of different species to different acoustic sources. In order to properly conduct these simulations, the behavioral parameters for different species have been gleaned from repeated literature searches. The results of these searches have been tabulated into a growing database of species behavioral characteristics. This document is intended to summarize these behavioral values and provide references to the original sources that were reviewed to construct this database.

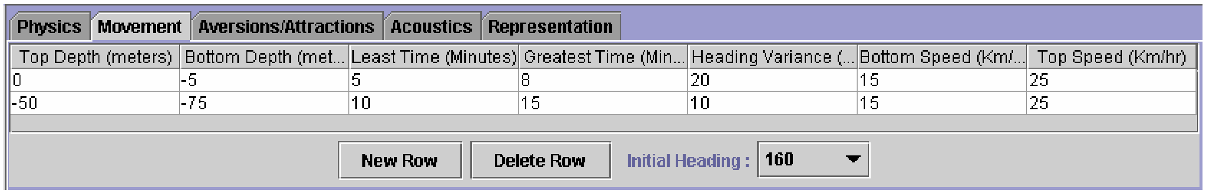
Model Parameters

Movement

Animals move through four dimensions: three-dimensional space and time. Several movement parameters are used in the model to produce a simulated movement pattern that accurately represents real animal movements. A typical dive pattern is shown below. It consists of two phases; the first is a shallow respiratory sequence, which is followed by a deeper, longer dive.



These two phases are represented in the model with the values as input into the box below.



Top Depth (meters)	Bottom Depth (met...	Least Time (Minutes)	Greatest Time (Min...	Heading Variance (...	Bottom Speed (Km/...	Top Speed (Km/hr)
0	-5	5	8	20	15	25
-50	-75	10	15	10	15	25

The top row has the values for the shallow, respiratory dive. The animal dives from the surface to a maximum depth of 5 meters. It is followed by the second line, which describes the second phase of the dive. In this phase the animal dives to a depth between 50 and 75 meters. In this example, the animal spends time at both 60 and 50 meters before surfacing. The pattern then repeats.

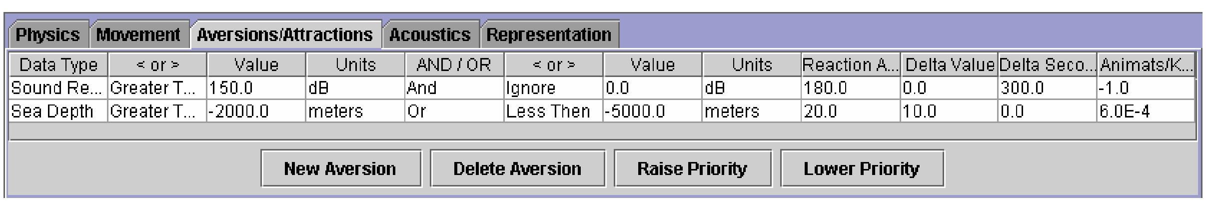
The horizontal component of the course is handled with the 'heading variance' term. It allows the animal to turn up to a certain number of degrees at each movement step. In this case, the animal can change course 20 degrees on the surface, but only 10 degrees underwater. This example is for a narrowly constrained set of variables, appropriate for a migratory animal.

Heading Variance

There is little data that summarizes movement in terms of heading variance, or the amount of course change per unit time. Therefore the default value used in the modeling is 30 degrees. Exceptions are made for migratory animals, which tend to have more linear travel, therefore these animals typically are assigned a value of 10 degrees. Foraging animals tend to have less linear travel, as they may be trying to remain within a food patch. Therefore foraging animals are assigned a higher heading variance value, typically 45 to 60 degrees.

Aversions

In addition to movement patterns, the animats can be programmed to avoid certain environmental characteristics. For example, this can be used to constrain an animal to a particular depth regime. The example below constrains the animal to waters between 2000 and 5000 meters deep.



Data Type	< or >	Value	Units	AND / OR	< or >	Value	Units	Reaction A...	Delta Value	Delta Seco...	Animats/K...
Sound Re...	Greater T...	150.0	dB	And	Ignore	0.0	dB	180.0	0.0	300.0	-1.0
Sea Depth	Greater T...	-2000.0	meters	Or	Less Then	-5000.0	meters	20.0	10.0	0.0	6.0E-4

Baleen Whales

Sei/Bryde's Whale

There is a paucity of data for these species. Since they are similar in size, data for both species have been pooled to derive parameters for these two species.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance	Min Speed (km/h)	Max Speed (km/h)	Depth Limit/ Reaction Angle
Sei/Bryde's whale	1	2	50	150	2	11	30	2	20	50/135

Dive Depth

Inferred from other species

Dive Time

Dive times ranged between 0.75 and 11 minutes, with a mean duration of 1.5 minutes (Schilling et al. 1992). Most of the dives were short in duration, presumably because they were associated with surface or near-surface foraging. The same paper reported surface times that ranged between 2 second and 15 minutes.

Heading Variance

Observations of foraging sei whales found that they had a very high reorientation rate, frequently resulting in minimal net movement (Schilling et al. 1992).

Speed

A tagging study found an overall speed of advance for sei whales was of 4.6 km/h (Brown 1977). The highest speed reported for a Bryde's whale was 20 km/h (Cummings 1985).

Habitat

Sei whales are known to feed on shallow banks, such as Stellwagen Bank (Kenney and Winn 1986). Therefore Sei and Bryde's whales are allowed to move into shallow water.

Large Odontocetes

Sperm Whale

Currently, sperm whales are modeled with a single animat. In the future, we should create separate animats for males and females, since their behavior is so different.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h) (s/d)	Max Speed (km/h) (s/d)	Depth Limit/ Reaction Angle
Sperm whale	6	11	300	1400	20	65	20	0/3	3/8	480/135

Dive Depth

The maximum, accurately measured, sperm whale dive depth was 1,330 meters (Watkins et al. 2002). Foraging dives typically begin at depths of 300 meters (Papastavrou et al. 1989).

Dive Time

Sperm whale dive times average 44.4 min in duration and range from 18.2-65.3 minutes (Watkins et al. 2002).

Speed

Sperm whales are typically slow or motionless on the surface. Mean surface speeds of 1.25 km/h (Jaquet et al. 2000) and 3.42 km/h (Whitehead et al. 1989). Their mean dive rate ranges from to 8.04 km/h (Lockyer 1997).

Habitat

Sperm whales are found almost everywhere, but they are usually in water deeper than 480 meters (Davis et al. 1998).

Beaked Whales

Data on the behavior of beaked whales is sparse. Therefore, all beaked whale species have been pooled into a single animat.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h) (s/d)	Max Speed (km/h) (s/d)	Depth Limit / Reaction Angle
Beaked whale	3	5	120	1453	16	70	30	3	6	253/135

Dive Depth

The minimum and maximum dive depth measured for a beaked whale was 120 and 1453 meters respectively (Hooker and Baird 1999).

Dive Time

The minimum and maximum dive time measured was 16 and 70.5 minutes respectively (Hooker and Baird 1999).

Speed

Dive rates averaged 1 m/s or 3.6 km/h (Hooker and Baird 1999). A mean surface speed of 5 km/h was reported by (Kastelein and Gerrits 1991).

Habitat

The minimum sea depth in which beaked whales were found was 253 meters (Davis et al. 1998).

Dwarf and Pygmy Sperm Whales (Kogia spp.)

Data on dwarf and pygmy sperm whales are rare, and these species are very similar, so data for these two species have been combined.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h) (s/d)	Max Speed (km/h) (s/d)	Depth Limit/ Reaction Angle
Kogia spp.	1	2	200	800	5	12	30	0	11	176/135

Dive Depth

In the Gulf of Mexico, Kogia were found in waters less than 1000 meters, along the upper continental slope (Baumgartner et al. 2001). Therefore the dive limits of 200-800 meters were chosen based on similar species diving deeply to feed, and within the physical constraints of the environment. It should be noted that Kogia have been seen in water almost 2000m deep (Davis et al. 1998), but they may not be diving to the bottom.

Dive Time

Maximum dive time reported for Kogia is 12 minutes (Hohn et al. 1995).

Speed

Tracking of a rehabilitated pygmy sperm whale found that speeds range from 0 to 6 knots (11 km/h) with a mean value of 3 knots (Scott et al. 2001).

Habitat

The minimum depth that Kogia was found in the Gulf of Mexico was 176 meters (Davis et al. 1998).

Blackfish: False Killer Whale, Melon-headed Whale, Pilot Whale

Studies describing the movements and diving patterns of these animals are rare and sparse. Therefore, they have been combined into a single "blackfish" category. As more data become available, these species will be split into separate animats.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h)	Max Speed (km/h)	Depth Limit/ Reaction Angle
Blackfish	2	5	200	1000	2	12	30	2	22.4	200/135

Dive Depth

Long-finned pilot whales in the Mediterranean were observed to display considerable diurnal variation in their dive depths. During the day they never dove to more than 16 meters. However, at night, they dove to a maximum depth of 648 meters (Baird et al. 2002).

Dive Time

Only one study has TDR data on pilot whales (to date). (Baird et al. 2002) reported on dives of two individuals, and dive times varied between 2.14 and 12.7 minutes.

Speed

Maximum speed recorded for false killer whales was 8.0 m/s (28.8 km/h) (Rohr et al. 2002), although the typical cruising speed is typically 20-24% less than the maximum speed (Fish and Rohr 1999). This "typical" maximum of 6.24 m/s (22 km/h) was used for AIM.

Shane (1995) reported a minimum speed of 2 km/h and a maximum of 12 km/h for pilot whales. It is believed that the Rohr et al. (2002) value is more accurate for maximum speed.

Habitat

The minimum water depth that pilot whales were seen in the Gulf of Mexico was 246 m (Davis et al. 1998).

Killer Whale

There is a remarkable paucity of quantitative data available for Killer whales, considering their coastal habitat and popular appeal. Nevertheless, most data from "blackfish" were used to model orca, with the exception of dive depth. The different feeding ecology of these species makes very deep dives apparently unnecessary. When additional data allow, we need to develop separate animats for "resident" and "transient" killer whales.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h)	Max Speed (km/h)	Depth Limit / Reaction Angle
Killer whale	1	5	10	180	1	10	30	6	10	25/135

Dive Depth

Killer whales feeding on herring were observed to dive to 180 meters (Nøttestad et al. 2002). Killer whales are found in at least two "races", transients and residents. Transients feed primarily on marine mammals whereas residents feed primarily on fish. Residents were reported to dive to the bottom (173m) (Baird 1994). Baird (1994) also reported that while residents dive deeper than transients, the transients spent a far greater amount of time in deeper water. Resident killer whales in the Pacific northwest dove to a maximum depth of 201 meters (Baird et al. 1998).

Dive Time

No data on dive times available – data from other species used.

Speed

No data available – data from other species used.

Habitat

Killer whales are known to occur in very shallow water (e.g. rubbing beaches) as well as cross open ocean basins. However, they are usually coastal and most often found in temperate waters.

Small Odontocetes

Risso's Dolphin

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h)	Max Speed (km/h)	Depth Limit/ Reaction Angle
Risso's dolphin	1	3	150	1000	2	12	30	2	12	150/135

Dive Depth

Dive depths of 150-1000 meters were inferred from its squid-eating habits, and from similar species.

Dive Time

No data on divetimes could be found. The values for blackfish, which have a similar ecological niche, were used.

Speed

Risso's dolphins off Santa Catalina Island were reported to have speeds that range between 2 and 12 km/h (Shane 1995).

Habitat

Risso's dolphins were seen in water deeper than 150 meters in the Gulf of Mexico (Davis et al. 1998). In the Gulf of Mexico they were most often observed between 300 and 750 meters. Off Chile they were seen in waters deeper than 1000 meters. In all cases this association seems to be driven by the local oceanographic upwelling conditions that increase primary productivity.

Bottlenose Dolphin

In many environments there can be coastal and pelagic stocks of bottlenose dolphins. This is certainly the case off the east coast of the United States, however defining the range of offshore form is difficult (Wells et al. 1999). Regardless of the genetic differences that may exist between these two forms, they frequently occur at different densities, and so they are split into two animat categories.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h)	Max Speed (km/h)	Depth Limit/ Reaction Angle
Bottlenose (coastal)	1	1	15	98	1	2	30	4	30	10/80
Bottlenose (pelagic)	1	1	15	200	1	2	30	4	30	101/1,226

Dive Depth

The maximum recorded dive depth for wild bottlenose dolphins is 200 meters (Kooyman and Andersen 1969). A satellite tagged dolphin, in Tampa Bay had a maximum dive depth of 98 meters (Mate et al. 1995). This value was used as the maximum dive depth for the coastal form of bottlenose.

Dive Time

Measured surface times ranged from 38 seconds to 1.2 minutes (Lockyer and Morris 1986; Lockyer and Morris 1987; Mate et al. 1995).

Speed

Bottlenose dolphins were observed to swim, for extended period, at speeds of 4 to 20 km/h, although they could burst at up to 54 km/h (Lockyer and Morris 1987). A more recent analysis found that maximum speed of wild dolphins was 5.7 m/s (20.5 km/h), although trained animals could double this speed when preparing to leap (Rohr et al. 2002).

Habitat

In the Gulf of Mexico, bottlenose where observed in water depths between 101 and 1,226 meters (Davis et al. 1998), However tagged animals have been observed to swim into water 5,000 meters deep (Wells et al. 1999).

Stenella: Clymene, Spinner, Spotted, and Striped Dolphins

Most *Stenella* species have strong diurnal variation in their behavior. We should build separate daytime and nighttime animats for this species, which requires a new ability in AIM. A temporary approach would be to populate the area with both types of animats, and then scale them by the local photoperiod.

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h)	Max Speed (km/h)	Depth Limit/ Reaction Angle
Stenella	1	1	10	400	1	4	30	2	20	100

Dive Depth

Spinner dolphins feed during the night, and rest inshore during the daytime. At night they dive to about 400 meters to feed (Dolar et al. 2003).

Pantropical spotted dolphins off Hawai‘i also dive deeper at night than during the day. The maximum daytime depth was 122 meters, whereas the nighttime maximum was 213 meters (Baird et al. 2001).

Dive Time

Pantropical spotted dolphins off Hawai‘i had a mean dive duration of 1.95 min (SD=0.92) (Baird et al. 2001), so a three minute dive time maximum was used for modeling purposes. An Atlantic spotted dolphin tagged with a satellite linked TDR had a maximum dive time of 3.5 minutes (Davis et al. 1996).

Speed

The mean speed of striped dolphins in the Mediterranean was 6.1 knots (11 km/h), and were observed to burst to 32 kts (Archer and Perrin 1999). A maximum speed of 20 km/h was chosen as a typical (non-burst) maximum speed.

Habitat

In the Gulf of Mexico, spinner dolphins were seen in water deeper than 526 meters, striped dolphins were seen in water deeper than 570 meters and spotted dolphins were seen in water deeper than 102 meters(Davis et al. 1998). Spinner dolphins in Hawai’i are known to move into shallow bays during the day (Norris and Dohl 1980).

Fraser's Dolphin

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h)	Max Speed (km/h)	Depth Limit/ Reaction Angle
Fraser's dolphin	1	1	10	600	1	4	30	2	20	100

Dive Depth

Fraser's dolphins dive to about 600-700 meters to feed, much deeper than spinner dolphins (Dolar et al. 2003). All other behavioral parameters are taken from *Stenella* species, since there are no direct data for Fraser's dolphin.

Rough-toothed Dolphin

Model Parameters

	Min. Surface Time (min)	Max Surface Time (min)	Min Dive Depth (m)	Max Dive Depth (m)	Min Dive Time (min)	Max Dive Time (min)	Heading Variance (surf/dive)	Min Speed (km/h)	Max Speed (km/h)	Depth Limit/ Reaction Angle
Rough-toothed dolphin	1	3	50	600	3	15	30	5	20	194/135

Dive Depth

No dive depth data is available; depths are based upon other species.

Dive Time

The maximum dive time reported for rough-toothed dolphins was 15 minutes (Miyazaki and Perrin 1994). A more typical range was 0.5 to 3.5 minutes (Ritter 2002).

Speed

Bow-riding *Steno* were observed at 16 km/h (Watkins et al. 1987). Porpoising *Steno* off the Canary Islands were tracked at ">3 knots" (Ritter 2002).

Habitat

Rough-toothed dolphins were seen in water deeper than 194 meters (Davis et al. 1998). Dolphins off the Canary Islands were most often seen in water 100-1000 m deep, with occasional shallow water sightings, and one group was seen in water 2500 m deep (Ritter 2002).

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Appendix E

Take-Estimate Calculations for Explosive-Severance Activities Conducted under the Proposed Action

Take-Estimate Calculations for Explosive-Severance Activities Conducted under the Proposed Action

Introduction

Underwater detonations of explosive-severance tools have the potential to cause negative physical impacts on marine mammals in the vicinity of structure-removal operations on the Outer Continental Shelf (OCS) of the Gulf of Mexico (GOM). The impacts could range from tactile perception and discomfort (harassment) to injury and mortality depending upon the amount of explosives used, charge configuration and placement, and the distance between the detonation and proximal animals. These impacts, or 'takes,' are defined by the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1361 *et seq.*) as,

> any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to migration, breathing, nursing, breeding, feeding, or sheltering.

The terms Level A and Level B harassment correspond to paragraphs (A)(i) and (A)(ii), respectively. The MMPA allows the Secretary of Commerce to allow a small number "takes" incidental to certain activities upon request to the National Oceanographic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries). This take-authorization responsibility charges NOAA Fisheries with establishing the impact criteria and thresholds necessary for determining when a marine mammal take would occur.

As discussed in Chapter 1.3.2 of this programmatic environmental assessment (PEA), NOAA Fisheries requested and the Minerals Management Service (MMS) agreed to petition for the next issuance of incidental-take regulations under Subpart I of the MMPA regulations (50 CFR 216.104). Data required in the petition "package" includes detailed descriptions of structure-removal activities that have the potential of resulting in incidental take, the scope and duration of these activities, and the suggested means of mitigating potential takes and accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species. Similarly, MMS must also determine the types of takes projected (§216.104(a)(5)) and estimate the number of marine mammals that may be taken under each level (§216.104(a)(6)).

In order to acquire the take data necessary for an appropriate National Environmental Policy Act (NEPA) analysis and to meet the petitioning guidelines of an incidental-take rulemaking application, fundamental modeling components required contracting, development, and evaluation. Under continuous guidance provided by NOAA Fisheries, MMS undertook the incidental-take determination and estimation tasking in the following steps:

- impact criteria/thresholds establishment,
- predictive modeling of detonation pressure/energy propagation,
- propagation model verification and utilization,
- predictive modeling of marine mammal take estimates, and
- take-estimate calculations and summaries

A discussion of each step is found below.

Impact Criteria and Thresholds Establishment

When the U.S. Navy requested "incidental take" for shock-trial testing of the USS *Winston Churchill* (66 FR 22450, May 4, 2001), NOAA Fisheries accepted the impact criteria and thresholds established in its environmental impact statement (EIS; U.S. Navy, 2001) as the best available science on underwater explosions (69 FR 21819, April 22, 2004). Despite the operational differences between shock-trial testing and explosive-severance activities, the extensive marine mammal impact and detonation effect research conducted for and presented in the EIS remained applicable for the purpose of analyses. The thresholds and criteria presented in the Churchill EIS and summarily adopted by MMS for use in this document and petition application are listed in Table E-1.

Table E-1

Impact Terminology for Marine Mammals from Underwater Explosives

Impact Level	Criterion	Threshold	Range
Level B *(Harassment)*	Temporary threshold shift (TTS)	12 psi, *or* 182 dB re 1 $\mu\text{Pa}^2\text{-s}^{1/3\ \text{Octave Band}}$	The maximum horizontal distance from the detonation to the point where the ***threshold level*** is predicted to occur.
Level A *(Injury)*	Incidence of 50-percent tympanic-membrane (TM) rupture and the onset of slight lung hemorrhage	100 psi*, *or* 205 dB re 1 $\mu\text{Pa}^2\text{-s}^{1/3\ \text{Octave Band}}$	
Mortality	Onset of extensive lung hemorrhage	30.5 psi-ms	

**from* Ketten, 1995.

Predictive Modeling of Detonation Pressure/Energy Propagation

To help determine the ranges for the blasting categories anticipated under the proposed action, MMS contracted Applied Research Associates (ARA), Inc. to develop a model and prepare a report that would estimate shock wave and acoustic energy propagation caused by underwater explosive-severance tools (Appendix B; Dzwilewski and Fenton, 2003). In addition to incorporating previous research on open-water or above-mudline (AML) explosions, ARA developed their "UnderWater Calculator" (UWC) to consider the overall reduction of energy released into the water column resulting from below-mudline (BML) detonations. Therefore, in application, the UWC can be configured so that its propagation estimates reflect either open-water/AML conditions or the affects of BML "attenuation"; the pressure and acoustic energy reduction related to its absorption by the surrounding sediments and the severance target.

As with most "theoretical" models developed to consider a wide range of parameters under multiple conditions, ARA suggested that the UWC results be repeatedly compared with *in-situ* data from actual explosive-severance activities (Dzwilewski and Fenton, 2003). A previous *in-situ* measurement attempt performed by the Naval Surface Warfare Center (NSWC; Conner, 1990) provided data on BML severances conducted at an OCS facility and similitude equations based on the study results. However, uncertainties concerning transducer ranging led NOAA Fisheries to devalue Conner's attenuation conclusions and after review of ARA's work, determine that before any BML propagation results from the UWC could be used in mitigation development or incidental-take rulemaking, additional *in-situ* data comparison must be conducted.

Propagation Model Verification and Utilization

In November 2002, MMS's Technology Assessment and Research (TAR) Program began working with MMS's GOM Region to modify an existing project designed to develop and test the efficiency of linear-shaped charges (LSC; http://www.mms.gov/tarprojects/429.htm). The modifications made it possible to allow BML, *in-situ* data measurements to be taken during the final testing on actual OCS targets. While developing the measurement phase of the project, MMS coordinated with NOAA Fisheries to address the concerns expressed over Conner's range uncertainties, ultimately modifying field procedures to include the use of a sector-scanning sonar in conjunction with reflectors attached to each transducer array string. The testing was conducted, and Annex B of the project's final report (Appendix C of this document) compares the peak overpressure (psi), impulse (psi-s), and energy flux density (EFD; psi-in) measurements collected from the testing with calculated results from both the ARA UWC and the applicable Conner similitude equations. In all but two occurrences/outliers (i.e., 4.05-lb LSC peak overpressure; transducers H and I), the ARA UWC range projections were much greater than those actually recorded (Saint-Arnaud et al., 2004). An example of the peak overpressure projections and actual 50-lb bulk charge measurements is provided in Figure E-1.

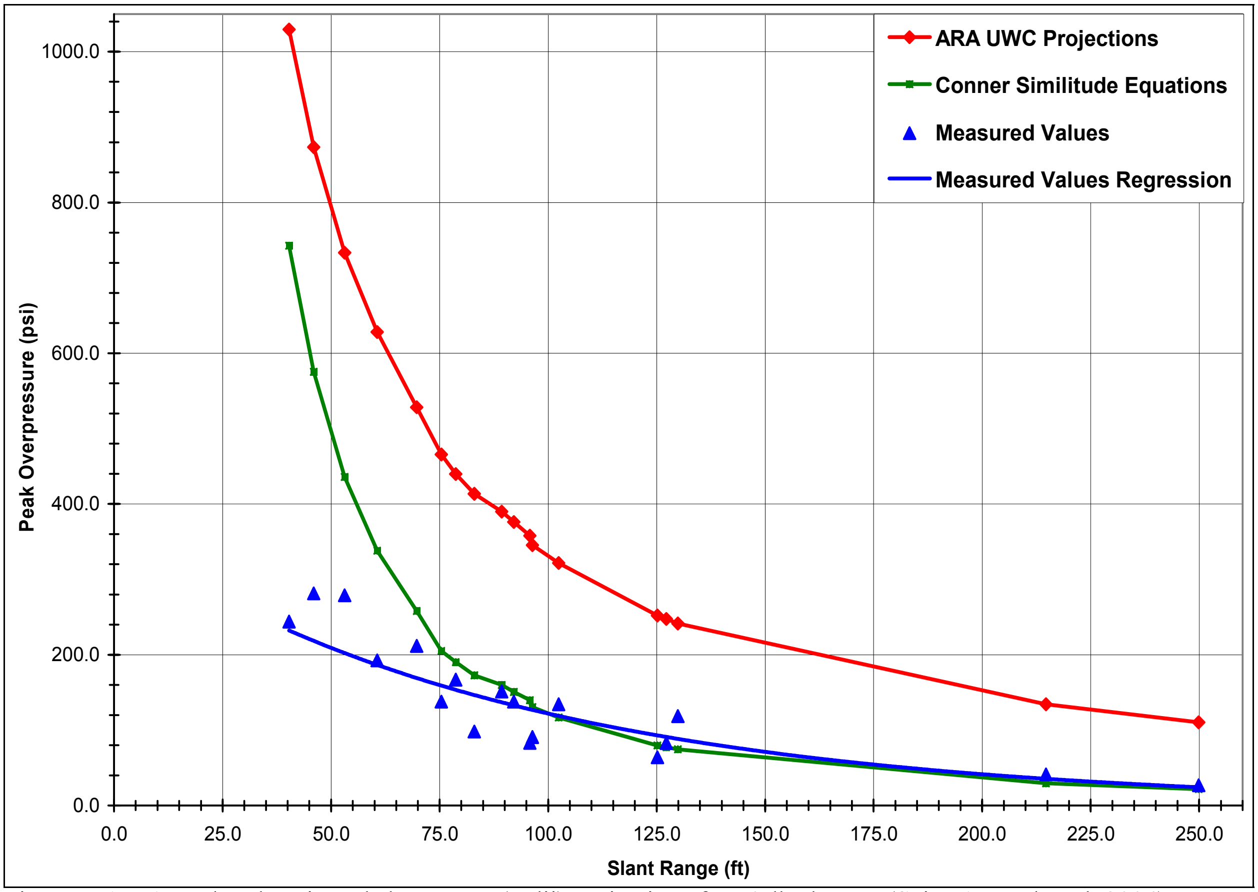

Figure E-1. Actual and projected slant range (radii) projections for 50-lb charges (Saint-Arnaud et al, 2004).

The comparisons of impulse and EFD indicated an even greater disparity between the ARA UWC calculations and *in-situ* measurements and in several instances; the UWC values were over 10-times greater than the actual readings. Based upon the comparison discussion and subsequent coordination with NOAA Fisheries, MMS determined that the impact ranges projected by ARA's UWC were highly conservative and would result in highly-protective impact-zone calculations. Therefore, MMS feels confident in using the UWC for both incidental-take estimate calculations and mitigation development for marine protected species (MPS).

The "dual" take thresholds for both Level B and Level A require that the ranges for each be calculated, with the greatest (most conservative/protective) distance taken as the range at which a take would occur. Using the "back-calculation" feature of the ARA UWC, MMS established that the peak pressure thresholds (12 psi/100 psi) would produce the largest impact radii for both Level B and Level A takes for all five blasting categories regardless of configuration. To aid in limiting the number of scenarios required for use in take-estimate modeling and subsequent mitigation development, the resultant impact zones were derived using only the upper range of each category in both BML and AML configurations (Table E-2).

Table E-2

Level B and Level A Impact Zone Radii for Blasting Categories and Severance Scenarios

Blasting Category	Severance Scenarios	Configuration *(Charge Range)*	Level B (12 psi) Impact Zone Radii	Level A (100 psi) Impact Zone Radii
Very-Small Blasting	A1, A2	BML *(0-10 lb)*	261 m (856 ft)	46 m (151 ft)
	A3, A4	AML *(0-5 lb)*	285 m (935 ft)	52 m (171 ft)
Small Blasting	B1, B2	BML *(>10-20 lb)*	373 m (1,224 ft)	59 m (194 ft)
	B3, B4	AML *(>5-20 lb)*	522 m (1,714 ft)	82 m (269 ft)
Standard Blasting	C1, C2	BML *(>20-80lb)*	631 m (2,069 ft)	99 m (325 ft)
	C3, C4	AML *(>20-80lb)*	829 m (2,721 ft)	130 m (427 ft)
Large Blasting	D1, D2	BML *(>80-200 lb)*	941 m (3,086 ft)	151 m (495 ft)
	D3, D4	AML *(>80-200 lb)*	1,126 m (3,693 ft)	176 m (577 ft)
Specialty Blasting	E1, E2	BML *(>200-500 lb)*	1,500 m (4,916 ft)	243 m (797 ft)
	E3, E4	AML *(>200-500 lb)*	1,528 m (5,012 ft)	239 m (784 ft)

Note: "Severance Scenarios" are synonymous with the "Mitigation Scenarios" detailed in Appendix F.

Predictive Modeling of Marine Mammal Take-Estimates

With a pressure/energy propagation model developed and validated, MMS then needed a method to help determine the types and numbers of marine mammal takes that could occur during explosive-severance activities. To derive the take-estimates, MMS contracted Marine Acoustics, Incorporated (MAI) for services related to explosive-severance simulation runs in their Acoustic Integration Model© (AIM). The AIM model can be configured to calculate a three-dimensional (3D) sound field that simulates a particular physical environment related to specific marine conditions and the propagation of pressure waves and acoustic energy generated by underwater explosions. The ARA UWC was therefore interfaced with AIM to provide the model with the appropriate pressure/energy propagation and range data for each blasting category; in which, the linear data (radii) was converted to its volumetric equivalence (3D).

Two species-specific delineation zones were also considered in the model's development with numerous virtual animals ("animats") developed to correlate to the marine mammal types and densities that can be found in the specific shelf (<200 m) or slope (>200 m) areas of the GOM. The animats were then exposed to the projected sound field in 3D and time in order to simulate the animals' real movement patterns and to allow AIM to predict the amount of pressure/acoustic energy exposure each animat received. When compared to the preestablished impact thresholds, the predictions could be used to determine the number of animals that might be taken by the proposed action (Appendix D; Frankel and Ellison, 2004). A total of 24 explosive-severance simulations were performed in 10 predetermined locations within the area of the proposed action (i.e., all of the Central and Western and a small portion of the Eastern GOM). The 10 simulation sites were chosen by MMS to correspond with both shelf and slope areas of the OCS that have preexisting structures possessing a high probability of removal over the next several years.

Early guidance from NOAA Fisheries indicated that take-estimates should be derived for Level B takes only, since subsequent mitigation had the potential to negate Level A takes and mortalities. The

AIM simulations were therefore configured for TTS thresholds and ranges; hence, the results listed in Appendix D are for Level B takes “and above” (&>) with the Level A take numbers inclusive of the overall totals. As represented in a recent application for incidental-take authorization from the U.S. Air Force for explosive-weapons testing in the GOM (69 FR 21816, April 22, 2004), NOAA Fisheries is currently asking for a breakdown of take number by specific take level regardless of mitigation. In addition, because additional blasting-category development and agency coordination continued after the initial MAI contract was completed, 10 of the final 20 severance scenarios were not addressed in the simulations (e.g., A1, A2, A3, A4, B2, C4, D3, E2, E3, and E4). Time restraints regarding the completion of the PEA and petition application discouraged modification of the contract with MAI to model the un-simulated scenarios and Level A take numbers. In order to compensate and ensure that an adequate number of takes were calculated and analyzed in this assessment, MMS chose to (1) calculate a percentage of the total Level B &> totals to account for Level A take-estimates and (2) correlate more-conservative (larger charge size/higher take numbers) AIM runs within the same species-delineation zone for the un-simulated scenarios.

Since the ARA UWC was used to establish the Level B &> pressure/energy propagation parameters for the AIM simulations, MMS used the UWC to back-calculate Level A ranges for each blasting category. Because the UWC’s range data is one-dimensional (1D), volumes (3D) were computed for each blasting category’s impact zone to correspond with the 3D parameters of the AIM model (Table E-3). The ranges were then used to derive percentages that could be used to determine what portion of the Level B &> take estimates would correspond with Level A takes.

Table E-3

Calculated Level B/Level A Impact Zone Volumes and Level A Percentage

Blasting Category	Level B (12 psi)		Level A (100 psi)		Level A Percentage of Level B Takes
	Range to take (m)	Volume of Impact Zone (m^3)	Range to take (m)	Volume of Impact Zone (m^3)	
Very Small BML	261	37,237,467	35	203,860	0.55%
Very Small AML	285	48,483,414	39	294,489	0.61%
Small BML	373	108,688,879	45	430,145	0.40%
Small AML	522	297,899,739	63	1,154,782	0.39%
Standard BML	631	526,194,969	76	2,032,189	0.39%
Standard AML	829	1,193,224,619	99	4,601,386	0.39%
Large BML	941	1,745,128,793	115	7,210,900	0.41%
Large AML	1,126	2,990,017,879	135	11,418,173	0.38%
Specialty BML	1,500	7,068,583,471	192	30,052,281	0.43%
Specialty AML	1,528	7,471,859,147	182	28,592,512	0.38%

The derived Level A volumes for the each category’s half-sphere (Figure E-2) averaged out to 0.43 percent of the Level B &> volumes. That percentage was applied to all of the take-estimate summaries found later in this appendix (Table E-6). Since the mortality percentage would be a small subset of Level A and an extremely-small percentage of Level B projections, only Level A take estimates were used in the PEA analyses and will be included in the MMPA take-regulation petition.

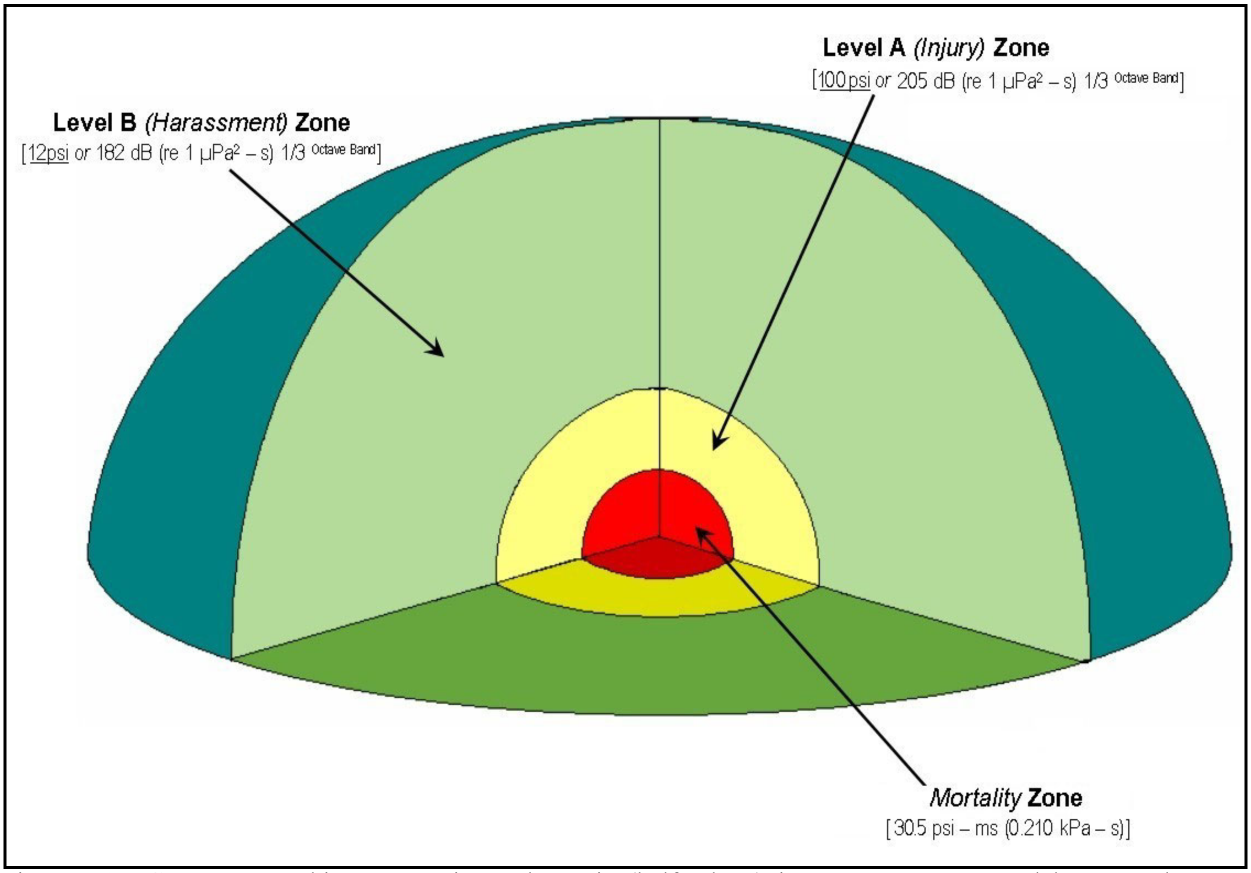

Figure E-2. Cut-away graphic representing volumetric (half-sphere) impact zones generated by an underwater detonation and the 3D sound field simulated in the AIM modeling (not to scale).

For the benefit of the marine mammal analysis in this PEA (Chapter 4.3.1) and subsequent take-regulation petitioning, a sufficient number of estimated marine mammal takes were required to represent projected annual and petition cycle (5-yr) activities for each of the explosive-severance scenarios. As indicated earlier, 10 of the 20 scenarios had yet to be established prior to the initial MAI contracting; therefore, half of the proposed activities did not have a corresponding simulation. In order to compensate for the modeling insufficiency, MMS chose to apply the 24 existing simulations in a conservative manner; i.e., using larger charge size and/or higher take projections AIM runs within the same species-delineation zone for the unsimulated scenarios. As with the overly-protective ARA UWC impact zones, MMS felt that the conservative-run compensation would ensure higher than expected projections and lead to more-protective and defensible analyses and conclusions.

For example, the development of the Very-Small severance scenarios (A1-A4) was not completed until after receiving the final AIM report (Appendix D); therefore, no simulations were conducted using 10-lb (BML) or 5-lb (AML) charges. Even though the final summaries would result in much higher projections, MMS compensated by applying the simulated runs conducted for the Small severance scenarios (modeled with 20-lb charges) to the Very-Small scenarios in order to calculate take. The same "protective" approach was used for Small charge scenario B2, Standard charge scenario C4, and Large charge scenario D3. Though there were no conservative simulations to apply to Specialty charge scenarios E2, E3, and E4, MMS severance activity projections (Appendix A) did not forecast any AML or slope (>200 m) Specialty blasting activities. Even though scenarios E2, E3, and E4 would be addressed for mitigation development, their absence from annual/5-yr projections did not necessitate take-estimate modeling and calculations (Table E-4).

Table E-4

Annual Severance Scenario Projections (Platform/Wells and Others) and Corresponding AIM Run Applications

Severance Scenario	Annual Projection (Low)	Annual Projection (High)	Corresponds with AIM Run Number(s)	AIM Run Number Applied	Reason for Applied Run
A1	22	31	Not Modeled	13	Larger impact area within the same density regime with the most conservative take-estimate projections.
A2	3	7	Not Modeled	18	Larger impact area within the same density regime with the most conservative take-estimate projections.
A3	11	17	Not Modeled	13	Larger impact area within the same density regime with the most conservative take-estimate projections.
A4	4	8	Not Modeled	18	Larger impact area within the same density regime with the most conservative take-estimate projections.
B1	33	44	1, 13	1	Highest species densities with the most conservative Take Estimate Projections.
B2	7	12	Not Modeled	18	Larger impact area within the same density regime with the most conservative take-estimate projections.
B3	9	16	6, 14	14	Highest species densities with the most conservative Take Estimate Projections.
B4	3	8	18, 22, 24	18	Highest species densities with the most conservative Take Estimate Projections.
C1	42	61	2, 8, 15	15	Highest species densities with the most conservative Take Estimate Projections.
C2	6	13	4, 11, 19, 21, 23	11	Highest species densities with the most conservative Take Estimate Projections.
C3	12	19	3, 7	3	Highest species densities with the most conservative Take Estimate Projections.
C4	5	10	Not Modeled	5	Larger impact area within the same density regime with the most conservative take-estimate projections.
D1	9	16	9, 16	16	Highest species densities with the most conservative Take Estimate Projections.
D2	1	4	5, 20	5	Highest species densities with the most conservative Take Estimate Projections.
D3	2	4	Not Modeled	17	Larger impact area within the same density regime with the most conservative take-estimate projections.
D4	0	1	12	12	Highest species densities with the most conservative Take Estimate Projections.
E1	1	2	10, 17	17	Highest species densities with the most conservative Take Estimate Projections.
E2	0	0	Not Modeled	None	No severances of this type are projected; therefore, take-estimate modeling not required.
E3	0	0	Not Modeled	None	No severances of this type are projected; therefore, take-estimate modeling not required.
E4	0	0	Not Modeled	None	No severances of this type are projected; therefore, take-estimate modeling not required.

Take-Estimate Calculations and Summaries

With the AIM modeling complete and acceptable methods to conservatively-compensate for Level A takes and un-simulated runs developed, MMS calculated the total estimated-take numbers for all of the projected explosive-severance activities. As discussed earlier, within each simulation, an animat was considered to have been taken if the exposure exceeded either TTS (Level B) criteria. The number of takes in each model run was scaled with the ratio of modeled and estimated animal densities to produce a Take Estimate per Event (TEPE). The estimated densities used for the runs were based on two recent reports on cetacean distribution and abundance in the GOM (Fulling et al., 2003; Mullin and Fulling, 2004). Table E-5 lists an example of TEPE's and density figures in addition to other simulation run information that can be found in Tables 9-22 of Appendix D; in which, detailed discussions of all of the simulation components are provided (Frankel and Ellison, 2004).

Table E-5

Take-Estimate Data Example for AIM Run No. 3

Species	Density (animals/km^2)	C.V. of Density	182 dB Takes	12 psi Takes	Take Estimate per Event	Lower Bound	Upper Bound	Pod Size	Events Needed for Take
bottlenose dolphin	0.095	0.30	0.85	1.35	1.35	0.94	1.75	10.00	1
rough-toothed dolphin	0.006	0.98	0.05	0.08	0.08	0.00	0.16	14.00	6
Atlantic spotted dolphin	0.026	0.42	0.27	0.34	0.34	0.20	0.48	15.60	2

From Table 9; *Explosive Removal Model Simulation Report* (Frankel and Ellison, 2004)

In order to determine the number of animals estimated to be taken in a year, the TEPE is multiplied by the annual, severance-scenario projections (Number of Events) as follows:

Number of Takes = TEPE x Number of Events

Since MMS severance estimates were developed with high (optimistic) and low (pessimistic) projections (Table A-5; Appendix A), the TEPE for each animal was multiplied by both event numbers to produce potential take ranges. Using the Table E-5 (AIM Run No. 3) data and the annual projections for severance scenario C3 (low - 12, high - 19) as an example, the following Level B &> take estimates would result:

Species	TEPE	Annual Take Low (12)	Annual Take High (19)
bottlenose dolphin	1.35	16.20	25.65
rough-toothed dolphin	0.08	0.96	1.52
Atlantic spotted dolphin	0.34	4.08	6.46

To derive 5-year estimates for the incidental-take petition, the annual severance projections were multiplied by 5 with the results multiplied by the TEPE's. Tables E-7 to E-23 list the total annual and 5-year takes (i.e., Level B &>) for severance scenarios A1 through E1 (scenarios E2, E3, and E4 were neither projected nor modeled). The annual and 5-year, Level B &> take-estimate totals for all explosive-severance scenarios are summarized in Table E-6. Applying the previously-discussed 0.43 percentage to the Level B totals, Table E-6 also lists the annual and 5-yr estimates for Level A takes. The Level B and Level A take-estimate summaries are referenced and analyzed in both the PEA's impact analysis (Chapter 4.3.1.2) and MMS's petition/application for incidental-take authorization. Though noted in Appendix D and discussed in the impact analysis, it is necessary to reemphasized that the numbers projected in the following tables were modeled and calculated absent of any mitigative measures. Based upon the same ARA UWC impact ranges as the take-estimation efforts, the mitigative requirements outlined in Appendix F and conditional for all explosive-severance activities, incorporate impact zone- and species-specific survey methodologies designed to offer protective (take-negating) pre-detonation detection and post-detonation monitoring for all applicable MPS.

Table E-6

Calculated Take-Estimate Totals for All Explosive-Severance Scenarios

Species	Level B (Harassment & >) (based on 12 psi)				Level A (Injury) (based on 100 psi - 0.43% of Level B)			
	Annual Projections (Low)	Annual Projections (High)	5-yr Projections (Low)	5-yr Projections (High)	Annual Projections (Low)	Annual Projections (High)	5-yr Projections (Low)	5-yr Projections (High)
Bryde's Whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
sperm whale	0.89	2.01	4.45	10.05	0.00	0.01	0.02	0.04
Kogia spp.	0.30	0.69	1.50	3.45	0.00	0.00	0.01	0.01
Beaked Whale								
Cuvier's beaked	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.12	0.28	0.60	1.40	0.00	0.00	0.00	0.01
killer whale	0.06	0.13	0.30	0.65	0.00	0.00	0.00	0.00
Blackfish								
Globicephala spp.	4.50	10.50	22.50	52.50	0.02	0.05	0.10	0.23
melon-headed whale	6.42	14.98	32.10	74.90	0.03	0.06	0.14	0.32
false killer whale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
pygmy killer whale	0.12	0.28	0.60	1.40	0.00	0.00	0.01	0.01
Fraser's dolphin	0.12	0.28	0.60	1.40	0.00	0.00	0.00	0.01
Risso's dolphin	1.44	3.32	7.20	16.60	0.01	0.01	0.03	0.07
bottlenose dolphin	148.77	227.54	743.85	1,137.70	0.64	0.98	3.20	4.89
rough-toothed dolphin	8.16	12.73	40.80	63.65	0.04	0.05	0.18	0.27
Stenella								
Atlantic spotted dolphin	35.52	54.62	177.60	273.10	0.15	0.23	0.76	1.17
pantropical spotted dolphin	33.80	77.41	169.00	387.05	0.15	0.33	0.73	1.66
Clymene dolphin	11.99	27.48	59.95	137.40	0.05	0.12	0.26	0.59
striped dolphin	6.35	14.53	31.75	72.65	0.03	0.06	0.14	0.31
spinner dolphin	2.10	4.82	10.50	24.10	0.01	0.02	0.05	0.10

Table E-7

Calculated Take Estimates for Severance Scenario A1

AIM Run Number 13 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	22	31	110	155
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.68	1	14.96	21.08	74.80	105.40
rough-toothed dolphin	0.03	15	0.66	0.93	3.30	4.65
Stenella						
Atlantic spotted dolphin	0.15	5	3.30	4.65	16.50	23.25
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-8

Calculated Take Estimates for Severance Scenario A2

AIM Run Number 18 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	3	7	15	35
Bryde's whale	0.00	N/A	0.00	0.00	0.00	0.00
sperm whale	0.01	61	0.03	0.07	0.15	0.35
Kogia spp.	0.00	559	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	0.00	366	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.00	433	0.00	0.00	0.00	0.00
killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	0.00	N/A	0.00	0.00	0.00	0.00
melon-headed whale	0.00	N/A	0.00	0.00	0.00	0.00
false killer whale	0.00	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	0.00	1,176	0.00	0.00	0.00	0.00
Risso's dolphin	0.00	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.00	N/A	0.00	0.00	0.00	0.00
rough-toothed dolphin	0.00	139	0.00	0.00	0.00	0.00
Stenella						
Atlantic spotted dolphin	0.00	12	0.00	0.00	0.00	0.00
pantropical spotted dolphin	0.04	13	0.12	0.28	0.60	1.40
Clymene dolphin	0.01	40	0.03	0.07	0.15	0.35
striped dolphin	0.01	79	0.03	0.07	0.15	0.35
spinner dolphin	0.00	229	0.00	0.00	0.00	0.00

Table E-9

Calculated Take Estimates for Severance Scenario A3

AIM Run Number 13 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	11	17	55	85
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.68	1	7.48	11.56	37.40	57.80
rough-toothed dolphin	0.03	15	0.33	0.51	1.65	2.55
Stenella						
Atlantic spotted dolphin	0.15	5	1.65	2.55	8.25	12.75
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-10

Calculated Take Estimates for Severance Scenario A4

AIM Run Number 18 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	4	8	20	40
Bryde's whale	0.00	N/A	0.00	0.00	0.00	0.00
sperm whale	0.01	61	0.04	0.08	0.20	0.40
Kogia spp.	0.00	559	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	0.00	366	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.00	433	0.00	0.00	0.00	0.00
killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	0.00	N/A	0.00	0.00	0.00	0.00
melon-headed whale	0.00	N/A	0.00	0.00	0.00	0.00
false killer whale	0.00	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	0.00	1176	0.00	0.00	0.00	0.00
Risso's dolphin	0.00	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.00	N/A	0.00	0.00	0.00	0.00
rough-toothed dolphin	0.00	139	0.00	0.00	0.00	0.00
Stenella						
Atlantic spotted dolphin	0.00	12	0.00	0.00	0.00	0.00
pantropical spotted dolphin	0.04	13	0.16	0.32	0.80	1.60
Clymene dolphin	0.01	40	0.04	0.08	0.20	0.40
striped dolphin	0.01	79	0.04	0.08	0.20	0.40
spinner dolphin	0.00	229	0.00	0.00	0.00	0.00

Table E-11

Calculated Take Estimates for Severance Scenario B1

AIM Run Number 1 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	33	44	165	220
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.86	1	28.38	37.84	141.90	189.20
rough-toothed dolphin	0.05	11	1.65	2.20	8.25	11.00
Stenella						
Atlantic spotted dolphin	0.21	3	6.93	9.24	34.65	46.20
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-12

Calculated Take Estimates for Severance Scenario B2

AIM Run Number 18 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	7	12	35	60
Bryde's whale	0.00	N/A	0.00	0.00	0.00	0.00
sperm whale	0.01	61	0.07	0.12	0.35	0.60
Kogia spp.	0.00	559	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	0.00	366	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.00	433	0.00	0.00	0.00	0.00
killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	0.00	N/A	0.00	0.00	0.00	0.00
melon-headed whale	0.00	N/A	0.00	0.00	0.00	0.00
false killer whale	0.00	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	0.00	1176	0.00	0.00	0.00	0.00
Risso's dolphin	0.00	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.00	N/A	0.00	0.00	0.00	0.00
rough-toothed dolphin	0.00	139	0.00	0.00	0.00	0.00
Stenella						
Atlantic spotted dolphin	0.00	12	0.00	0.00	0.00	0.00
pantropical spotted dolphin	0.04	13	0.28	0.48	1.40	2.40
Clymene dolphin	0.01	40	0.07	0.12	0.35	0.60
striped dolphin	0.01	79	0.07	0.12	0.35	0.60
spinner dolphin	0.00	229	0.00	0.00	0.00	0.00

Table E-13

Calculated Take Estimates for Severance Scenario B3

AIM Run Number 14 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	9	16	45	80
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.98	1	8.82	15.68	44.10	78.40
rough-toothed dolphin	0.05	10	0.45	0.80	2.25	4.00
Stenella						
Atlantic spotted dolphin	0.21	3	1.89	3.36	9.45	16.80
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-14

Calculated Take Estimates for Severance Scenario B4

AIM Run Number 18 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	3	8	15	40
Bryde's whale	0.00	N/A	0.00	0.00	0.00	0.00
sperm whale	0.01	61	0.03	0.08	0.15	0.40
Kogia spp.	0.00	559	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	0.00	366	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.00	433	0.00	0.00	0.00	0.00
killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	0.00	N/A	0.00	0.00	0.00	0.00
melon-headed whale	0.00	N/A	0.00	0.00	0.00	0.00
false killer whale	0.00	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	0.00	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	0.00	1176	0.00	0.00	0.00	0.00
Risso's dolphin	0.00	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	0.00	N/A	0.00	0.00	0.00	0.00
rough-toothed dolphin	0.00	139	0.00	0.00	0.00	0.00
Stenella						
Atlantic spotted dolphin	0.00	12	0.00	0.00	0.00	0.00
pantropical spotted dolphin	0.04	13	0.12	0.32	0.60	1.60
Clymene dolphin	0.01	40	0.03	0.08	0.15	0.40
striped dolphin	0.01	79	0.03	0.08	0.15	0.40
spinner dolphin	0.00	229	0.00	0.00	0.00	0.00

Table E-15

Calculated Take Estimates for Severance Scenario C1

AIM Run Number 15 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	42	61	210	305
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	1.17	1	49.14	71.37	245.70	356.85
rough-toothed dolphin	0.06	9	2.52	3.66	12.60	18.30
Stenella						
Atlantic spotted dolphin	0.27	3	11.34	16.47	56.70	82.35
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-16

Calculated Take Estimates for Severance Scenario C2

AIM Run Number 11 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	6	13	30	65
Bryde's whale	0.00	N/A	0.00	0.00	0.00	0.00
sperm whale	0.07	10	0.42	0.91	2.10	4.55
Kogia spp.	0.03	22	0.18	0.39	0.90	1.95
beaked whale						
Cuvier's beaked	0.00	116	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.01	82	0.06	0.13	0.30	0.65
killer whale	0.01	86	0.06	0.13	0.30	0.65
Blackfish						
Globicephala spp.	0.44	2	2.64	5.72	13.20	28.60
melon-headed whale	0.63	1	3.78	8.19	18.90	40.95
false killer whale	0.00	225	0.00	0.00	0.00	0.00
pygmy killer whale	0.01	72	0.06	0.13	0.30	0.65
Fraser's dolphin	0.01	54	0.06	0.13	0.30	0.65
Risso's dolphin	0.14	5	0.84	1.82	4.20	9.10
bottlenose dolphin	0.06	8	0.36	0.78	1.80	3.90
rough-toothed dolphin	0.03	15	0.18	0.39	0.90	1.95
Stenella						
Atlantic spotted dolphin	0.03	1	0.18	0.39	0.90	1.95
pantropical spotted dolphin	3.28	1	19.68	42.64	98.40	213.20
Clymene dolphin	1.17	1	7.02	15.21	35.10	76.05
striped dolphin	0.61	1	3.66	7.93	18.30	39.65
spinner dolphin	0.21	3	1.26	2.73	6.30	13.65

Table E-17

Calculated Take Estimates for Severance Scenario C3

AIM Run Number 3 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	12	19	60	95
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	1.35	1	16.20	25.65	81.00	128.25
rough-toothed dolphin	0.08	6	0.96	1.52	4.80	7.60
Stenella						
Atlantic spotted dolphin	0.34	2	4.08	6.46	20.40	32.30
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-18

Calculated Take Estimates for Severance Scenario C4

AIM Run Number 5 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	5	10	25	50
Bryde's whale	0.00	1,553	0.00	0.00	0.00	0.00
sperm whale	0.05	14	0.25	0.50	1.25	2.50
Kogia spp.	0.02	34	0.10	0.20	0.50	1.00
beaked whale						
Cuvier's beaked	0.00	161	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.01	114	0.05	0.10	0.25	0.50
killer whale	0.00	136	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	0.31	2	1.55	3.10	7.75	15.50
melon-headed whale	0.44	1	2.20	4.40	11.00	22.00
false killer whale	0.00	320	0.00	0.00	0.00	0.00
pygmy killer whale	0.01	102	0.05	0.10	0.25	0.50
Fraser's dolphin	0.01	83	0.05	0.10	0.25	0.50
Risso's dolphin	0.10	7	0.50	1.00	2.50	5.00
bottlenose dolphin	0.04	14	0.20	0.40	1.00	2.00
rough-toothed dolphin	0.03	19	0.15	0.30	0.75	1.50
Stenella						
Atlantic spotted dolphin	0.02	1	0.10	0.20	0.50	1.00
pantropical spotted dolphin	2.24	1	11.20	22.40	56.00	112.00
Clymene dolphin	0.80	1	4.00	8.00	20.00	40.00
striped dolphin	0.42	1	2.10	4.20	10.50	21.00
spinner dolphin	0.14	4	0.70	1.40	3.50	7.00

Table E-19

Calculated Take Estimates for Severance Scenario D1

AIM Run Number 16 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	9	16	45	80
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	1.70	1	15.30	27.20	76.50	136.00
rough-toothed dolphin	0.09	6	0.81	1.44	4.05	7.20
Stenella						
Atlantic spotted dolphin	0.43	2	3.87	6.88	19.35	34.40
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-20

Calculated Take Estimates for Severance Scenario D2

AIM Run Number 5 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	1	4	5	20
Bryde's whale	0.00	1,553	0.00	0.00	0.00	0.00
sperm whale	0.05	14	0.05	0.20	0.25	1.00
Kogia spp.	0.02	34	0.02	0.08	0.10	0.40
beaked whale						
Cuvier's beaked	0.00	161	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.01	114	0.01	0.04	0.05	0.20
killer whale	0.00	136	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	0.31	2	0.31	1.24	1.55	6.20
melon-headed whale	0.44	1	0.44	1.76	2.20	8.80
false killer whale	0.00	320	0.00	0.00	0.00	0.00
pygmy killer whale	0.01	102	0.01	0.04	0.05	0.20
Fraser's dolphin	0.01	83	0.01	0.04	0.05	0.20
Risso's dolphin	0.10	7	0.10	0.40	0.50	2.00
bottlenose dolphin	0.04	14	0.04	0.16	0.20	0.80
rough-toothed dolphin	0.03	19	0.03	0.12	0.15	0.60
Stenella						
Atlantic spotted dolphin	0.02	1	0.02	0.08	0.10	0.40
pantropical spotted dolphin	2.24	1	2.24	8.96	11.20	44.80
Clymene dolphin	0.80	1	0.80	3.20	4.00	16.00
striped dolphin	0.42	1	0.42	1.68	2.10	8.40
spinner dolphin	0.14	4	0.14	0.56	0.70	2.80

Table E-21

Calculated Take Estimates for Severance Scenario D3

AIM Run Number 17 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	2	4	10	20
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	2.63	1	5.26	10.52	26.30	52.60
rough-toothed dolphin	0.14	3	0.28	0.56	1.40	2.80
Stenella						
Atlantic spotted dolphin	0.72	1	1.44	2.88	7.20	14.40
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

Table E-22

Calculated Take Estimates for Severance Scenario D4

AIM Run Number 12 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	0	1	0	5
Bryde's whale	0.00	1,553	0.00	0.00	0.00	0.00
sperm whale	0.05	15	0.00	0.05	0.00	0.25
Kogia spp.	0.02	36	0.00	0.02	0.00	0.10
beaked whale						
Cuvier's beaked	0.00	173	0.00	0.00	0.00	0.00
Mesoplodon spp.	0.01	123	0.00	0.01	0.00	0.05
killer whale	0.00	146	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	0.44	2	0.00	0.44	0.00	2.20
melon-headed whale	0.63	1	0.00	0.63	0.00	3.15
false killer whale	0.00	225	0.00	0.00	0.00	0.00
pygmy killer whale	0.01	72	0.00	0.01	0.00	0.05
Fraser's dolphin	0.01	85	0.00	0.01	0.00	0.05
Risso's dolphin	0.10	7	0.00	0.10	0.00	0.50
bottlenose dolphin	0.04	13	0.00	0.04	0.00	0.20
rough-toothed dolphin	0.02	26	0.00	0.02	0.00	0.10
Stenella						
Atlantic spotted dolphin	0.02	1	0.00	0.02	0.00	0.10
pantropical spotted dolphin	2.01	1	0.00	2.01	0.00	10.05
Clymene dolphin	0.72	1	0.00	0.72	0.00	3.60
striped dolphin	0.37	2	0.00	0.37	0.00	1.85
spinner dolphin	0.13	5	0.00	0.13	0.00	0.65

Table E-23

Calculated Take Estimates for Severance Scenario E1

AIM Run Number 17 Data			Annual Activity Projections (Low)	Annual Activity Projections (High)	5-yr Activity Projections (Low)	5-yr Activity Projections (High)
Species	TEPE	Events Needed for Take	1	2	5	10
Bryde's whale	N/A	N/A	0.00	0.00	0.00	0.00
sperm whale	N/A	N/A	0.00	0.00	0.00	0.00
Kogia spp.	N/A	N/A	0.00	0.00	0.00	0.00
beaked whale						
Cuvier's beaked	N/A	N/A	0.00	0.00	0.00	0.00
Mesoplodon spp.	N/A	N/A	0.00	0.00	0.00	0.00
killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Blackfish						
Globicephala spp.	N/A	N/A	0.00	0.00	0.00	0.00
melon-headed whale	N/A	N/A	0.00	0.00	0.00	0.00
false killer whale	N/A	N/A	0.00	0.00	0.00	0.00
pygmy killer whale	N/A	N/A	0.00	0.00	0.00	0.00
Fraser's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Risso's dolphin	N/A	N/A	0.00	0.00	0.00	0.00
bottlenose dolphin	2.63	1	2.63	5.26	13.15	26.30
rough-toothed dolphin	0.14	3	0.14	0.28	0.70	1.40
Stenella						
Atlantic spotted dolphin	0.72	1	0.72	1.44	3.60	7.20
pantropical spotted dolphin	N/A	N/A	0.00	0.00	0.00	0.00
Clymene dolphin	N/A	N/A	0.00	0.00	0.00	0.00
striped dolphin	N/A	N/A	0.00	0.00	0.00	0.00
spinner dolphin	N/A	N/A	0.00	0.00	0.00	0.00

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Appendix F

Programmatic Mitigation for the Proposed Action

Programmatic Mitigation for the Proposed Action

Introduction

Many of the activities that make up the Proposed Action, as described in Chapter 1.4 of the programmatic Environmental Assessment (PEA) on Structure-Removal Operations, have the potential to cause negative impacts on the marine environment and or other uses of the Gulf of Mexico (GOM) Outer Continental Shelf (OCS). Based upon the PEA's analyses, the Minerals Management Service (MMS) believes the mitigation measures listed in this appendix would prevent any significant impacts from occurring if used during removal operations. The mitigation can be categorized as it applies to the four primary impact-producing factors of decommissionings: (1) support vessel mobilization/demobilization; (2) progressive transport; (3) site-clearance trawling; and 4) explosive-severance activities.

The programmatic mitigation described below was developed considering a wide array of activities that could be conducted during most decommissioning operations. Depending on the specifics of each proposal and incorporation of the PEA mitigation into pending Marine Mammal Protection Act (MMPA) rulemaking and an Endangered Species Act (ESA) consultation, only portions/variations of the mitigation listed in this appendix may be required. Site-specific, National Environmental Policy Act (NEPA) analyses will be conducted on individual applications; specifying supplementary mitigation. Any supplemental requirements and all applicable MMPA/ESA incidental-take mitigation will be integrated into MMS's removal-permitting process and conveyed to operators as conditions of permit approval.

Support Vessel Mobilization/Demobilization Mitigation

One of the primary decommissioning activities associated with seafloor impacts involves the mobilization/demobilization of lift and support vessels. As described in Chapters 4.3.4 and 4.4.1, anchoring and "jack-up" activities have the potential to damage both known and unknown benthic and archaeological resources in the vicinity of structures scheduled for removal. The seafloor disturbances associated with these activities also have the potential to harm proximal pipelines and cables (Chapter 4.4.2), which in turn, could lead to additional environmental impacts. To counteract these potential seafloor impacts, MMS will require the following vessel mobilization/demobilization mitigation when any nondynamically positioned support vessel is used in a decommissioning operation:

> When utilizing anchored or "jack-up" vessels in your removal operations, you must buoy all existing pipelines and other potential hazards located within 150 m (490 ft) of your operations (including all anchor lines) as described in the Shallow Hazards Requirements Notice to Lessees and Operators (NTL) No. 98-20, Section IV (B)(1) and (2). If the block(s) proximal to your operations have not been surveyed as outlined in NTL No. 98-20, NTL No. 2002-G01 (Archaeological Resource Surveys and Reports), or NTL No. 2004-G05 (Biologically Sensitive Areas of the Gulf of Mexico), you are required to conduct the necessary surveys/reporting prior to mobilizing on site and conducting any seafloor disturbing activities. Your decommissioning operations must also abide by any installation requirements (if designated) such as "avoidance mitigation" and anchor restrictions. In addition to structure position, the location plat required in your removal application should show all nearby structures, pipelines, archaeological and sensitive biological features (if any), and anchor patterns.

Progressive-Transport Mitigation

Much like mobilization operations, progressive-transport or jacket-hopping activities (Chapter 1.4.7.2) would result in seafloor disturbances that have the potential to cause negative impacts on benthic, archaeological, and infrastructure resources on the OCS. In addition to support vessel anchoring, the physical placement of the severed structure onto the seabed at one or more locations increases the likelihood of an incident. Since the "set-down" site(s) is generally off-lease, there is also a greater degree of uncertainty concerning the unknown or unsurveyed seafloor resources. For this reason, MMS will require the following progressive-transport mitigation:

If at any point in your decommissioning schedule progressive-transport/"hopping" activities are required to section your jacket assembly, a prior written approval must be obtained from the Regional Supervisor. An application to use progressive transport should include a separate location plat for each "set-down" site, showing pipelines, anchor patterns for the derrick barge, and archaeological and sensitive biological features (if any). A route survey from the initial structure location along the transport path to each site must also be prepared and submitted with your application. If blocks potentially-impacted by your operations have not been surveyed as per NTL No. 98-20, NTL No. 2002-G01, and NTL 2004-G05, you are required to conduct the necessary surveys/reporting prior to mobilizing on site and conducting any seafloor-disturbing activities. Three copies of the application should be submitted to the Regional Supervisor for review and approval.

Site-Clearance Trawling Mitigation

Under the guidelines provided in MMS's site-clearance NTL (No. 98-26) and lease agreement conditions, operators are required to ensure that the seafloor of their lease is returned to its prelease state once all structures and facilities have been removed. Since a variety of lost and discarded objects (e.g., tools, containers, batteries, etc.) end up on the seabed during the life of an oil and gas structure, many operators choose to conduct trawling in order to facilitate the site-clearance requirements. Similar to trawling activities conducted by commercial fishermen, the nets are attached to weighted wooden or metal "doors" that pull the net down to the seafloor as the entire assembly is drug behind a boat. The "footrope" attached to the bottom of the net is pulled taut between the doors with the forward motion of the vessel, dragging the rope along the seabed as the area is trawled. Seabed resources and infrastructure could become snagged and/or damaged by trawl doors and footropes. In addition, the trawls have the potential to capture and drown slow-moving sea turtles in the vicinity of the trawl site. To reduce the potential for seabed resource/infrastructure damage and possible harassment, injury, or mortality of threatened and endangered sea turtles, MMS will require the following site-clearance trawling mitigation:

When trawling contractors are used to perform site-clearance work under the guidelines listed in NTL No. 98-26 (Minimum Interim Requirements for Site Clearance (and Verification) of Abandoned Oil and Gas Structures in the Gulf of Mexico), each trawler is to be supplied with a hazards plat as directed by Section IV (B)(2) of NTL No. 98-20. The hazards plat will have the locations of all known benthic, archaeological, and infrastructure resources clearly marked and labeled to enable the trawler to avoid potential impact to the resources. Since turtle excluder devices (TED) are to be removed from the trawl nets to permit the collecting seabed debris, the trawling contractor must:

- use trawl net(s) with a minimum mesh size <u>no smaller</u> than 4 in;
- abide by maximum trawl times of 30 min, allowing for the removal of any captured sea turtles;
- resuscitate and release any captured sea turtles as per the guidelines described in the Endangered Species Act (ESA) regulations at 50 CFR 223.206(d)(1); and
- include a description and/or identification of any sea turtle(s) captured in your net(s), resuscitated, released, or killed. Since the sea turtle could have been recovered post-mortem, the description should include the animal's condition (i.e., rigor-mortis, decaying, cracked carapace/shell, etc.).

Explosive-Severance Mitigation

As described in Chapter 1.4.6.2, explosive tools such as bulk, shaped, and fracturing charges could be used to sever tubular/structural targets during decommissioning operations. The underwater detonation of these cutting tools results in the release of shock (pressure) waves and acoustic energy that has the potential to harass, injure, or kill marine protected species (MPS) such as marine mammals and sea turtles. Since the level of pressure and energy released during detonation is primarily related to the amount of the explosives used, five blasting categories were developed based upon the specific range of charge weights needed to conduct current and future OCS decommissionings (Chapter 2.2.1). Depending upon the design of the decommissioning target and variable marine conditions, the charges developed under each of these categories could be arranged for use in two primary configurations: below-mudline (BML) or above-mudline (AML) cutting (Figure F-1).

Very-Small Blasting	0-5 lb AML/0-10 lb BML
Small Blasting	>5-20 lb AML/>10-20 lb BML
Standard Blasting	>20-80 lb AML/>20-80 lb BML
Large Blasting	>80-200 lb AML/>80-200 lb BML
Specialty Blasting	>200-500 lb AML/>200-500 lb BML

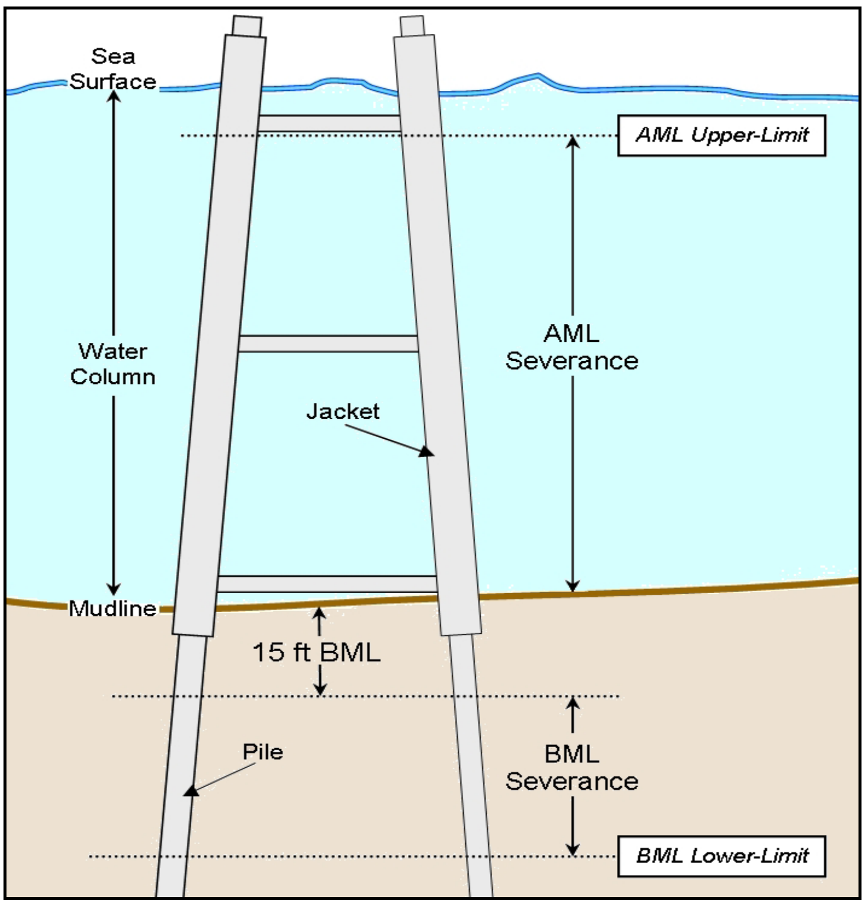


Figure F-1. Explosive-Severance Charge Configurations.

Charges configured for BML severance are generally deployed internal to the target; however, with adequate sediment jetting, external charge deployments are possible. Since they are most often conducted to conform with OCSLA requirements, BML severances range from 15 ft BML to a ***lower-limit*** dependent upon the lift vessel's ability of the to break suction on the severed target. Because of the closed-tubular design of most jacket assemblies, AML charges are designed for external deployment. Capable of placement at any point above the seabed, the AML ***upper-limit*** will be determined by blasting experts, considering the charge size/design and the need for human health and safety. Projected primarily for use in mid-water jacket sectioning, AML severance increases decommissioning options, but it does not negate an operator's lease responsibility or minimum cut requirements under OCSLA.

The five blasting categories can also be used within two species-specific delineation zones: OCS shelf (<200 m) and OCS slope (>200 m). Because of animal distributions and densities, explosive-severance activities taking place on the shelf have a greater opportunity to impact sea turtles (e.g., green, loggerhead, leatherback, Kemp's ridley, and hawksbill) and coastal dolphin (e.g., bottlenose, Atlantic spotted, and rough-toothed). In addition to the sea turtles and coastal dolphin, explosive work in slope waters has the potential to impact deepwater dolphin (i.e., Fraser's, pan-tropical spotted, etc.) and a number of different whales (i.e., sperm, melon-headed, etc.).

Considering both charge configuration (BML/AML) and species-delineation zone (shelf/slope), MMS developed 20 specific, mitigation scenarios to address severance activities that could be conducted under the five blasting categories (Table F-1). Operators applying for structure-removal permits using explosive severance would indicate the appropriate scenario based upon the removal location and their severance needs. In addition to other application data, the noted scenario requirements would be considered during subsequent NEPA analyses.

Table F-1

Blasting Categories and Associated Mitigation Scenarios

Blasting Category	Configuration *(Charge Range)*	Impact-Zone Radius	Species-Delineation Zone	Mitigation Scenario
Very-Small Blasting	BML *(0-10 lb)*	261 m (856 ft)	Shelf (<200 m)	A1
			Slope (>200 m)	A2
	AML *(0-5 lb)*	293 m (961 ft)	Shelf (<200 m)	A3
			Slope (>200 m)	A4
Small Blasting	BML *(>10-20 lb)*	373 m (1,224 ft)	Shelf (<200 m)	B1
			Slope (>200 m)	B2
	AML *(>5-20 lb)*	522 m (1,714 ft)	Shelf (<200 m)	B3
			Slope (>200 m)	B4
Standard Blasting	BML *(>20-80 lb)*	631 m (2,069 ft)	Shelf (<200 m)	C1
			Slope (>200 m)	C2
	AML *(>20-80 lb)*	829 m (2,721 ft)	Shelf (<200 m)	C3
			Slope (>200 m)	C4
Large Blasting	BML *(>80-200 lb)*	941 m (3,086 ft)	Shelf (<200 m)	D1
			Slope (>200 m)	D2
	AML *(>80-200 lb)*	1,126 m (3,693 ft)	Shelf (<200 m)	D3
			Slope (>200 m)	D4
Specialty Blasting	BML *(>200-500 lb)*	1,500 m (4,916 ft)	Shelf (<200 m)	E1
			Slope (>200 m)	E2
	AML *(>200-500 lb)*	1,528 m (5,012 ft)	Shelf (<200 m)	E3
			Slope (>200 m)	E4

The monitoring requirements and methodologies for the 20 scenarios were developed in coordination with explosive-severance experts and protected species scientists from NOAA Fisheries and MMS, taking into consideration MPS characteristics and surfacing rates, calculated impact parameters, and current/*status quo* mitigation requirements. While charge criteria and reporting requirements are standard for all scenarios, the individual survey requirements and requisite times vary. General descriptions of the charge criteria, monitoring terms/methods, and reporting requirements are provided below. The specific survey, time, and methodology requirements for each explosive-severance scenario follow.

General Requirements

Charge Criteria

The charge criteria discussed below (e.g., charge size, detonation staggering, and explosive material) are applicable for all of the explosive-severance scenarios conducted under the proposed action.

Charge Size *(All Scenarios)*

The options available under the multiple explosive-severance scenarios allow for the development of any size charge between 0 and 500 lb. Most often determined in the early planning stages, the final/actual charge weight establishes the specific mitigation scenario that must be adhered to as a permit condition. Charges greater than 500 lb are prohibited and their proposed usage will require additional NEPA analyses and site-specific MMPA authorization and ESA consultation.

Detonation Staggering *(All Scenarios)*

Multiple charge detonations shall be staggered at an interval of 0.9 sec (900 msec) between blasts to prevent an additive pressure event. For decommissioning purposes, a "multiple charge detonation" refers to any configuration where more than one charge is required in a single detonation "event."

Explosive Material *(All Scenarios)*

There are many important properties (i.e., velocity, brisance, specific-energy, etc.) related to the explosive material(s) used in developing severance charges. Material needs vary widely depending upon target characteristics, marine conditions, and charge placement. Since specific material and personnel safety requirements must be established and followed, MMS feels that all decisions on explosive composition, configuration, and usage should be made by the qualified (i.e., licensed and permitted) explosive contractors in accordance with of the applicable explosive-related laws and regulations.

Monitoring Terms and Methods

The following monitoring terms are general descriptions of the terminology applicable to all explosive-severance activities. The monitoring methods are observation activities (i.e., visual or electronic surveys) designed to detect MPS in the vicinity of decommissioning operations. The requisite survey(s) and related time-period(s) will vary depending upon the nature of the severance-scenario.

Impact Zone *(Term; All Scenarios)*

The impact zone is the area (i.e., a horizontal radius around a decommissioning target) in which a MPS could be affected by the pressure and or acoustic energy released during the detonation of an explosive-severance charge. As discussed in Appendix E, the impact zone radii were derived using conservative pressure/energy propagation data from Applied Research Associates, Inc.'s UnderWater Calculator (UWC). The monitoring surveys and associated time periods were designed to allow for adequate detection of MPS that may be present within each impact zone based upon potential species and the overall size of the impact area.

Predetonation Survey *(Term; All Scenarios)*

A predetonation (pre-det) survey refers to any MPS monitoring survey (e.g., surface, aerial, or acoustic) conducted prior to the detonation of any explosive severance tool. The primary purpose of pre-det surveys is to allow detection of any possible MPS within the scenario-specific impact zone and to continue monitoring the animal(s) until it leaves the area for the allotted time period.

Postdetonation Survey *(Term; All Scenarios)*

A postdetonation (post-det) survey refers to any MPS monitoring survey (e.g., surface, aerial, or post-post-det aerial) conducted after the detonation "event" occurs. The primary purpose of post-det surveys is to detect any MPS that may have been impacted (i.e., stunned, injured, or killed) by the detonation and resultant pressure/energy release. The post-det surveys are key in providing essential reporting information on the effectiveness of the pre-det survey efforts.

Waiting Period *(Term; All Scenarios)*

Variable by scenario, the waiting period refers to the time in which detonation operations must hold before the requisite monitoring survey(s) can be reconducted. The purpose of a waiting period is to allow any inbound or previously detected outbound MPS to exit the impact zone under their own volition.

Company Observer *(Term; Scenarios A1- A4)*

Trained company observers will be allowed to perform MPS detection surveys for Very-Small blasting scenarios A1-A4. An "adequately-trained" observer is an employee of the company or severance contractor who has attended observer training courses offered by private or government entities.

NOAA Fisheries Observer *(Term; Scenarios B1-E4)*

NOAA Fisheries observers are required to perform MPS detection surveys for all blasting scenarios with the exception of Scenarios A1-A4. These observers are qualified NOAA Fisheries employees or third-party contractors delegated under the Platform Removal Observer Program (PROP) of NOAA Fisheries' Galveston Laboratory. Generally, two observers will be assigned to each operation for detection survey duties. However, because mitigation-scenarios C2, C4, D2, D4, E2, and E4 require a minimum of three (3) observers for the simultaneous surface, aerial, and acoustic surveys, at least two (2) "teams" of observers will be required. The PROP Coordinator will determine each "team" size depending upon the nature of the operations, target structure configuration, support vessel accommodations, and other environmental monitoring conditions.

Surface Monitoring Survey *(Method; All Scenarios)*

Surface monitoring surveys are to be conducted from the highest vantage point available on the structure being removed or proximal surface vessels (i.e., crewboats, derrick barges, etc.). Surface surveys will be restricted to daylight hours only, and the monitoring will cease upon inclement weather or when it is determined that marine conditions are not adequate for visual observations.

Aerial Monitoring Survey *(Method; Scenarios B1-E4)*

Aerial monitoring surveys are to be conducted from helicopters running low-altitude search patterns over the extent of the potential impact area. Aerial surveys will be restricted to daylight hours only, and they cannot begin until the requisite surface monitoring survey has been completed. Aerial surveys will cease upon inclement weather, when marine conditions are not adequate for visual observations, or when the pilot/removal supervisor determines that helicopter operations must be suspended. Aerial surveys are required for all severance scenarios with the exception of scenarios A1-A4.

Acoustic Monitoring Survey *(Method; Scenarios C2, C4, D2, D4, E2, and E4)*

Acoustic monitoring surveys are required to be conducted on all Standard, Large, and Specialty blasting scenarios conducted on slope (>200 m) activities (e.g., C2, C4, D2, D4, E2, and E4). Contractors conducting acoustic surveys will be required to use NOAA-approved passive acoustic monitoring devices and technicians. Acoustic surveys will be run concurrent with requisite pre-det surveys; beginning with the surface observations and concluded at the finish of the aerial surveys when the detonation(s) is allowed to proceed.

Post-Post-Det Aerial Monitoring Survey *(Method; Scenarios C4, D2, D4, E2, and E4)*

Post-post-det aerial monitoring surveys will be to be conducted within 2-7 days after detonation activities conclude, by either helicopter or fixed-wing aircraft. Observations are to start at the removal site and proceed leeward and outward of wind and current movement. Any injured or killed MPS must be noted in your survey report, and if possible, tracked and collected after notifying NOAA Fisheries. Post-post-det aerial surveys are only required for mitigation-scenarios C4, D2, D4, E2, and E4.

Reporting Requirements

All explosive-severance activities in the GOM are subject to the reporting requirements listed in this section. The information collected under these requirements will be used by MMS and NOAA Fisheries to continually assess mitigation effectiveness and the level of MPS impacts.

Reporting Responsibilities and Filing Times

The reporting responsibilities will be assumed by the NOAA Fisheries' MPS observer for scenarios B1-E4 and the collected data will be prepared and routed in accordance with PROP guidelines for filing times and distribution. For Very-Small scenarios A1-A4, the company observer will be responsible for recording the data and preparing a trip report for submittal within 30-days of completion of the severance activities. Trip reports for scenarios A1-A4 will be sent to MMS and NOAA Fisheries at the following addresses:

Minerals Management Service
Gulf of Mexico Region
1201 Elmwood Park Blvd
New Orleans, LA 70123-2394
Attention: Regional Supervisor,
Office of Leasing and Environment

NOAA Fisheries
Southeast Region
9721 Executive Center Drive N
St. Petersburg, FL 33702
Attention: Assistant Regional Administrator,
Protected Resources Division

Information Requirements

In addition to basic operational data (i.e., area and block, water depth, company/platform information, etc.), the trip reports must contain all of the applicable information listed in Table F-2.

Table F-2

Minimum Information Requirements for Explosive-Severance Monitoring Reports

Information Type	Details
Target	• Type/Composition – pile, caisson, concrete piling, nylon mooring, etc. • Diameter and thickness – *example*; 30" x 1 ½" pile, ¾" wire rope, etc.
Charge	• Type – bulk, configured-bulk, linear-shaped, etc. • Charge weight/material – RDX, C4, HMX, etc. • Configuration – internal/external, cut depth (BML), water depth (AML), etc. • Deployment method – diver, ROV, from surface, etc.
Monitoring	• Survey Type – pre-det and post-det; surface, aerial, etc. • Time(s) initiated/terminated • Marine Conditions
Observed MPS	• Type/number – basic description or species identification (if possible) • Location/orientation – inside/outside impact zone, inbound/outbound, etc. • Any "halted-detonation" details – i.e., waiting periods, re-surveys, etc. • Any "Take-Event" details – actual MPS injury/mortality

Take-Event Procedures

In the event that a MPS is shocked, injured, or killed during the severance activities, the operations will cease and the observer will contact MMS at (504) 736-3245 and NOAA Fisheries' Southeast Regional Office (SERO) at (727) 570-5312. If the animal does not revive, effort should be made to recover the carcass for necropsy in consultation with the appropriate NOAA Fisheries' Stranding Coordinator. The Sea Turtle Standing and Salvage Network can be reached at (305) 361-4478, and the SERO Marine Mammal Stranding Coordinator can be reached via a 24-hour pager at (305) 862-2850. As noted above, details concerning the take event are required to be recorded in the trip report.

Specific Requirements

As noted, the charge criteria and reporting requirements listed above will be standard for all decommissionings employing explosive-severance activities. However, depending upon the severance scenario, there are six different MPS monitoring surveys that could be conducted before and after all detonation events. The specific monitoring requirements, survey times, and impact zone radii for all explosive-severance scenarios are summarized in Table F-3.

Table F-3

Survey and Time Requisite Summary for All Explosive-Severance Scenarios

Blasting Category	Impact Zone Radius	Scenario	Pre-Det Surface Survey (min)	Pre-Det Aerial Survey (min)	Pre-Det Acoustic Survey (min)	Post-Det Surface Survey (min)	Post-Det Aerial Survey (min)	Post-Post-Det Aerial Survey (Yes/No)
Very-Small	261 m (856 ft)	A1	60	N/A	N/A	30	N/A	No
		A2	90	N/A	N/A	30	N/A	No
	293 m (961 ft)	A3	60	N/A	N/A	30	N/A	No
		A4	90	N/A	N/A	30	N/A	No
Small	373 m (1,224 ft)	B1	90	30	N/A	N/A	30	No
		B2	90	30	N/A	N/A	30	No
	522 m (1,714 ft)	B3	90	30	N/A	N/A	30	No
		B4	90	30	N/A	N/A	30	No
Standard	631 m (2,069 ft)	C1	90	30	N/A	N/A	30	No
		C2	90	30	120	N/A	30	No
	829 m (2,721 ft)	C3	90	45	N/A	N/A	30	No
		C4	90	60	150	N/A	30	Yes
Large	941 m (3,086 ft)	D1	120	45	N/A	N/A	30	No
		D2	120	60	180	N/A	30	Yes
	1,126m (3,693ft)	D3	120	60	N/A	N/A	30	No
		D4	150	60	210	N/A	30	Yes
Specialty	1,500 m (4,916 ft)	E1	150	90	N/A	N/A	45	No
		E2	180	90	270	N/A	45	Yes
	1,528 m (5,012 ft)	E3	150	90	N/A	N/A	45	No
		E4	180	90	270	N/A	45	Yes

Accounting for similar pre- and post-det surveys, the 20 explosive-severance scenarios correspond roughly with 8 basic mitigation processes that vary only in differences in impact zone ranges and survey times. As discussed in Appendix E of this PEA (pg E-4), the impact zone radii were derived using the "UnderWater Calculator" (UWC), a verified model that predicts the detonation pressure/energy propagation resulting from underwater detonations. The survey-time requisites were established by NOAA Fisheries and MMS protected species scientists, taking into consideration likely MPS and their surfacing rates. The mitigation process details for each of the explosive-severance scenarios follows.

Very-Small Blasting Category

Shelf (<200 m) and Slope (>200 m) Scenarios A1, A2, A3, and A4

An operator proposing explosive-severance activities conduced under the very-small blasting category will be limited to 5-lb (AML) and 10-lb (BML) charge sizes and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

A1 and A2 – 261 m (856 ft)
A3 and A4 – 293 m (961 ft)

Required Observers

Owing to the small impact zone and in an effort to encourage industry to develop and use smaller/more effective cutting charges, company observers would be allowed to conduct the MPS monitoring for all of the very-small blasting scenarios. To qualify as an "adequately trained" observer, operator/contractor personnel must attend observer training courses offered by private or government entities. In addition to meeting all reporting requirements, company observers would:

- Brief appropriate crew of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with blasting personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring and not secondary tasking.

Pre-Det Monitoring

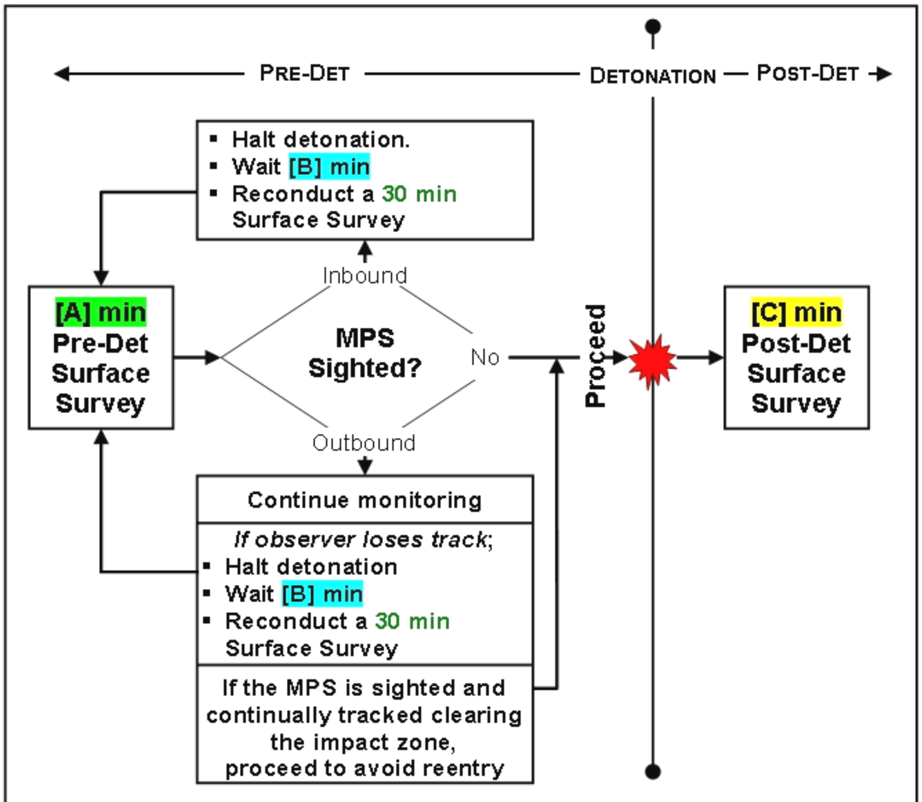
Before severance charge detonation, the company observer will conduct a 60 min (Scenarios A1 and A3) or 90 min (Scenarios A2 and A4) **surface monitoring survey** of the impact zone. The monitoring will be conducted from the highest vantage point available from either the decommissioning target or proximal surface vessels. If during the survey a MPS is:

- **Not sighted**, proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone**, proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
  - Halt the detonation,
  - Wait 30 min, and
  - Reconduct a 30 min **surface monitoring survey**; or
- **Sighted inbound**,
  - Halt the detonation,
  - Wait 30 min, and
  - Reconduct a 30 min **surface monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the company observer will conduct a 30 min **surface monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts should be made to collect/resuscitate the animal, and the observer will contact MMS and NOAA Fisheries as per the take event procedures described on page F-9 of this appendix. If no MPS are observed to be impacted by the detonation, the company observer is to record all of the necessary information as per the conditions detailed in MMS's permit approval letter (i.e., MMPA/ESA incidental-take requirements) and prepare a trip report for routing to MMS and NOAA Fisheries.

If unforeseen conditions or events occur during a very-small blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the company observer, severance contractor, and company representatives are directed to contact the NOAA Fisheries' PROP coordinator and MMS's GOM Region for additional guidance. A flowchart of the monitoring process and associated survey times for very-small severance-scenarios A1, A2, A3, and A4 is provided in Figure F-2.



Scenario	Pre-Det Surface [A]	Waiting Period [B]	Post-Det Surface [C]
	(Minutes)		
A1	60	30	30
A2	90	30	30
A3	60	30	30
A4	90	30	30

Figure F-2. Surveys, time requisites, and monitoring process for very-small severance-scenarios A1, A2, A3, and A4.

Small Blasting Category

Shelf (<200 m) and Slope (>200 m) Scenarios B1, B2, B3, and B4

An operator proposing explosive-severance activities conduced under the small blasting category will be limited to 20-lb charge sizes (AML or BML) and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

B1 and B2 – 373 m (1,224 ft)
B3 and B4 – 522 m (1,714 ft)

Required Observers

Generally, two NOAA Fisheries observers (PROP or contracted personnel) are required to perform MPS detection surveys for small-blasting scenarios. If necessary, the PROP Coordinator will determine if additional observers are required to compensate for the complexity of severance activities and or structure configuration. In addition to meeting all reporting requirements, the NOAA Fisheries observers would:

- Brief affected crew and severance contractors of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with company and blasting personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring.

Pre-Det Monitoring

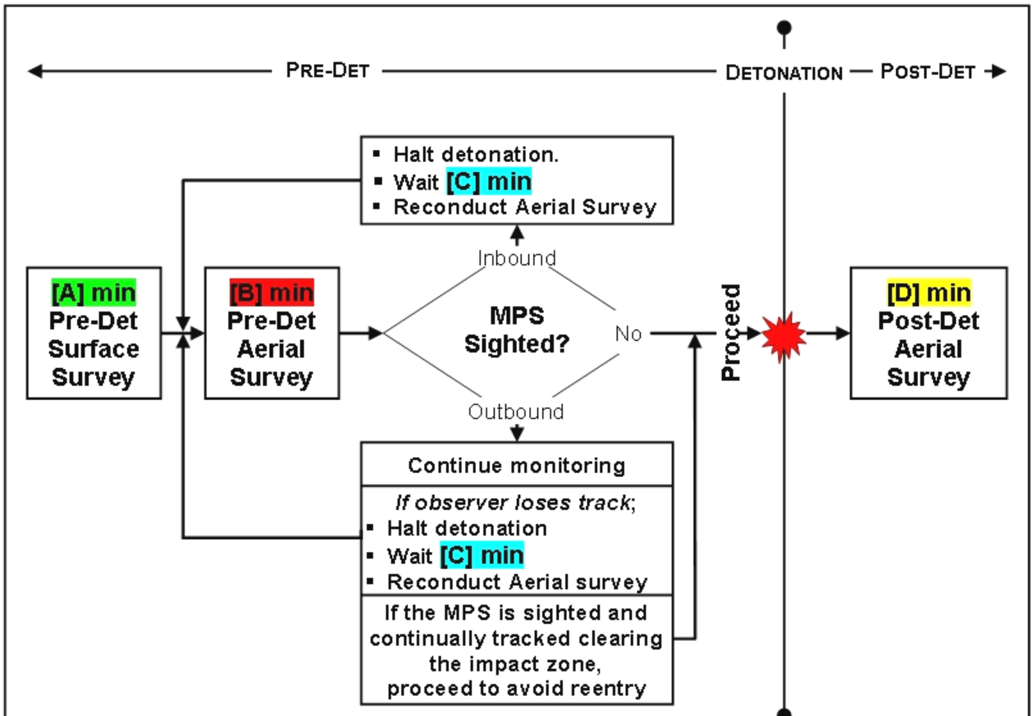
Before severance charge detonation, both NOAA Fisheries observers will conduct a 60 min (Scenarios B1 and B3) or 90 min (Scenarios B2 and B4) **surface monitoring survey** of the impact zone. The monitoring will be conducted from the highest vantage point available from either the decommissioning target or proximal surface vessels. Once the surface monitoring is complete (i.e., the impact zone cleared of MPS), one of the NOAA Fisheries observers will transfer to a helicopter to conduct a 30 min **aerial monitoring survey**. As per PROP-approved guidelines, the helicopter will transverse the impact zone at low speed/altitude in a specified grid pattern. If during the aerial survey a MPS is:

- **Not sighted**, proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone**, proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
    - Halt the detonation,
    - Wait 30 min, and
    - Reconduct a 30 min **aerial monitoring survey**; or
- **Sighted inbound**,
    - Halt the detonation,
    - Wait 30 min, and
    - Reconduct a 30 min **aerial monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the NOAA Fisheries observer will conduct a 30 min **aerial monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts will be made to collect/resuscitate the animal, and NOAA Fisheries SERO will be contacted as per the take event procedures described on page F-9 of this appendix. If no MPS are observed to be impacted by the detonation, the NOAA Fisheries observer will record all of the necessary information as per the conditions detailed in MMS's permit approval letter and PROP guidelines for the preparation of a trip report.

If unforeseen conditions or events occur during a small-blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the NOAA Fisheries observer will contact the PROP coordinator and/or MMS's GOM Region for additional guidance. A flowchart of the monitoring process and associated survey times for small severance-scenarios B1, B2, B3, and B4 is provided in Figure F-3.



Scenario	Pre-Det Surface [A]	Pre-Det Aerial [B]	Waiting Period [C]	Post-Det Aerial [D]
	(Minutes)			
B1	60	30	30	30
B2	90	30	30	30
B3	60	30	30	30
B4	90	30	30	30

Figure F-3. Surveys, time requisites, and monitoring process for small severance-scenarios B1, B2, B3, and B4.

Standard Blasting Category

Shelf (<200 m) Scenarios C1 and C3

An operator proposing shelf-based (<200 m), explosive-severance activities conduced under the standard blasting category will be limited to 80-lb charge sizes (BML or AML) and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

C1 – 631 m (2,069 ft)
C3 – 829 m (2,721 ft)

Required Observers

Generally, two NOAA Fisheries observers (PROP or contracted personnel) are required to perform MPS detection surveys for standard-blasting, shelf scenarios C1 and C3. If necessary, the PROP Coordinator will determine if additional observers are required to compensate for the complexity of severance activities and or structure configuration. In addition to meeting all reporting requirements, the NOAA Fisheries observers would:

- Brief affected crew and severance contractors of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with company and blasting personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring.

Pre-Det Monitoring

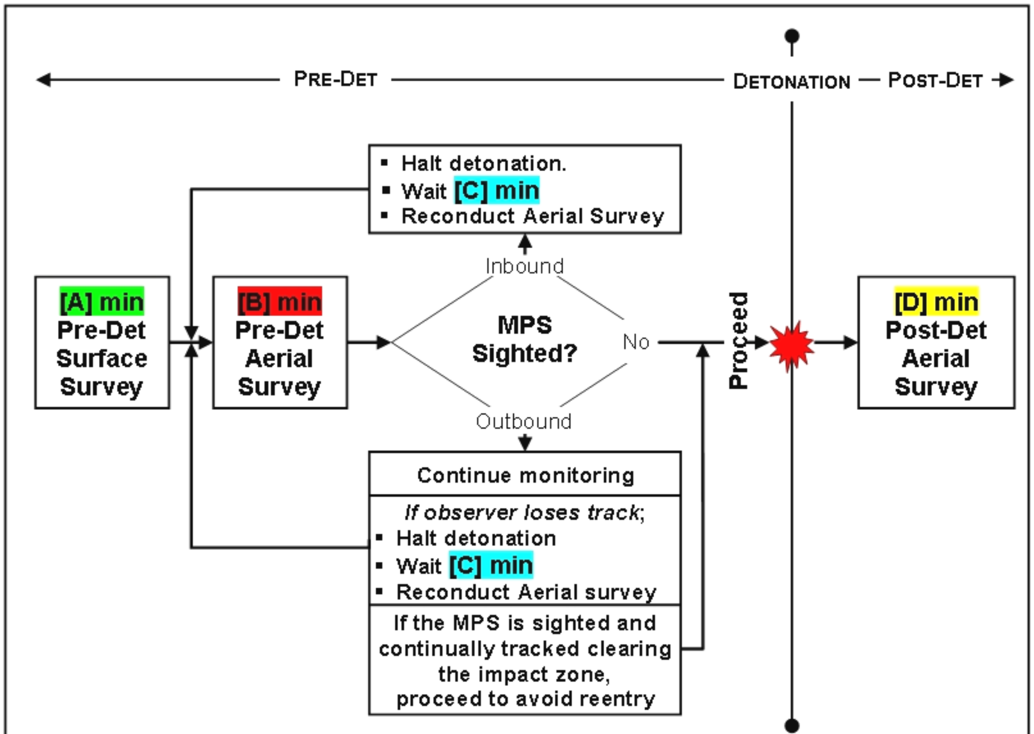
Before severance charge detonation, both NOAA Fisheries observers will conduct a 90 min **surface monitoring survey** of the impact zone. The monitoring will be conducted from the highest vantage point available from either the decommissioning target or proximal surface vessels. Once the surface monitoring is complete (i.e., the impact zone cleared of MPS), one of the NOAA Fisheries observers will transfer to a helicopter to conduct a 30 min (Scenario C1) or 45 min (Scenario C3) **aerial monitoring survey**. As per PROP-approved guidelines, the helicopter will transverse the impact zone at low speed/altitude in a specified grid pattern. If during the aerial survey a MPS is:

- **Not sighted**, proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone**, proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
  - Halt the detonation,
  - Wait 30 min, and
  - Reconduct the 30 min (C1) or 45 min (C3) **aerial monitoring survey**; or
- **Sighted inbound**,
  - Halt the detonation,
  - Wait 30 min, and
  - Reconduct the 30 min (C1) or 45 min (C3) **aerial monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the NOAA Fisheries observer will conduct a 30 min **aerial monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts will be made to collect/resuscitate the animal, and NOAA Fisheries SERO will be contacted as per the take event procedures described on page F-9 of this appendix. If no MPS are observed to be impacted by the detonation, the NOAA Fisheries observer will record all of the necessary information as per the conditions detailed in MMS's permit approval letter and PROP guidelines for the preparation of a trip report.

If unforeseen conditions or events occur during a standard-blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the NOAA Fisheries observer will contact the PROP coordinator and/or MMS's GOM Region for additional guidance. A flowchart of the monitoring process and associated survey times for standard severance-scenarios C1 and C3 is provided in Figure F-4.



Scenario	Pre-Det Surface [A]	Pre-Det Aerial [B]	Waiting Period [C]	Post-Det Aerial [D]
	(Minutes)			
C1	90	30	30	30
C3	90	45	30	30

Figure F-4. Surveys, time requisites, and monitoring process for standard severance-scenarios C1 and C3.

Slope (>200 m) Scenarios C2 and C4

An operator proposing slope-based (>200 m), explosive-severance activities conduced under the standard blasting category will be limited to 80-lb charge sizes (BML or AML) and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

C2 – 631 m (2,069 ft)
C4 – 829 m (2,721 ft)

Required Observers

Since standard-blasting, slope scenarios require a minimum of three (3) NOAA Fisheries observers (PROP or contracted personnel) for the simultaneous surface, aerial, and acoustic monitoring surveys, at least two (2) "teams" of observers will be required. The PROP Coordinator will determine each "team" size depending upon the complexity of severance activities and or structure configuration. In addition to meeting all reporting requirements, the NOAA Fisheries observers would:

- Brief affected crew and severance contractors of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with company, blasting, and acoustic monitoring personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring.

Pre-Det Monitoring

Before severance charge detonation, NOAA Fisheries observers will begin a 90 min **surface monitoring survey** and a 120 min (Scenario C2) or 150 min (Scenario C4) **passive-acoustic monitoring survey** of the impact zone. The surface monitoring will be conducted from the highest vantage point available and the acoustic monitoring will be conducted using NOAA-approved passive-acoustic monitoring devices and technicians. Once the surface monitoring is complete (i.e., the impact zone cleared of MPS), the acoustic survey will continue while one of the NOAA Fisheries observers transfer to a helicopter to conduct a 30 min (Scenario C2) or 60 min (Scenario C4) **aerial monitoring survey**. As per PROP-approved guidelines, the helicopter will transverse the impact zone at low speed/altitude in a specified grid pattern. If during the aerial survey a MPS is:

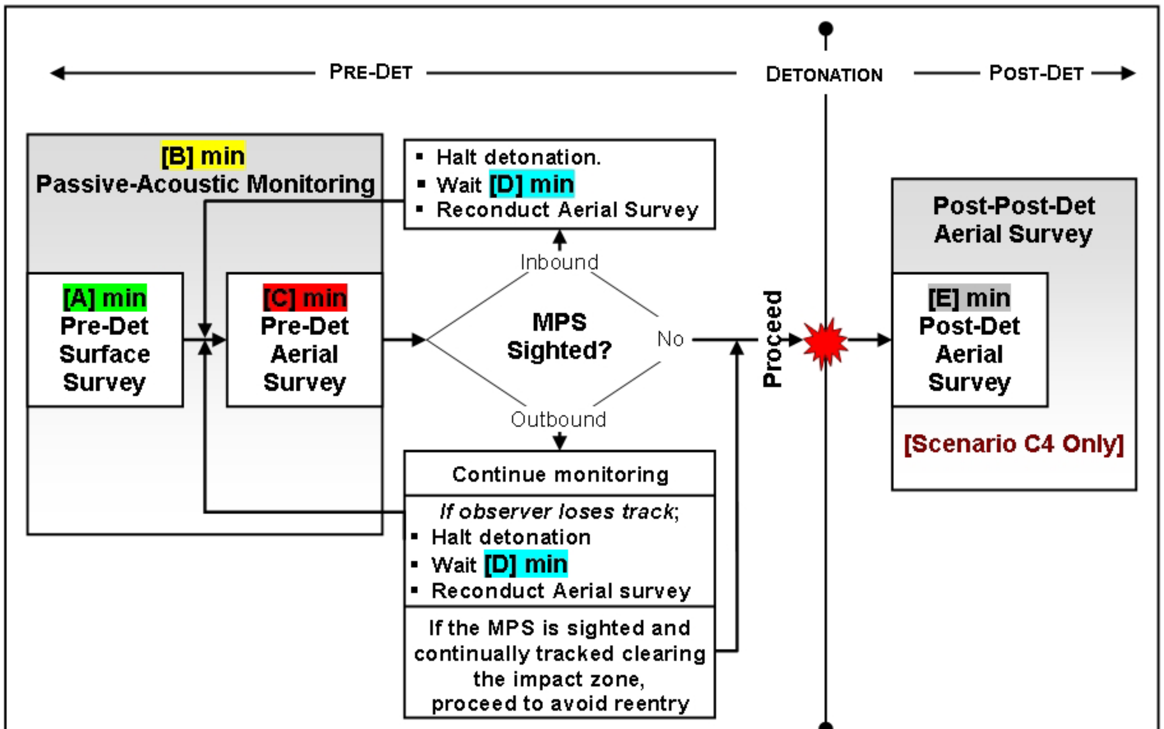
- **Not sighted or detected** (acoustically), proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone and not detected** (acoustically), proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
  - Halt the detonation,
  - Wait 30 min (C2) or 45 min (C4), and
  - Reconduct the 30 min (C2) or 60 min (C4) **aerial monitoring survey**; or
- **Sighted inbound or detected** (acoustically),
  - Halt the detonation,
  - Wait 30 min (C2) or 45 min (C4), and
  - Reconduct the 30 min (C2) or 60 min (C4) **aerial monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the NOAA Fisheries observer will conduct a 30 min **aerial monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts will be made to collect/resuscitate the animal, and NOAA Fisheries SERO will be contacted as per the take event procedures described on page F-9 of this appendix.

Scenario C4 also requires a **post-post-det aerial monitoring survey** to be conducted within 2-7 days after detonation activities conclude. Conducted by helicopter or fixed-wing aircraft, observations are to start at the removal site and proceed leeward and outward of wind and current movement. Any injured or killed MPS must be recorded, and if possible, tracked and collected after notifying NOAA Fisheries SERO. If no MPS are observed to be impacted during either aerial survey, the NOAA Fisheries observers will record all of the necessary information as per the conditions detailed in MMS's permit approval letter and PROP guidelines for the preparation of a trip report.

If unforeseen conditions or events occur during a standard-blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the NOAA Fisheries observer will contact the PROP coordinator and/or MMS's GOM Region for additional guidance. A flowchart of the monitoring process and associated survey times for standard severance-scenarios C2 and C4 is provided in Figure F-5.



Scenario	Pre-Det Surface [A]	Passive Acoustic [B]	Pre-Det Aerial [C]	Waiting Period [D]	Post-Det Aerial [E]
	(Minutes)				
C2	90	120	30	30	30
C4	90	150	60	45	30

Figure F-5. Surveys, time requisites, and monitoring process for standard severance-scenarios C2 and C4.

Large Blasting Category

Shelf (<200 m) Scenarios D1 and D3

An operator proposing shelf-based (<200 m), explosive-severance activities conduced under the large blasting category will be limited to 200-lb charge sizes (BML or AML) and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

D1 – 941 m (3,086 ft)
D3 – 1,126 m (3,693 ft)

Required Observers

Generally, two NOAA Fisheries observers (PROP or contracted personnel) are required to perform MPS detection surveys for large-blasting, shelf scenarios D1 and D3. If necessary, the PROP Coordinator will determine if additional observers are required to compensate for the complexity of severance activities and or structure configuration. In addition to meeting all reporting requirements, the NOAA Fisheries observers would:

- Brief affected crew and severance contractors of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with company and blasting personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring.

Pre-Det Monitoring

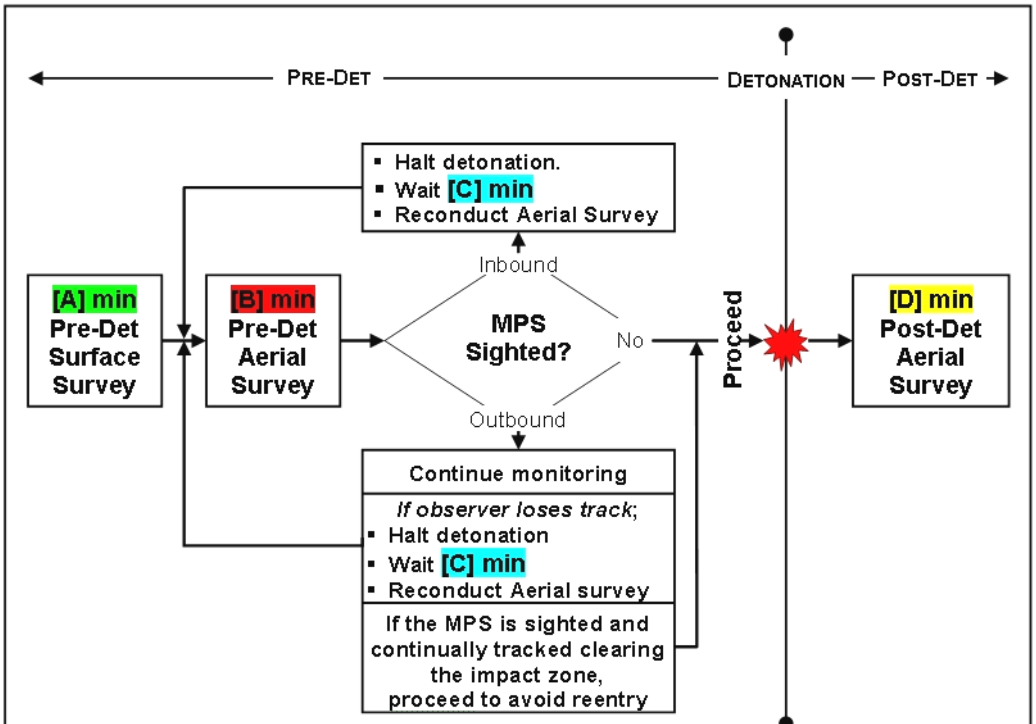
Before severance charge detonation, both NOAA Fisheries observers will conduct a 120 min **surface monitoring survey** of the impact zone. The monitoring will be conducted from the highest vantage point available from either the decommissioning target or proximal surface vessels. Once the surface monitoring is complete (i.e., the impact zone cleared of MPS), one of the NOAA Fisheries observers will transfer to a helicopter to conduct a 45 min (Scenario D1) or 60 min (Scenario D3) **aerial monitoring survey**. As per PROP-approved guidelines, the helicopter will transverse the impact zone at low speed/altitude in a specified grid pattern. If during the aerial survey a MPS is:

- **Not sighted**, proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone**, proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
    - o Halt the detonation,
    - o Wait 30 min, and
    - o Reconduct the 45 min (D1) or 60 min (D3) **aerial monitoring survey**; or
- **Sighted inbound**,
    - o Halt the detonation,
    - o Wait 30 min, and
    - o Reconduct the 45 min (D1) or 60 min (D3) **aerial monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the NOAA Fisheries observer will conduct a 30 min **aerial monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts will be made to collect/resuscitate the animal, and NOAA Fisheries SERO will be contacted as per the take event procedures described on page F-9 of this appendix. If no MPS are observed to be impacted by the detonation, the NOAA Fisheries observer will record all of the necessary information as per the conditions detailed in MMS's permit approval letter and PROP guidelines for the preparation of a trip report.

If unforeseen conditions or events occur during a large-blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the NOAA Fisheries observer will contact the PROP coordinator and/or MMS's GOM Region for additional guidance. A flowchart of the monitoring process and associated survey times for large severance-scenarios D1 and D3 is provided in Figure F-6.



Scenario	Pre-Det Surface [A]	Pre-Det Aerial [B]	Waiting Period [C]	Post-Det Aerial [D]
	(Minutes)			
D1	120	45	30	30
D3	120	60	30	30

Figure F-6. Surveys, time requisites, and monitoring process for large severance-scenarios D1 and D3.

Slope (>200 m) Scenarios D2 and D4

An operator proposing slope-based (<200 m), explosive-severance activities conduced under the large blasting category will be limited to 200-lb charge sizes (BML or AML) and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

D2 – 941 m (3,086 ft)
D4 – 1,126 m (3,693 ft)

Required Observers

Since large-blasting, slope scenarios require a minimum of three (3) NOAA Fisheries observers (PROP or contracted personnel) for the simultaneous surface, aerial, and acoustic monitoring surveys, at least two (2) "teams" of observers will be required. The PROP Coordinator will determine each "team" size depending upon the complexity of severance activities and or structure configuration. In addition to meeting all reporting requirements, the NOAA Fisheries observers would:

- Brief affected crew and severance contractors of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with company, blasting, and acoustic monitoring personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring.

Pre-Det Monitoring

Before severance charge detonation, NOAA Fisheries observers will begin a 120 min **surface monitoring survey** and a 180 min (Scenario D2) or 210 min (Scenario D4) **passive-acoustic monitoring survey** of the impact zone. The surface monitoring will be conducted from the highest vantage point available and the acoustic monitoring will be conducted using NOAA-approved passive-acoustic monitoring devices and technicians. Once the surface monitoring is complete (i.e., the impact zone cleared of MPS), the acoustic survey will continue while one of the NOAA Fisheries observers transfer to a helicopter to conduct a 60 min **aerial monitoring survey**. As per PROP-approved guidelines, the helicopter will transverse the impact zone at low speed/altitude in a specified grid pattern. If during the aerial survey a MPS is:

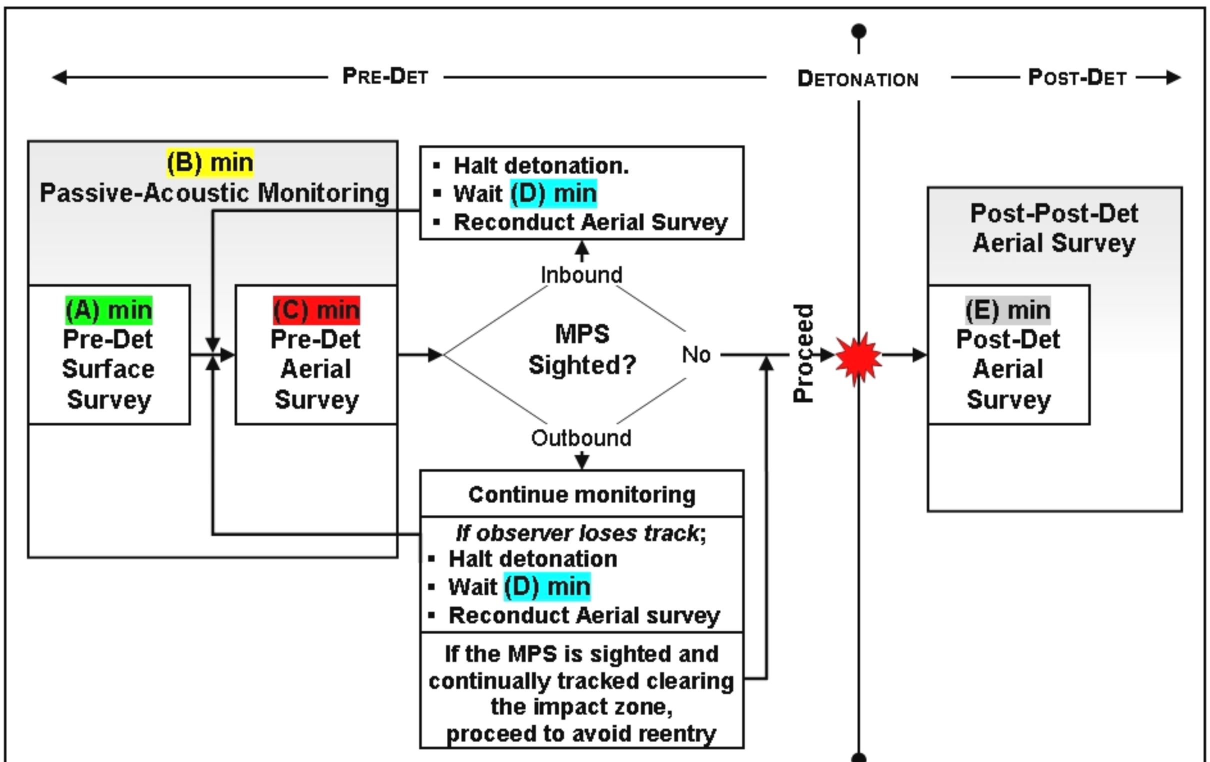
- **Not sighted or detected** (acoustically), proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone and not detected** (acoustically), proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
    - Halt the detonation,
    - Wait 45 min, and
    - Reconduct the 60 min **aerial monitoring survey**; or
- **Sighted inbound or detected** (acoustically),
    - Halt the detonation,
    - Wait 45 min, and
    - Reconduct the 60 min **aerial monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the NOAA Fisheries observer will conduct a 30 min **aerial monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts will be made to collect/resuscitate the animal, and NOAA Fisheries SERO will be contacted as per the take event procedures described on page F-9 of this appendix.

Scenarios D2 and D4 also require a **post-post-det aerial monitoring survey** to be conducted within 2-7 days after detonation activities conclude. Conducted by helicopter or fixed-wing aircraft, observations are to start at the removal site and proceed leeward and outward of wind and current movement. Any injured or killed MPS must be recorded, and if possible, tracked and collected after notifying NOAA Fisheries SERO. If no MPS are observed to be impacted during either aerial survey, the NOAA Fisheries observers will record all of the necessary information as per the conditions detailed in MMS's permit approval letter and PROP guidelines for the preparation of a trip report.

If unforeseen conditions or events occur during a large-blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the NOAA Fisheries observer will contact the PROP coordinator and/or MMS's GOM Region for additional guidance. A flowchart of the standard monitoring process and associated survey times for large severance-scenarios D2 and D4 is provided in Figure F-7.



Scenario	Pre-Det Surface [A]	Passive Acoustic [B]	Pre-Det Aerial [C]	Waiting Period [D]	Post-Det Aerial [E]
	(Minutes)				
D2	120	180	60	45	30
D4	120	210	60	45	30

Figure F-7. Surveys, time requisites, and monitoring process for large severance-scenarios D2 and D4.

Specialty Blasting Category

Shelf (<200 m) Scenarios E1 and E3

An operator proposing shelf-based (<200 m), explosive-severance activities conduced under the specialty blasting category will be limited to 500-lb charge sizes (BML or AML) and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

E1 – 1,500 m (4,916 ft)
E3 – 1,528 m (5,012 ft)

Required Observers

Generally, two NOAA Fisheries observers (PROP or contracted personnel) are required to perform MPS detection surveys for specialty-blasting, shelf scenarios E1 and E3. If necessary, the PROP Coordinator will determine if additional observers are required to compensate for the complexity of severance activities and or structure configuration. In addition to meeting all reporting requirements, the NOAA Fisheries observers would:

- Brief affected crew and severance contractors of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with company and blasting personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring.

Pre-Det Monitoring

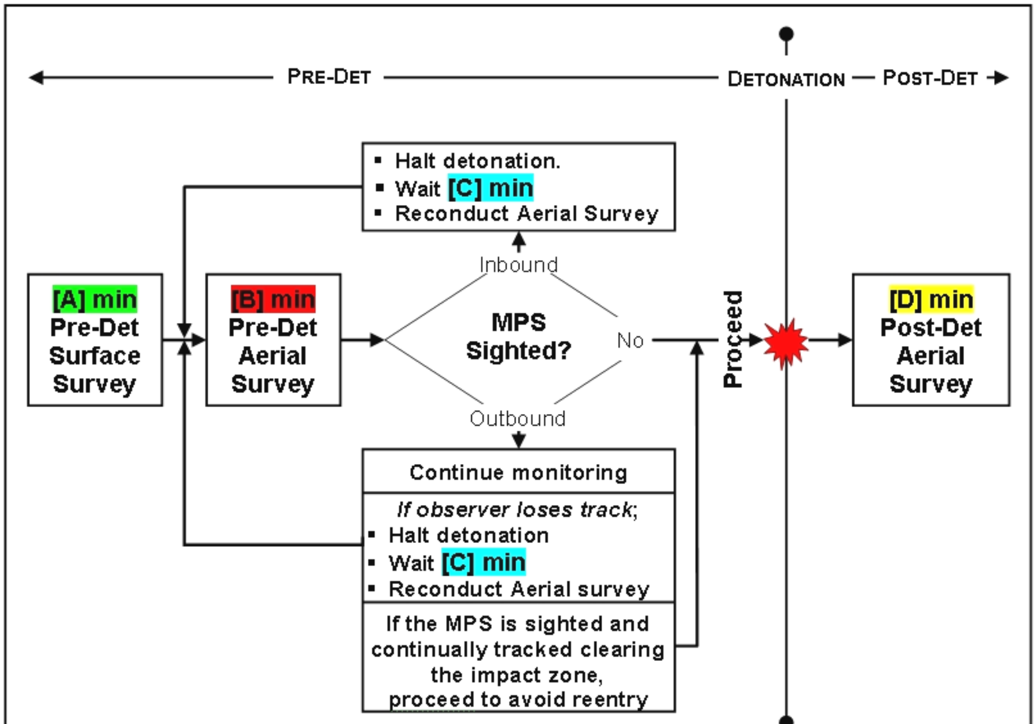
Before severance charge detonation, both NOAA Fisheries observers will conduct a 150 min **surface monitoring survey** of the impact zone. The monitoring will be conducted from the highest vantage point available from either the decommissioning target or proximal surface vessels. Once the surface monitoring is complete (i.e., the impact zone cleared of MPS), one of the NOAA Fisheries observers will transfer to a helicopter to conduct a 90 min **aerial monitoring survey**. As per PROP-approved guidelines, the helicopter will transverse the impact zone at low speed/altitude in a specified grid pattern. If during the aerial survey a MPS is:

- **Not sighted**, proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone**, proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
    - Halt the detonation,
    - Wait 45 min, and
    - Reconduct the 90 min **aerial monitoring survey**; or
- **Sighted inbound**,
    - Halt the detonation,
    - Wait 45 min, and
    - Reconduct the 90 min **aerial monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the NOAA Fisheries observer will conduct a 45 min **aerial monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts will be made to collect/resuscitate the animal, and NOAA Fisheries SERO will be contacted as per the take event procedures described on page F-9 of this appendix. If no MPS are observed to be impacted by the detonation, the NOAA Fisheries observer will record all of the necessary information as per the conditions detailed in MMS's permit approval letter and PROP guidelines for the preparation of a trip report.

If unforeseen conditions or events occur during a specialty-blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the NOAA Fisheries observer will contact the PROP coordinator and/or MMS's GOM Region for additional guidance. A flowchart of the monitoring process and associated survey times for specialty severance-scenarios E1 and E3 is provided in Figure F-8.



Scenario	Pre-Det Surface [A]	Pre-Det Aerial [B]	Waiting Period [C]	Post-Det Aerial [D]
	(Minutes)			
E1	150	90	45	45
E3	150	90	45	45

Figure F-8. Surveys, time requisites, and monitoring process for large severance-scenarios E1 and E3.

Slope (>200 m) Scenarios E2 and E4

An operator proposing slope-based (>200 m), explosive-severance activities conduced under the specialty blasting category will be limited to 500-lb charge sizes (BML or AML) and conduct all requisite monitoring during daylight hours out to the associated impact-zone radii listed below:

E2 – 1,500 m (4,916 ft)
E4 – 1,528 m (5,012 ft)

Required Observers

Since specialty-blasting, slope scenarios require a minimum of three (3) NOAA Fisheries observers (PROP or contracted personnel) for the simultaneous surface, aerial, and acoustic monitoring surveys, at least two (2) "teams" of observers will be required. The PROP Coordinator will determine each "team" size depending upon the complexity of severance activities and or structure configuration. In addition to meeting all reporting requirements, the NOAA Fisheries observers would:

- Brief affected crew and severance contractors of the monitoring efforts and notify topsides personnel to report any sighted MPS to the observer or company representative immediately;
- Establish an active line of communication (i.e., 2-way radio, visual signals, etc.) with company, blasting, and acoustic monitoring personnel; and
- Devote the entire, uninterrupted survey time to MPS monitoring.

Pre-Det Monitoring

Before severance charge detonation, NOAA Fisheries observers will begin a 180 min **surface monitoring survey** and a 270 min **passive-acoustic monitoring survey** of the impact zone. The surface monitoring will be conducted from the highest vantage point available and the acoustic monitoring will be conducted using NOAA-approved passive-acoustic monitoring devices and technicians. Once the surface monitoring is complete (i.e., the impact zone cleared of MPS), the acoustic survey will continue while one of the NOAA Fisheries observers transfer to a helicopter to conduct a 90 min **aerial monitoring survey**. As per PROP-approved guidelines, the helicopter will transverse the impact zone at low speed/altitude in a specified grid pattern. If during the aerial survey a MPS is:

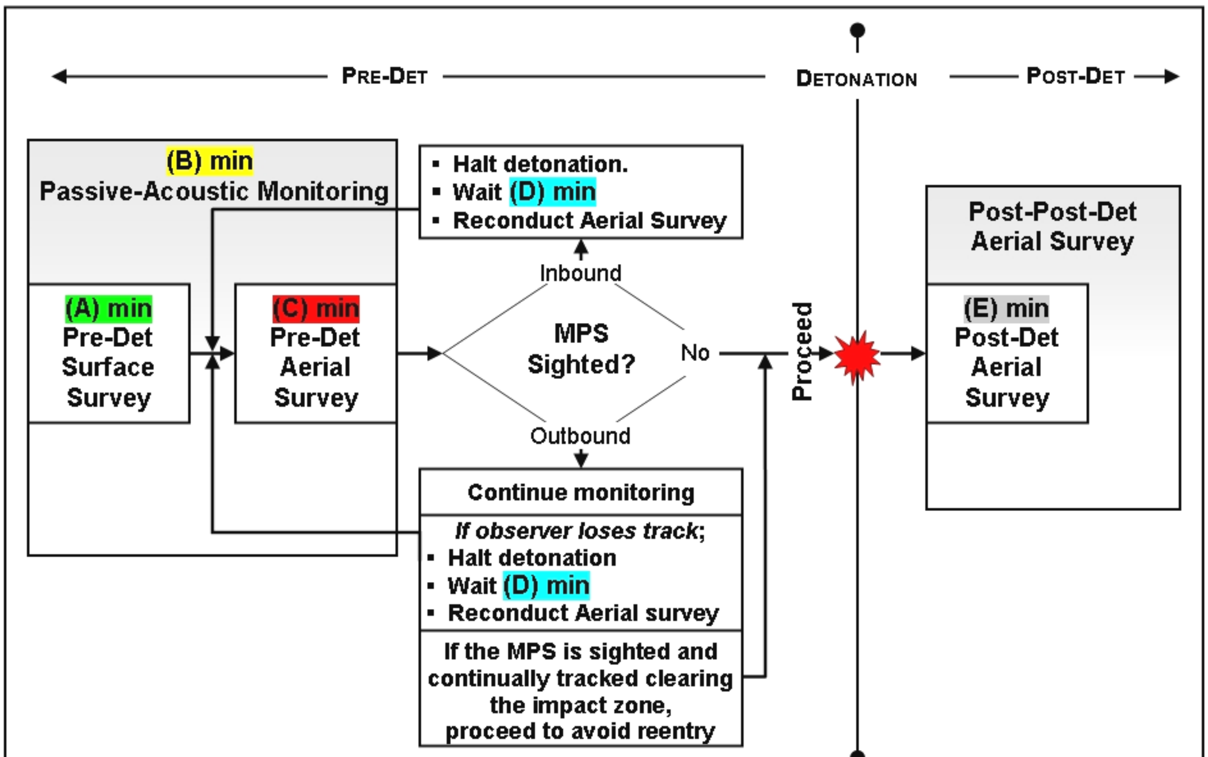
- **Not sighted or detected** (acoustically), proceed with the detonation;
- **Sighted outbound and continuously tracked clearing the impact zone and not detected** (acoustically), proceed with the detonation after the monitoring time is complete to avoid reentry;
- **Sighted outbound and the MPS track is lost** (i.e., the animal dives below the surface),
    - Halt the detonation,
    - Wait 45 min, and
    - Reconduct the 90 min **aerial monitoring survey**; or
- **Sighted inbound or detected** (acoustically),
    - Halt the detonation,
    - Wait 45 min, and
    - Reconduct the 90 min **aerial monitoring survey**.

Post-Det Monitoring

After severance charge detonation, the NOAA Fisheries observer will conduct a 45 min **aerial monitoring survey** of the impact zone to detect for impacted MPS. If a MPS is observed shocked, injured, or killed, the operations will cease, attempts will be made to collect/resuscitate the animal, and NOAA Fisheries SERO will be contacted as per the take event procedures described on page F-9 of this appendix.

Scenarios E2 and E4 also require a **post-post-det aerial monitoring survey** to be conducted within 2-7 days after detonation activities conclude. Conducted by helicopter or fixed-wing aircraft, observations are to start at the removal site and proceed leeward and outward of wind and current movement. Any injured or killed MPS must be recorded, and if possible, tracked and collected after notifying NOAA Fisheries SERO. If no MPS are observed to be impacted during either aerial survey, the NOAA Fisheries observers will record all of the necessary information as per the conditions detailed in MMS's permit approval letter and PROP guidelines for the preparation of a trip report.

If unforeseen conditions or events occur during a specialty-blasting operation that necessitates monitoring requirements fall outside of the applicable regulations, the NOAA Fisheries observer will contact the PROP coordinator and/or MMS's GOM Region for additional guidance. A flowchart of the monitoring process and associated survey times for specialty severance-scenarios E2 and E4 is provided in Figure F-9.



Scenario	Pre-Det Surface [A]	Passive Acoustic [B]	Pre-Det Aerial [C]	Waiting Period [D]	Post-Det Aerial [E]
	(Minutes)				
E2	180	270	90	45	45
E4	180	270	90	45	45

Figure F-9. Surveys, time requisites, and monitoring process for large severance-scenarios E2 and E4.

All of the mitigation discussed in this appendix relates to minimum requirements that were analyzed as part of the proposed action. As noted in the Introduction, the programmatic explosive-severance and site-clearance trawling mitigation will be incorporated into pending MMPA incidental-take rulemaking and an ESA, Section 7 consultation; therefore, additions to and variations of the mitigation could occur. The resultant MMPA/ESA incidental-take mitigation will be integrated into MMS's removal-permitting process and conveyed to operators as conditions of permit approval. However, operators may ultimately wish to increase the number, type, or duration of certain survey requirements depending upon the situation and suggestions from the assigned MPS observer.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.

MMS Securing Ocean Energy & Economic Value for America