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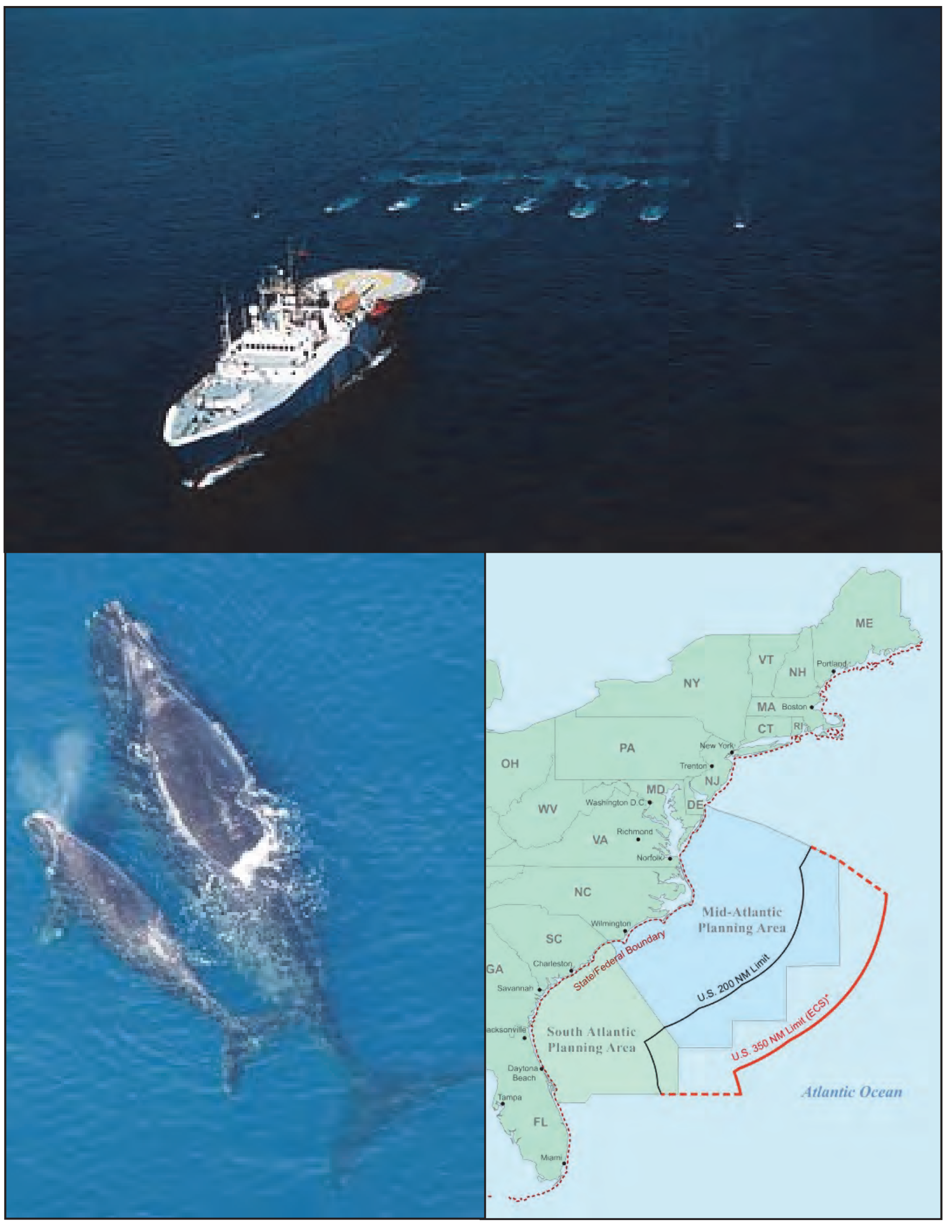
BOEM 2014-001

Atlantic OCS
Proposed Geological and Geophysical Activities

Mid-Atlantic and South Atlantic Planning Areas

Final Programmatic Environmental Impact Statement

Volume III: Appendices B-M



U.S. Department of the Interior
Bureau of Ocean Energy Management
Gulf of Mexico OCS Region

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Author

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Gulf of Mexico OCS Region

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APPENDIX B

STATE COASTAL ZONE MANAGEMENT PROGRAMS

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The Coastal Zone Management Act (CZMA) was established to develop comprehensive programs to manage and balance competing uses of and impacts to coastal resources. The CZMA emphasizes the primacy of State decision-making regarding the coastal zone preserve, to protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations; and to encourage and assist the States to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development. In order to implement CZMA, each State has a Coastal Management Program (CMP) that is federally approved by the National Oceanic and Atmospheric Administration (NOAA). These CMPs are a comprehensive statement setting forth objectives, enforceable policies, and standards for public and private use of land and water resources and uses in that State's coastal zone.

Federal consistency is the CZMA requirement where Federal agency activities that have reasonably foreseeable effects on any land or water use or natural resource of the coastal zone must be consistent to the maximum extent practicable with the enforceable policies of a coastal State’s federally approved CMP. The State requirements for Federal consistency review are based on the requirements of State statutes, CZMA regulations at 15 Code of Federal Regulations (CFR) part 930, and U.S. Dept. of the Interior (USDOI) regulations at 30 CFR part 250, 30 CFR part 254, and 30 CFR part 256. There are currently changes being undertaken within the CZMA program regulations, and NOAA intends to replace the CZMA program change regulations, 15 CFR part 923 subpart H, and the Office of Ocean and Coastal Resource Management’s (OCRM’s) Program Change Guidance (July 1996) with new regulations at 15 CFR part 923 subpart H (U.S. Dept. of Commerce [USDOC], NOAA, 2008).

Each coastal State’s official coastal boundary can be identified from NOAA’s website (USDOC, NOAA, 2011). Federal agencies provide feedback to the States through each Section 312 evaluation conducted by NOAA.

A State’s approved CMP may also provide for the State’s review of permits and license activities to determine whether they will be conducted in a manner consistent with the State’s CMP. This review authority is applicable to activities conducted in any area that has been leased under the Outer Continental Shelf Lands Act (OCSLA) and that affect any land or water use or natural resource within the State’s coastal zone (16 United States Code § 1456(c)(3)(B)).

This section provides an overview of the CMP within each State within the area of interest.

1. STATE OF NEW JERSEY’S COASTAL MANAGEMENT PROGRAM

The New Jersey Coastal Management Program (CMP) was first approved by NOAA in 1978 and is directly administered by its lead agency, the New Jersey Department of Environmental Protection, in partnership with the New Jersey Meadowlands Commission, as the lead planning agency for the Hackensack Meadowlands District. The New Jersey CMP is based on three major laws: the Coastal Area Facilities Review Act, the Wetlands Act of 1970, and the Waterfront Development Law.

Concerted coastal management efforts began in New Jersey in 1970 with the passage of the Wetlands Act of 1970, followed by the Coastal Area Facility Review Act in 1973. In response to the Federal CZMA of 1972, New Jersey developed and gained Federal approval of the New Jersey Coastal Management program, which addresses the complex coastal ecosystem as a whole, integrating goals and standards for protection/enhancement of natural resources, for appropriate land use and development, and for public access to and use of coastal resources. The Program brought together the above laws as well as the Waterfront Development Law, the Public Trust Doctrine for access to and use of State-owned tidelands and the regulatory activities of the New Jersey Meadowlands Commission.

The regulatory authority of the New Jersey CMP has evolved over the years through amendments to the coastal zone management rules and the Coastal Permit Program rules. In addition, the Freshwater Wetlands Protection Act and implementing rules have been incorporated into the Program. The non-regulatory coastal Non-Point Pollution Control Program, recently developed as required by the CZMA, is also being integrated into the Program.

New Jersey’s coastal zone encompasses tidal and non-tidal waters, waterfronts, and inland areas. The coastal zone includes the Hudson River from the interstate border with New York and related tidal waters, south to Raritan Bay. It continues along the Raritan Bay then extends south from Sandy Hook to Cape

May Point encompassing the State territorial waters of the Atlantic Ocean and associated tidal water bodies. From Cape May Point, the coastal zone trends north to Trenton and it contains waters of the Delaware Bay and River and includes tidal portions of their tributaries. Upland areas along these tidal waterways are included within the coastal zone.

New Jersey's coastal zone boundary encompasses approximately 1,800 miles (2,897 kilometers) of tidal coastline, including 126 miles (203 kilometers) along the Atlantic oceanfront from Sandy Hook to Cape May. It ranges in width from 100 ft (30 meters) to 16.5 miles (26.6 kilometers).

For Federal Consistency, the State of New Jersey requires a detailed description of all proposed federally licensed or permitted activities and facilities for Outer Continental Shelf (OCS) activities that significantly affect the coastal zone. More information regarding the New Jersey CMP and its Federal consistency process can be found at the New Jersey CMP website (New Jersey Department of Environmental Protection, 2012).

2. STATE OF DELAWARE'S COASTAL MANAGEMENT PROGRAM

Delaware's Coastal Zone Act was passed in 1971 and provides to the Secretary of the Department of Natural Resources and Environmental Control (DNREC) and the Coastal Zone Industrial Control Board the authority to promulgate regulations to carry out the requirements contained within the Act. Delaware has defined its Coastal Management Area as the entire State for the purposes of the federally approved CMP. The management of Delaware's coastal resources is shared by a number of entities within DNREC including the Delaware Coastal Management Program (DCMP) and the Delaware National Estuarine Research Reserve (DNERR). These programs help to preserve, protect, develop and enhance the State's coastal resources and resolve conflicts related to coastal zone issues. Functions of the DCMP include management of coastal resources through research projects, education and grant programs, and policy development; administration of the Coastal Zone Federal Consistency Certification program; special area management planning; and providing technical assistance to State and local governments for local land use planning. The function of DNERR is to preserve and manage the natural resources within the Reserve and to promote informed coastal decision-making.

In 2004, the DCMP was responsible for the State's Coastal and Estuarine Land Conservation Program (CELCP) development. The CELCP is a land acquisition program funded by NOAA that provides grants to eligible State agencies and local governments to acquire property or conservation easements from willing sellers within a State's coastal zone or coastal watershed boundary.

The State of Delaware requires a detailed description and the coastal zone effects, objective, and schedule for all activities associated with a project; an analysis of the project's likely coastal zone effects and a description of how it will comply with applicable Coastal Zone Management policies; and an evaluation of the relevant enforceable policies of the DCMP. Individual exploration activities on the OCS with foreseeable impacts to Delaware's coastal resources or uses are subject to review to ensure compliance with Delaware's coastal management policies. As applicable geological and geophysical (G&G) projects are submitted for a Federal consistency determination, the DCMP will review potential impacts. The details of the survey type, location, and equipment used will dictate the State's position on each project. Supporting information can include copies of Federal permit applications, construction plans, environmental assessments or environmental impact statements, monitoring data, modeling data and verification of other permits received. The DCMP has an updated Program and Policy Document as of June 2011, which serves as a guide to the Delaware's coastal consistency process, and can be found at DNREC's website (DNREC, 2012).

3. STATE OF MARYLAND'S COASTAL PROGRAM

Maryland's Coastal Program, established by executive order and approved in 1978, is a network of State laws and policies designed to protect coastal and marine resources. Maryland's coastal zone includes 16 counties (Anne Arundel, Baltimore, Calvert, Caroline, Charles, Cecil, Dorchester, Harford, Kent, Prince George's, Queene Anne's, Somerset, St. Mary's, Talbot, Wicomico, and Worcester), Baltimore City, the Chesapeake Bay, other coastal bays, and the boundary extends to the limit of Maryland's 3-mile (5-kilometer) jurisdiction in the Atlantic Ocean. Through partnerships and funding to local governments, State agencies, non-profit organizations, and universities, the Coastal Program addresses a variety of coastal issues including provision of public access, nonpoint source pollution reduction, coastal hazards mitigation, habitat and living resources protection and growth management.

The Department of Natural Resources (DNR) is the lead agency for the State's CMP. Within DNR, the Coastal Zone Management Division of the Watershed Services Unit is the lead agency for the CMP. The Federal consistency requirements are carried out by the Coastal Zone Consistency Division in the Wetlands and Waterways Program of the Water Management Administration (WMA) in the Maryland Department of the Environment. WMA is responsible for coordinating the Federal consistency review with appropriate State agencies, consolidating the State's comments, and forwarding the State's response and decision to the appropriate applicant. Maryland does not require a separate coastal zone management application for, but requires that applicants for actions including OCS-related permits or approvals must certify that their proposed activity will be conducted in a manner consistent with the State's CMP. Typically, either the Federal permits and licenses or the Joint Federal/State Permit Application will be reviewed for consistency with the CMP. The State's permit authorization for permitted activities will include the required Federal consistency decision. A guide to Maryland's coastal consistency program (Ghigiarelli, 2004) can be found at Maryland's DNR website.

4. COMMONWEALTH OF VIRGINIA'S COASTAL ZONE MANAGEMENT PROGRAM

The Virginia CZM Program was established in 1986 through an Executive Order to protect and manage Virginia's "coastal zone." The Program is a network of State agencies and local governments through which the coastal resources of Virginia are managed. The network consists of 13 State agencies and local governments including the Marine Resources Commission; Department of Environmental Quality Lead coordinating agency; Department of Game and Inland Fisheries; Department of Conservation and Recreation; Department of Health; Tidewater Cities and Counties; Department of Agriculture and Consumer Affairs; Department of Forestry; Department of Historic Resources; Department of Mines, Minerals and Energy; Department of Transportation; Economic Development Partnership; and the Virginia Institute of Marine Science.

Virginia's coastal zone encompasses 29 counties, 15 cities, and 42 incorporated towns and all of the waters therein, and out to, the three nautical mile Territorial Sea boundary, including all of Virginia's Atlantic coast watershed as well as parts of the Chesapeake Bay and Albemarle-Pamlico Sound watersheds.

The Department of Environmental Quality (DEQ) serves as the lead agency for Virginia's networked CZM Program and helps agencies and localities to develop and implement coordinated coastal policies and solve coastal management problems while Coastal Policy Teams (CPTs) facilitate cooperation among the State agencies and local governments. The CPT members represent all of Virginia's key CZM partners and provide a forum for discussion and resolution of cross-cutting coastal resource management issues. Virginia's eight coastal planning district commissions (PDCs) also participate in the implementation of the Virginia CZM Program by providing a link between the State agencies and 87 localities that constitute Virginia's network of coastal resource managers. A representative from each PDC serves on the Virginia CZM Program's CPT. Virginia's eight PDCs are Accomack-Northampton Planning District Commission, Crater Planning District Commission, Hampton Roads Planning District Commission, Middle Peninsula Planning District Commission, Northern Neck Planning District Commission, Northern Virginia Regional Commission, George Washington Regional Commission, and Richmond Regional Planning District Commission.

For Federal consistency review, Virginia requires an adequate description including aspects of the project that may cause direct or indirect environmental impacts, objective, and schedule for all activities associated with a project; an evaluation that includes a set of findings relating to the probable coastal effects of the proposed project and its associated facilities to the relevant enforceable policies of the Virginia CZM Program. Further information on the Virginia consistency determination process may be found at DEQ's website (Virginia DEQ, 2011).

5. STATE OF NORTH CAROLINA'S COASTAL MANAGEMENT PROGRAM

The North Carolina Coastal Area Management Act (CAMA) was created in 1974. The CAMA established the Coastal Resources Commission (CRC), required local land use planning in 20 coastal counties, and provided for a program for regulating development. The North Carolina Coastal Management Program was federally approved in 1978. The CRC administers the CAMA, establishes policies for the North Carolina Coastal Management Program, and adopts implementing rules for both CAMA and the North Carolina Dredge and Fill Act. The commission also designates areas of environmental concern, adopts rules and policies for coastal development within those areas, and certifies local land-use plans. As part of this program, the CRC designated "Areas of Environmental Concern" within the 20 coastal counties and set rules for managing development within these areas.

The Division of Coastal Management (DCM), in the Department of Environment and Natural Resources, provides staffing services to the CRC, implements CRC rules, and issues CAMA permits. DCM is the lead agency of the North Carolina Coastal Management Program and implements and supervises all the various CZMPs in the State. North Carolina's coastal zone includes 20 coastal counties (Beaufort, Hertford, Bertie, Hyde, Brunswick, New Hanover, Camden, Onslow, Carteret, Pamlico, Chowan, Pasquotank, Craven, Pender, Currituck, Perquimans, Dare, Tyrrell, Gates, and Washington) that in whole or in part are adjacent to, adjoining, intersected or bounded by the Atlantic Ocean.

The consistency review process can be divided into two classifications, one for Federal activities and the other for non-Federal projects that require a Federal permit and/or license. For non-Federal projects, a Consistency Certification document must be submitted that demonstrates how the proposed project would be considered consistent with the State's Coastal program. The procedures for making this submission are contained in 15 CFR part 930 subpart D and further information on the North Carolina coastal zone management process can be found at the North Carolina Department of Environment and Natural Resources (2010) website.

For Federal consistency, any project must comply with the key elements of North Carolina's Coastal Management Program such as the CAMA, the State's Dredge and Fill Law, Chapter 7 of Title 15A of North Carolina's Administrative Code, regulations passed by the CRC, and local land use plans certified by the CRC.

6. STATE OF SOUTH CAROLINA'S COASTAL ZONE MANAGEMENT PROGRAM

The South Carolina CMP was established under the guidelines of the National Coastal Zone Management Act (1972) as a State-Federal partnership to comprehensively manage coastal resources. It was authorized in 1977 under South Carolina's Coastal Tidelands and Wetlands Act (SC Code Ann. §§ 48-39-10 *et seq*.) with the goal of achieving balance between the appropriate use, development, and conservation of coastal resources in the best interest of all citizens of the State.

The South Carolina Coastal Program established a permanent South Carolina Coastal Council; provided for the development and administration of a comprehensive Coastal Management Program; set up a permitting process for activities occurring in the four "critical areas" of the coastal zone (tidelands, coastal waters, beaches, and primary oceanfront sand dunes); and provided a mechanism for State and local agency consistency with the State's approved Coastal Management Program throughout the coastal zone.

The South Carolina Department of Health and Environmental Control Office of Ocean and Coastal Resource Management (DHEC-OCRM) is the designated State coastal management agency and is responsible for implementing the approved South Carolina CZMP through the authorities specified in the Coastal Tidelands and Wetlands Act (SC Code Ann. §§ 48-39-110 et seq.); the DHEC Coastal Division Regulations and the enforceable policies of the South Carolina Coastal Program Document.

The DHEC-OCRM has direct permitting authority for proposed activities within the "critical areas" of the coast. The DHEC-OCRM also has broader management authority over activities within the 8-county Coastal Zone (Beaufort, Berkeley, Charleston, Colleton, Dorchester, Horry, Jasper, and Georgetown) through consistency certification of both Federal and State permits, Federal licenses, and requests for funding assistance. The "critical areas" receive more intensive attention through a direct permitting system, while the remainder of the coastal zone is managed through cooperation with other State and local agencies.

The burden of implementing the South Carolina CMP rests not only with the Coastal Council but also with all other State and local agencies and commissions. Seventeen State agencies, including the Archeology Institute; South Carolina Department of Health and Environmental Control; South Carolina Department of Parks, Recreation, and Tourism; South Carolina Forestry Commission; South Carolina Land Resources Conservation Commission; South Carolina State Ports Authority; South Carolina Water Resources Commission; and the South Carolina Wildlife & Marine Resources Department, exercise authority over the use of coastal resources, specific areas in the coastal zone, or activities in the coastal zone. Memoranda of Agreement are used to effectively coordinate all State agency activities with the CMP.

South Carolina requires a detailed description of the proposed activities and their associated facilities, objective, and schedule for all activities associated with a project; a brief assessment relating the probable coastal zone effects of the activities; and specific information on onshore support base, support vessels, shallow hazards, oil-spill response, wastes and discharges, transportation activities, and air emissions; and all relevant State and/or local government permits.

7. STATE OF GEORGIA'S COASTAL MANAGEMENT PROGRAM

In 1992, the State of Georgia initiated the development of the Georgia Coastal Management Program (GCMP). The Georgia General Assembly authorized the GCMP with the passage of the Georgia Coastal Management Act (O.C.G.A.12-5-320 et. seq.) in April 1997, and designated the Georgia DNR, Coastal Resources Division (CDR) as the lead agency for administering the GCMP. NOAA subsequently approved the Program in January 1998, at which time Georgia became the 32nd State participating in the National CZMP.

In 1992, the GCMP was advised by a 25-member Coastal Zone Advisory Committee appointed by the Governor of Georgia. The Committee was made up of a diverse cross-section of the coastal Georgia citizenry with the goal of providing public input throughout the development of the GCMP. In 1994, a new Coastal Advisory Committee was appointed by the Commissioner of the DNR to review the draft Program Document, to assist with public education throughout the program development process, and to provide technical assistance. In 1997, the committee was expanded to increase participation from interested local governments. Finally, in 2003, the Committee was revamped and reauthorized by the Commissioner of the DNR as the Coastal Advisory Council with by-laws and an appointed membership. The Council is charged with developing annual themes and funding criteria for the Coastal Incentive Grant Program, and providing a communication loop between the CZMP and coastal citizens.

The GCMP consists of 33 State codes, which constitute the enforceable policies and is administered by the DNR, CRD. The Program works with coastal local governments and other State and Federal agencies to enhance service to the public, increase coordination and communication, provide assistance with the Program, among its many other activities. The Program also implements the Georgia Coastal Marshlands Protection Act (O.C.G.A. 12-5-280), Shore Protection Act (O.C.G.A. 12-5-230), and Revocable License Program (O.C.G.A. 50-16-61).

For effective coastal management, the GCMP encompasses all tidally influenced water bodies and all areas economically tied to coastal resources including such industries as shrimping, crabbing, recreational fishing, tourism, shipping, and manufacturing. The GCMP's service area includes the following 11 counties: Brantley, Bryan, Camden, Charlton, Chatham, Effingham, Glynn, Liberty, Long, McIntosh, and Wayne. Within the 11 counties, all waters of the State including the coastal ocean to the limit of the State's jurisdiction (3 nautical miles [3.5 miles; 5.6 kilometers]), and all submerged lands are part of the coastal area.

As lead agency for the GCMP, the CRD conducts several functions including resource management, ecological monitoring, permitting, technical assistance (such as Best Management Practices), and Federal consistency review. Additional activities covered by the Program include Outreach and Education, Coastal Nonpoint Source (6217) Program, and Coastal Incentive Grants. Local, State, and Federal agencies perform their respective functions in accordance with the GCMP and coordinated with the DNR. In addition, research institutes and other organizations assist in information gathering and analysis with coastal resource issues.

Activities implemented through the Coastal Management Network are divided into Local Governments, State Agencies, and Federal Agencies. Local governments assist in long-term planning, economic development, and natural resource protection through preparation and implementation of their respective comprehensive plans, local laws, and zoning regulations, as well as through their chambers of commerce and economic development authorities. State agencies continue to administer their respective coastal management efforts as defined by existing Georgia State law. Memoranda of Agreement between the CRD and other State agencies with regulatory authority in the coastal area help ensure that all agencies act in accordance with the policies of the GCMP. State agencies involved in the GCMP include the CRD; Department of Community Affairs; Department of Human Resources; Environmental Protection Division; Georgia Department of Transportation; Georgia Forestry Commission; Georgia Ports Authority; Historic Preservation Division; Jekyll Island Authority; Office of the Secretary of State, Parks, Recreation; and Historic Sites Division; Public Service Commission, and Wildlife Resources Division (WRD). The Georgia DNR, WRD Nongame Section serves as Georgia's Coordinating Agency for marine mammals, sea turtles, and coastal and marine birds. Federal agencies continue to administer their respective programs as they are renewed for consistency with the GCMP. The following Federal agencies are involved in the GCMP: Army Corps of Engineers; Bureau of Lands Management; Coast Guard; Department of Agriculture; Department of Defense; Environmental Protection Agency; Federal Aviation Administration; Federal Emergency Management Agency; Federal Energy Regulatory Commission; Federal Highway Administration; Federal Law Enforcement Training Center; Fish and Wildlife Service; General Services Administration; General Services Administration; Bureau of Ocean Energy Management (BOEM); National Park Service; and Nuclear Regulatory Commission.

For Federal consistency review, the State of Georgia requires a detailed description of the proposed activity, its expected effects upon the land or water uses or natural resources of Georgia's coastal zone, and an evaluation of the proposed activity in light of applicable enforceable policies.

8. STATE OF FLORIDA'S COASTAL MANAGEMENT PROGRAM

For purposes of the CZMA, the State of Florida's coastal zone includes the area encompassed by the State's 67 counties and its territorial seas. Lands owned by the Federal Government and the Seminole and Miccosukee Indian tribes are not included in the State's coastal zone; however, Federal activities in or outside the coastal zone, including those on Federal or tribal lands, that affect any land or water or natural resource of the State's coastal zone are subject to review by Florida under the CZMA. The Florida Coastal Management Act, codified as Chapter 380, Part II, Florida Statutes, authorized the development of a CZMP. In 1981, the Florida Coastal Management Program (FCMP) was approved by NOAA.

The policies identified by the State of Florida as being enforceable in the FCMP are the 24 statutes that NOAA approved for incorporation in the State's program. The 2010 Florida Statutes are the most recent version approved by NOAA and include the listing of OCSLA permits under Subpart E; and the addition of draft environmental assessments and environmental impact statements as necessary data and information for Federal consistency review.

A network of 10 State agencies and five regional water management districts implement the FCMP's 24 statutes. The water management districts are responsible for water quantity and quality throughout the State's watersheds. The State agencies include the following: the Department of Environmental Protection (DEP), the lead agency for the FCMP and the State's chief environmental regulatory agency and steward of its natural resources; the Department of Economic Opportunity, which serves as the State's land planning agency; the Department of Health, Division of Environmental Health, which, among other responsibilities, regulates on-site sewage disposal; the Department of State, Division of Historical Resources, which protects historic and archaeological resources; the Division of Emergency Management, which ensures that Florida is prepared to respond to emergencies; the Fish and Wildlife Conservation Commission, which protects and regulates fresh and saltwater fisheries, marine mammals, and birds and upland species, including protected species and the habitat used by these species; the Department of Transportation, which is charged with the development, maintenance, and protection of the transportation system; the Department of Agriculture and Consumer Services, which manages State forests and administers aquaculture and mosquito control programs; the Florida Building Commission, which is responsible for the adoption of the Florida Building Code; and the Governor's Office of Planning and Budget, which plays a role in the comprehensive planning process.

The DEP is designated as the lead agency for the FCMP pursuant to the CZMA 14. The DEP's Office of Intergovernmental Programs is charged with overseeing the State's CMP and coordinates the review of OCS plans with FCMP member agencies to ensure that the plan is consistent with applicable State enforceable policies and the Governor's responsibilities under the Act. The OCS is a jurisdictional term used to describe those submerged lands (sea bed and subsoil) that lie seaward of State water boundaries (3 nautical miles off the east coast). An OCS plan is any plan for offshore exploration; development of oil, natural gas, and other mineral resources; or production activity that is conducted in any area leased under the OCSLA. The Federal Government manages natural resources on the OCS, while the States manage the resources directly off their coasts.

The State of Florida requires an adequate description, objective, and schedule for all activities associated with a project; specific information on the natural resources potentially affected by the proposed activities; and specific information on onshore support base, support vessels, shallow hazards, oil-spill response, wastes and discharges, transportation activities, and air emissions; and a Federal consistency certification, assessment, and findings. As identified by the State of Florida, the State-enforceable policies that must be addressed for OCS activities are found at the BOEM website (USDOI, BOEM, 2011).

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APPENDIX C

EXISTING REGULATIONS, PROTECTIVE MEASURES, AND MITIGATION

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LIST OF ACRONYMS AND ABBREVIATIONS

1D	one-dimensional
2D	two-dimensional
3D	three-dimensional
4D	four-dimensional
AAM	active acoustic monitoring
AN(SW)T	ambient-noise (surfacewave) tomography
AOI	Area of Interest
AUV	autonomous underwater vehicle
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CFR	Code of Federal Regulations
COA	conditions of approval
DLI	daylight imaging
DMA	Dynamic Management Area
DoD	Department of Defense
DTAGS	deep-towed acoustics/geophysics system
EEZ	Exclusive Economic Zone
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FAZ	full azimuth
G&G	geological and geophysical
HAPC	Habitat Areas of Particular Concern
HRG	high-resolution geophysical
HyMAS	hydrocarbon microtremor analysis
IAGC	International Association of Geophysical Contractors
ITA	Incidental Take Authorization
IVI	Industrial Vehicles International, Inc.
LACS	low level acoustic combustion source
LET	local earthquake tomography
LFS	low-frequency spectroscopy
LFPS	low frequency passive seismic
LISA	low impact seismic array
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MPA	Marine Protected Area
NASA	National Aeronautics and Space Administration
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NMS	National Marine Sanctuary
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
NTL	Notice to Lessees and Operators
NWR	National Wildlife Refuge
OBS	ocean bottom seismometer
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
PAM	passive acoustic monitoring
PGS	Petroleum Geo-Services
PSO	protected species observers
SEL	sound exposure level
SMA	Seasonal Management Area
SWA	surface-wave amplitude
TTS	temporary threshold shift
UAS	unmanned aircraft system
U.S.C.	United States Code
USDOI	U.S. Dept. of the Interior
WAZ	wide azimuth

1. INTRODUCTION

The Bureau of Ocean Energy Management (BOEM) is proposing to authorize geological and geophysical (G&G) activities in support of its oil and gas, renewable energy, and marine minerals programs in Federal waters of the Mid- and South Atlantic Outer Continental Shelf (OCS) and adjacent State waters. The Area of Interest (AOI) for the proposed action includes the Mid- and South Atlantic OCS Planning Areas, as well as adjacent State waters (outside of estuaries) and waters beyond the Exclusive Economic Zone (EEZ) extending to 648 km (350 nmi) from shore (**Figure C-1**). The AOI is the area in which the activities of the proposed action would take place and therefore the area of potential effect of the Programmatic EIS.

All G&G activities authorized by BOEM must comply with existing laws and regulations as described in **Chapter 1** of the Programmatic Environmental Impact Statement (EIS). These include measures to avoid or reduce potential impacts of G&G activities. Compliance with existing laws and regulations – by BOEM as well as individual operators, when required – may result in additional measures or changes to the measures described here. In addition, a suite of protective measures is included in the proposed action as described in **Chapter 2** of the Programmatic EIS. This appendix describes and discusses the rationale for the measures selected for this program. It also describes measures that were considered but not selected, including measures and technologies identified for possible future use when proven effective and feasible.

2. EXISTING REGULATIONS

This section identifies mitigation or protective measures already in place as a result of current G&G requirements, including G&G operator compliance with lease stipulations and other protective measures, as well as applicable guidance documents. Requirements and existing mitigation or protective measures are included in the proposed action.

2.1. G&G REQUIREMENTS

Pursuant to 30 Code of Federal Regulations (CFR) § 551.4, a permit must be obtained to conduct prelease geological or geophysical exploration for oil, gas, and sulphur resources. Authorizations for the exploration for other minerals in support of competitive leasing are granted pursuant to requirements outlined in 30 CFR § 580.3. Requirements for renewable energy are outlined in 30 CFR part 585. Permit applications must be submitted to BOEM in accordance with the requirements outlined in 30 CFR § 551.5 and 30 CFR § 551.6 and are explained further in applicable Letters to Permittees. The Letter to Permittees dated January 20, 1989, specifies forms and maps, stipulations, and special provisions applicable to most permit activity. The 30 CFR part 551 regulations do not apply to G&G activities conducted by, or on behalf of, a lessee on a leased block. Such G&G activities are governed by 30 CFR § 550.201 regulations and by applicable Notices to Lessees and Operators. **Table C-1** identifies the appropriate Federal regulations and their applicability to select mineral resources and activity phase.

Table C-1

Federal Regulations Applicable to Prelease and Postlease Activities
by Mineral Resource of Interest

Regulatory Citation	Mineral Resource	Activity Phase
30 CFR part 550	Oil, gas, and sulphur	Postlease (i.e., on-lease)
30 CFR part 551	Oil, gas, and sulphur	Prelease or off-lease exploration or scientific research
30 CFR part 580[a]	All minerals exclusive of oil, gas, and sulphur	Prelease (prospecting)
30 CFR part 585	Renewable energy	Postlease

[a] 30 CFR part 580 regulations apply only to G&G activities in support of competitive leasing. For noncompetitive leasing for public works, authorizations are issued pursuant to Section 11 of the Outer Continental Shelf Lands Act.

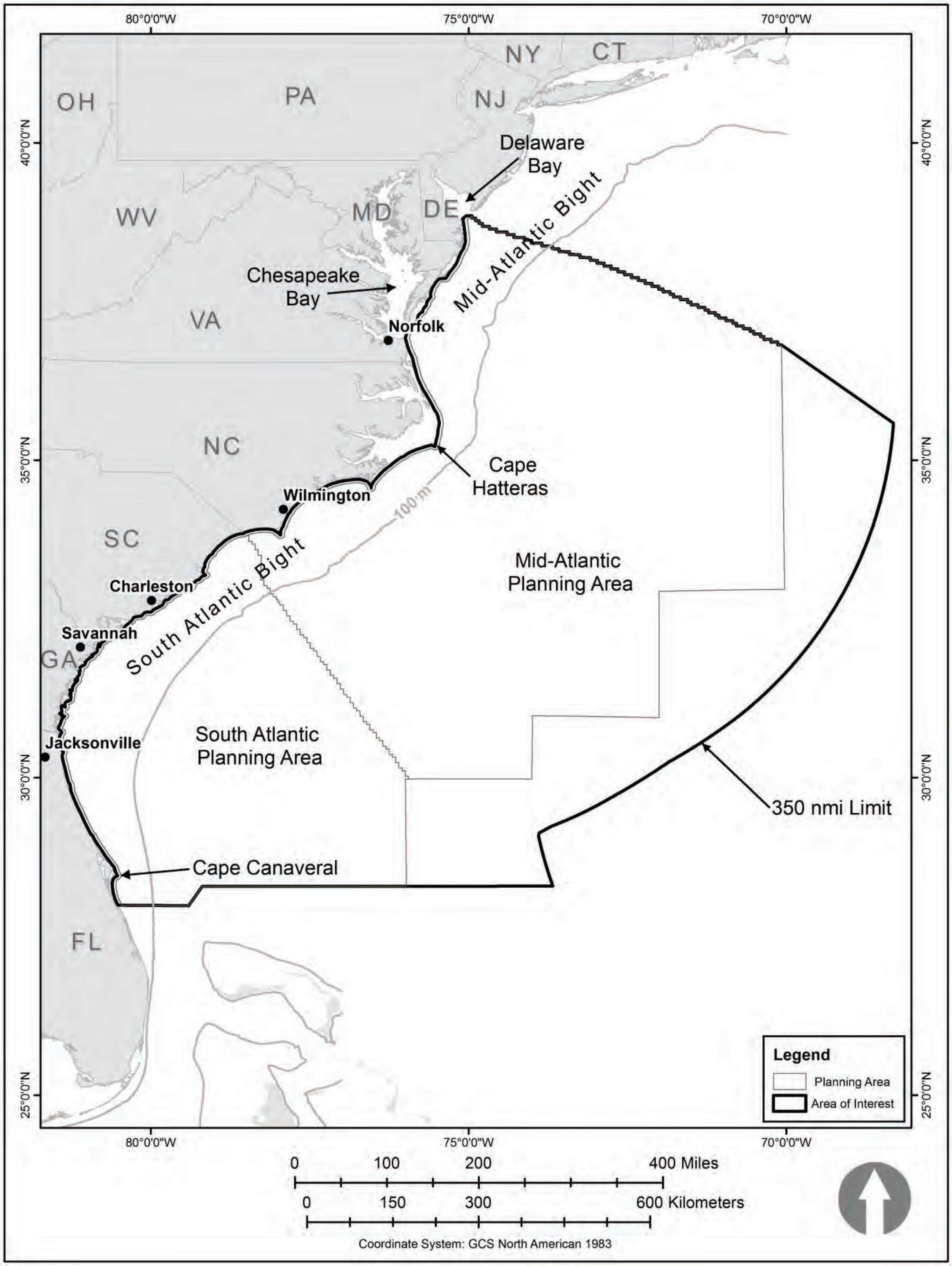


Figure C-1. Area of Interest for the Proposed Action.

Geological and geophysical explorations for mineral resources may not be conducted in the OCS without an approved authorization unless such activities are being conducted pursuant to a lease issued or maintained under the Outer Continental Shelf Lands Act (OCSLA). Separate authorizations must be obtained for either G&G explorations for mineral resources.

The OCSLA directs the U.S. Department of the Interior (USDOI) to ensure that G&G data are obtained in a technically safe and environmentally sound manner. Regulations at 30 CFR § 551.6 state that permit holders for G&G activities must not

- interfere with or endanger operations under any lease, right-of-way, easement, right-of-use, notice, or permit issued or maintained under the Act;
- cause harm or damage to life (including fishes and other aquatic life), property, or to the marine, coastal, or human environment;
- cause harm or damage to any mineral resource (in areas leased or not leased);
- cause pollution;
- disturb archaeological resources;
- create hazardous or unsafe conditions; or
- unreasonably interfere with or cause harm to other uses of the area.

Geological and geophysical operators conducting activities under 30 CFR part 551 must immediately report to the Director, BOEM, when

- hydrocarbon occurrences are detected;
- environmental hazards are encountered that constitute an imminent threat to human life or property; or
- activities occur that adversely affect the environment, aquatic life, archaeological resources, or other uses of the area in which the exploration or scientific research activities are conducted.

The Energy Policy Act of 2005 (Public Law 109-58) added Section 8(p)(1)(C) to the OCSLA, which mandated that the Secretary of the Interior issue leases, easements, or rights-of-way on the OCS for the purpose of renewable energy development. The Secretary delegated this authority to the former Minerals Management Service (MMS), now BOEM. In addition to providing the authority to issue leases, easements, and rights-of-way, the Energy Policy Act included a requirement that any activity authorized under this authority be carried out in a manner that provides for various factors, including the following:

- safety;
- protection of the environment;
- prevention of waste;
- conservation of the natural resources of the OCS;
- prevention of interference with reasonable uses of the exclusive economic zone, the high seas, and the territorial seas;
- consideration of any other use of the sea or seabed, including use for a fishery, a sea lane, a potential site of a deepwater port, or navigation;
- public notice and comment on any proposal submitted for a lease, easement, or right-of-way under this subsection; and
- oversight, inspection, research, monitoring, and enforcement relating to a lease, easement, or right-of-way under this subsection.

On April 22, 2009, BOEM promulgated final regulations implementing this authority at 30 CFR part 585 (*Federal Register*, 2009). Under the renewable energy regulations, after a lease is issued, the lessee may not commence construction of meteorological or other site assessment facilities until a Site Assessment Plan and the site characterization survey reports are submitted to and reviewed by BOEM (30 CFR §§ 585.605-618). The lessee's Site Assessment Plan must contain a description of environmental protection features or measures that the lessee will use. Similarly, when a grant is made for a right of way, or right of use and easement, the grantee may not commence construction or perform other site assessment activities until a General Activities Plan and site characterization survey reports are submitted to and reviewed by BOEM (30 CFR §§ 285.645-648).

BOEM has developed guidelines for providing G&G, hazards, and archaeological information pursuant to 30 CFR part 585 (USDOI, BOEM, 2012). The guidelines specify that BOEM recommends avoidance as a primary mitigation strategy. Avoidance strategies seek to ensure that harm or damage to objects of historical or archaeological significance will be less likely. The applicant has the option to demonstrate through additional investigations that an archaeological resource either does not exist or would not be adversely affected by the seafloor/bottom-disturbing activities. If an applicant, while conducting activities, discovers a potential archaeological resource such as the presence of a shipwreck (e.g., a sonar image or visual confirmation of an iron, steel, or wooden hull, wooden timbers, anchors, concentrations of historic objects, piles of ballast rock), prehistoric artifacts, and/or relict landforms, etc. within the project area, the applicant is to

- immediately halt seafloor/bottom-disturbing activities within the area of discovery;
- notify the appropriate BOEM/Office of Offshore Alternative Energy Programs Environmental Branch Chief within 72 hours (hr) of its discovery; and
- keep the location of the discovery confidential and take no action that may adversely affect the archaeological resource until BOEM has made an evaluation and instructs the applicant on how to proceed.

BOEM may require the applicant to conduct additional investigations to determine if the resource is eligible for listing in the National Register of Historic Places.

In addition, BOEM has published guidelines for providing avian species, benthic habitat, and marine mammals and sea turtles survey information for renewable energy projects on the Atlantic OCS (USDOI, BOEM, 2013). These guidelines provide recommendations for complying with information requirements of BOEM's renewable energy regulations outlined within 30 CFR part 585 subpart F.

2.2. BOEM Stipulations, Mitigation, and Protective Measures

BOEM currently requires operators to comply with a series of stipulations and protective measures during G&G activities. These requirements effectively represent mitigation measures designed to reduce or avoid impacts to sensitive resources. Such measures are implemented through regulations governing prelease and postlease G&G activities. Key points consist of the following:

- **Explosives Prohibition:** Explosives cannot be used for G&G activities except under written authorization from the Regional Supervisor. Further protective measures (including Endangered Species Act [ESA] Section 7 consultation with the National Marine Fisheries Service [NMFS]) and a Marine Mammal Protection Act [MMPA] authorization apply in the event that explosives are proposed for use.
- **Archaeological Resources:** The permittee must report discovery of any archaeological resource (i.e., shipwreck/prehistoric site) to BOEM and take precautions to protect the resource from operational activities.
- **Seismic Safety:** All pipes, buoys, and other markers used in connection with seismic work must be properly flagged and lighted according to the navigation rules of the U.S. Army Corps of Engineers and the U.S. Coast Guard.

There are no active oil and gas leases in the Atlantic OCS. In the event that leasing occurs during the period of the proposed action, BOEM may add measures to mitigate the impacts of lease-specific activities in the form of lease stipulations. In addition, BOEM provides additional guidance to lessees and operators through Notices to Lessees and Operators (NTLs), conditions of approval (COA), and best management practices.

As defined by the Council on Environmental Quality (CEQ), mitigation includes the following:

1. avoiding an impact by not taking a certain action or parts of an action;
2. minimizing an impact by limiting the degree or magnitude of the action and its implementation;
3. rectifying an impact by repairing, rehabilitating, or restoring the affected environment;

4. reducing or eliminating an impact over time, through preservation and maintenance operations during the life of the action; and
5. compensating for an impact by replacing or providing substitute resources or environments. Of these BOEM's regulated programs effectively use avoidance and minimization as the main, and most effective, strategy for environmental protection.

BOEM assigns mitigation by imposing COA on a plan, authorization, or permit. Mitigation is the effect of conditioned approval, which may originate from programmatic NEPA evaluations such as this one, from interpretations BOEM makes of regulations in NTLs, from the site-specific review of a plan, authorization or permit in which additional impacts to resources need to be mitigated to the maximum extent practicable, or they may evolve into best management practices through common or accepted use.

Conditions of Approval enforce more than just environmental mitigations originating through the NEPA process and are used in many different contexts within the oil and gas, renewable energy, and marine minerals program areas being considered in this Programmatic EIS. Conditions of Approval are used to pass on other requirements or advisories to operators. Among these are the following:

1. other approvals prerequisite to BOEM approval (i.e., CZMA);
2. safety precautions (i.e., H_2S present);
3. post-approval submittals (i.e., surveys and interpretive reports);
4. inspection requirements (i.e., pipeline pressure testing);
5. pre-deployment notifications (i.e., Department of Defense [DoD] space use or warning areas); and
6. reduction or avoidance of environmental impacts on resources originating from NEPA.

If a COA assigns a mitigation that originates from a NEPA evaluation to reduce or avoid impacts on biological, physical, or socioeconomic resources, it is synonymous with "protective measure" (6, above).

At a programmatic level, there are no mitigation measures that apply to G&G activities conducted in support of renewable energy development; however, best management practices were documented in the Programmatic EIS for the renewable energy program (USDOI, MMS, 2007, pages 2-20). A NEPA evaluation is part of the approval process for OCS plans, without exception, under the renewable energy program. A proposed action at a specific location, tool type, and intensity of G&G activity are subjected to evaluation, which may be an Environmental Assessment (EA) or an EIS. The consultations required under environmental law for protected species are part of the NEPA evaluation. Through the NEPA process, BOEM may identify mitigation measures to avoid/minimize environmental impacts during G&G surveys and assign them as a condition for OCS permit approval. Additional mitigation measures may be required as a result of consultations under the ESA or MMPA.

Similarly, at a programmatic level, there are no mitigation measures that apply to G&G activities under the marine minerals program. Under Section 11 of the OCSLA, BOEM may authorize G&G prospecting for non-energy marine minerals, except in the case that another Federal agency is performing the survey on the OCS. Before authorizing any proposed prospecting, BOEM undertakes the necessary environmental review, including preparation of a NEPA document and consultations for protected species. Through the NEPA process, BOEM may identify mitigation measures to avoid/minimize environmental impacts during G&G surveys. Mitigation measures may be implemented as a condition for survey authorization.

3. PROTECTIVE MEASURES INCLUDED IN THE PROPOSED ACTION

The proposed action includes protective measures that are either applicable to all G&G surveys or specific survey types. The measures are listed below and their applicability to G&G survey types is summarized in **Table C-2**. Each measure is discussed in a separate subsection.

Table C-2

Applicability of Mitigation Measures to G&G Survey Types under Alternative A
(an "X" indicates the time-area closure or mitigation measure is applicable)

Survey Type	Time-Area Closures				Other Applicable Mitigation							
	NARW Critical Habitat (Nov 15-Apr 15)	Southeast & Mid-Atlantic U. S. SMAs (Nov 1-Apr 30)	DMAs	Rest of AOI	Seismic Airgun Protocol	HRG Protocol	Vessel Strike Avoidance	Marine Debris Guidance	Avoidance of Historic & Prehistoric Sites	Avoidance of Sensitive Benthic Communities	NMS Guidance	Military & NASA Guidance
Seismic Airgun Surveys	X	X	X	--	X	--	X	X	X[1]	X[1]	X	X
Non-airgun HRG Surveys with frequencies >200 kHz	--	--	--	--	--	X (but no Acoustic Exclusion Zone)	X	X	X[1]	X[1]	X	X
Non-airgun HRG Surveys with frequencies ≤ 200 kHz	--	--	--	--	--	X (including Acoustic Exclusion Zone)	X	X	X[1]	X[1]	X	X
Non-airgun HRG Surveys with at least one source having frequencies ≤30 kHz	X (unless survey is critical)	--	X (unless survey is critical)	--	--	X (including Acoustic Exclusion Zone)	X	X	X[1]	X[1]	X	X
Other G&G Surveys	--	--	--	--	--	--	X	X	X[1]	X[1]	X	X

AOI = Area of Interest; DMA = Dynamic Management Area; G&G = geological & geophysical; HRG = high-resolution geophysical; NASA = National Aeronautics and Space Administration; NMS = National Marine Sanctuary; SMA = Seasonal Management Area; NARW = North Atlantic Right Whale

[1] Avoidance of historic and prehistoric sites and sensitive benthic communities applies only to surveys that involve seafloor-disturbing activities. Seismic airgun surveys and non-airgun HRG surveys that do not disturb the seafloor are not required to avoid these sites or features. Non-airgun HRG surveys and most seismic airgun surveys (except those in which cables or sensors are placed in or on the seafloor) do not disturb the seafloor.

Measures applicable to all G&G surveys:

- guidance for vessel strike avoidance;
- guidance for marine debris awareness;
- avoidance of sensitive seafloor resources;
- guidance for activities in or near National Marine Sanctuaries (NMS); and
- guidance for military and National Aeronautics and Space Administration (NASA) coordination.

Additional measures applicable to specific survey types:

- mitigation for seismic airgun surveys (time-area closures and Seismic Airgun Survey Protocol); and
- mitigation for non-airgun HRG surveys (time-area closures and HRG Survey Protocol).

This document was created using the best available information to identify mitigation plans for reducing or eliminating the potential for adverse effects. The document also notes, where applicable, limits to existing scientific knowledge about the known effectiveness of certain mitigations. Each specific authorization will require additional analyses where BOEM employs an adaptive management approach (see **Section 7**), to adjust mitigation strategy(ies) based on the best available information at that time.

3.1. MEASURES APPLICABLE TO ALL SURVEYS

3.1.1. Guidance for Vessel Strike Avoidance

All authorizations for shipboard surveys would include guidance for vessel strike avoidance. The guidance would be similar to Joint BOEM-BSEE NTL 2012-G01 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") (USDOI, BOEM and BSEE, 2012a), which incorporates and expands measures from NMFS "Vessel Strike Avoidance Measures and Reporting for Mariners" addressing protected species identification, vessel strike avoidance, and injured/dead protected species reporting. Key elements of the guidance are as follows:

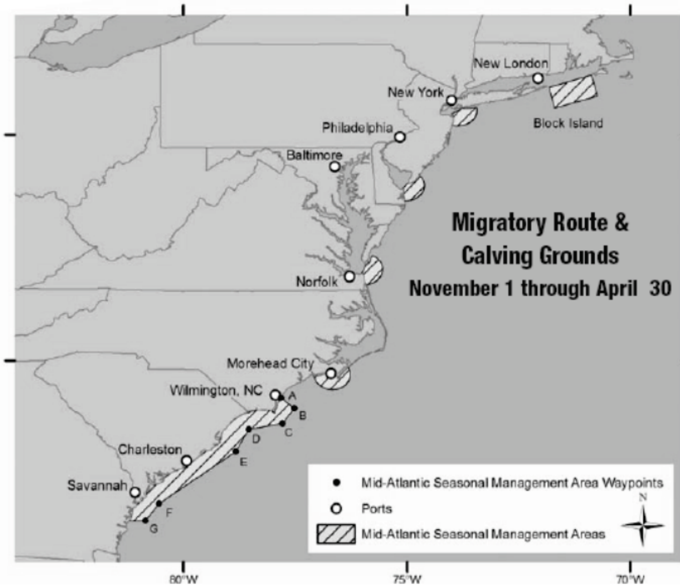
1. Vessel operators and crews must maintain a vigilant watch for all marine mammals and sea turtles and slow down or stop their vessel, regardless of vessel size, to avoid striking protected species. A visual observer aboard all survey vessels would monitor an area around a transiting survey vessel, the vessel strike exclusion zone, according to the parameters stated in items 2 through 7 below, to help ensure it is free of all marine mammals and sea turtles. Visual observers monitoring solely for vessel strike avoidance can be crew members, trained third party observers, or a combination of both. They do not have specific training requirements nor will they need to be approved by BOEM or BSEE.

2. In accordance with NMFS Compliance Guide for the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105), when safety allows, vessels, regardless of size, shall transit within the 10 knot (kn) (18.5 kilometers/hour [km/h]) speed restriction in Dynamic Management Areas (DMA), the Mid-Atlantic U.S. Seasonal Management Area (SMA) from November 1 through April 30, and critical habitat and Southeast U.S. SMA from November 15 through April 15 (**Figure C-2**).

3. When safety permits, vessel speeds should also be reduced to 10 kn (18.5 km/h) or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a transiting vessel. A single cetacean at the surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, precautionary measures should be exercised when an animal is observed.

Science, Service, Stewardship

Mid-Atlantic U.S. Seasonal Management Areas



Migratory Route

November 1 through April 30

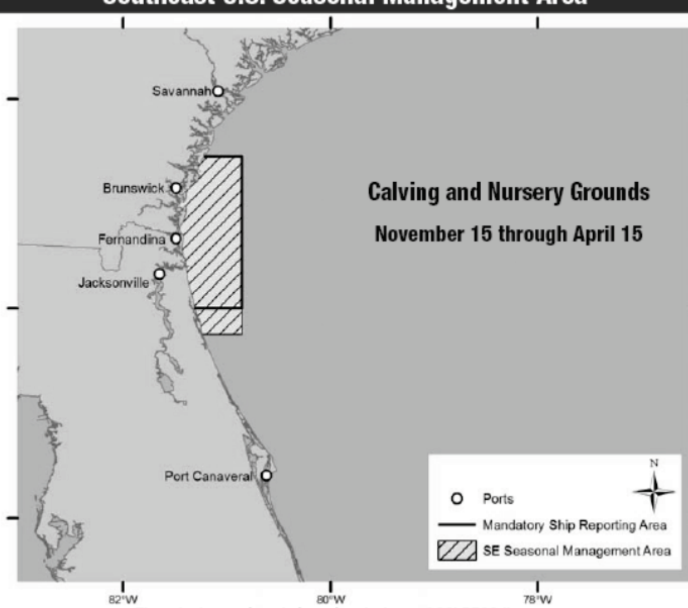
Vessel speed is restricted in the following areas:

- Block Island Sound waters bounded by:
  - 40°51'53.7" N 070°36'44.9" W
  - 41°20'14.1" N 070°49'44.1" W
  - 41°04'16.7" N 071°51'21.0" W
  - 40°35'56.5" N 071°38'25.1" W
  - then back to starting point.
- Within a 20-nm (37 km) radius of the following (as measured seaward from the COLREGS lines):
  - -Ports of New York/New Jersey: 40°29'42.2"N 073°55'57.6"W
  - -Entrance to the Delaware Bay (Ports of Philadelphia and Wilmington): 38°52'27.4"N 075°01'32.1"W
  - -Entrance to the Chesapeake Bay (Ports of Hampton Roads and Baltimore): 37°00'36.9"N 075°57'50.5"W
  - -Ports of Morehead City and Beaufort, NC: 34°41'32.0"N 076°40'08.3"W
- Within a continuous area 20 nm from shore between Wilmington, NC, to Brunswick, GA, bounded by the following:

Point	Latitude	Longitude
A	34°10'30"N	077°49'12"W
B	33°56'42"N	077°31'30"W
C	33°36'30"N	077°47'06"W
D	33°28'24"N	078°32'30"W
E	32°59'06"N	078°50'18"W
F	31°50'00"N	080°33'12"W
G	31°27'00"N	080°51'36"W

and west back to the shore.

Southeast U.S. Seasonal Management Area



The rule does not apply to waters inshore of COLREGS lines.

Calving and Nursery Grounds

November 15 through April 15

Vessel speed is restricted in the area bounded to the north by latitude 31°27'N; to the south by latitude 29°45'N; to the east by longitude 080°51'36"W.

For more information, visit:
http://www.nmfs.noaa.gov/pr/shipstrike
http://nero.noaa.gov/shipstrike
http://rightwhalessouth.nmfs.noaa.gov

Right Whale Ship Strike Reduction Rule expires on December 9, 2013

Voluntary Dynamic Management Areas (DMAs) may also be established by NOAA Fisheries Service. Mariners are encouraged to avoid these areas or reduce speeds to 10 knots or less while transiting through these areas. NOAA Fisheries Service will announce DMAs to mariners through its customary maritime communication media.

Figure C-2. Summary of Speed Restrictions and Locations for Vessel Operators to Comply with the Right Whale Strike Reduction Rule (50 CFR § 224.105) (Source: USDOC, NOAA, 2011).

4. When North Atlantic Right Whales (NARW) are sighted, at any time during the year, vessels regardless of size, must maintain a minimum separation distance of 500 meters (m) (1,640 feet [ft]). The following avoidance measures must be taken if a vessel comes within 500 m (1,640 ft) of an NARW:

   a. While underway the vessel operator shall steer a course away from the NARW at 10 kn (18.5 km/h) or less until the minimum separation distance has been established.

   b. If a NARW is spotted in the path of a vessel or within 100 m (328 ft) of a vessel underway, the operator shall reduce speed and shift engines to neutral. The operator shall only re-engage engines after the NARW has moved out of the path of the vessel and is more than 100 m (328 ft) away. If the NARW is still within 500 m (1,640 ft) of the vessel, the vessel shall select a course away from the whale's course at a speed of 10 kn (18.5 km/h) or less. This procedure shall also be followed if an NARW is spotted while a vessel is stationary. Whenever possible a vessel should remain parallel to the whale's course while transiting, avoiding abrupt changes in direction until it has left the area.

5. Year-round, when ESA-listed whales other than NARWs are sighted, vessels, regardless of size, must maintain a minimum separation distance of 100 m (328 ft). The lessee and/or operator must ensure that following avoidance measures are taken if a vessel comes within 100 m (328 ft) of an ESA-listed whale(s) species:

   a. The vessel underway must reduce speed and shift the engine to neutral, and must not engage the engines until the whale(s) has moved outside of the vessel's path and the minimum separation distance has been established.

   b. If a vessel is stationary, the vessel must not engage in engines until the ESA-listed whale(s) has moved out of the vessel's path and beyond 100 m (328 ft).

6. Year-round, vessels, regardless of size, shall maintain a distance of 50 m (164 ft) or greater from all other marine mammals (cetaceans, pinnipeds, and manatees). If encountered during transit, a vessel shall attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course.

7. Year-round, when sea turtles are sighted, the vessel, regardless of size, must maintain a distance of 50 m (164 ft) or greater whenever possible.

8. Vessel crews would be required to report sightings of any injured or dead marine mammals or sea turtles to BOEM and NMFS within 24 hr, regardless of whether the injury or death was caused by their vessel.

In addition, vessel operators would be required to comply with the NMFS marine mammal and sea turtle viewing guidelines for the Northeast Region (USDOC, NMFS [2011a] for surveys offshore Delaware, Maryland, or Virginia) or the Southeast Region (USDOC, NMFS [2011b] for surveys offshore North Carolina, South Carolina, Georgia, or Florida) or combined guidance if recommended by NMFS. These measures are meant to reduce the potential for vessel harassment or collision with marine mammals or sea turtles regardless of what activity a vessel is engaged in.

3.1.2. Guidance for Marine Debris Awareness

All authorizations for shipboard surveys would include guidance for marine debris awareness. The guidance would be similar to BSEE's NTL 2012-G01 ("Marine Trash and Debris Awareness and Elimination") (USDOI, BSEE, 2012). All vessel operators, employees, and contractors actively engaged in G&G surveys must be briefed on marine trash and debris awareness elimination as described in this NTL. The applicant will be required to ensure that its employees and contractors are made aware of the environmental and socioeconomic impacts associated with marine trash and debris and their responsibilities for ensuring that trash and debris are not intentionally or accidentally discharged into the marine environment where it could affect protected species. The above-referenced NTL provides information that applicants may use for this awareness training.

3.1.3. Avoidance of Sensitive Seafloor Resources

A basic mitigation philosophy for BOEM is to mitigate by avoidance. That is, BOEM must know enough about the nature of the seafloor area where activities are proposed so that the activities can be moved or offset to another area if sensitive resources are already there. This principle applies to sensitive cultural resources such as shipwrecks and prehistoric archaeological resources as well as sensitive benthic communities, and it applies to all G&G activities.

In addition to the cultural resources and benthic communities discussed in the following sections, there are significant undersea cables and infrastructure on the ocean bottom within the Mid- and South Atlantic Planning Areas. Applicants who propose seafloor-disturbing activities will be required to provide site-specific data identifying the existing cables and infrastructure for avoidance. Cable data is available from numerous sources and applicants will have access to this data. Where appropriate, operators will be required to coordinate with the North American Submarine Cable Association to avoid impacts to submarine cable infrastructure.

Avoidance of historic and prehistoric sites and sensitive benthic communities applies only to surveys that involve seafloor-disturbing activities. Seismic airgun surveys and non-airgun HRG surveys that do not disturb the seafloor are not required to avoid these sites or features. Non-airgun HRG surveys and most seismic airgun surveys (except those in which cables or sensors are placed in or on the seafloor) do not disturb the seafloor.

3.1.3.1. Avoidance and Reporting of Historic and Prehistoric Sites

BOEM and BSEE would require site-specific information regarding potential archaeological resources prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom-founded equipment or structures in the AOI. BOEM and BSEE would use this information to ensure that physical impacts to archaeological resources do not take place.

All authorizations for G&G activities that involve seafloor-disturbing activities would include requirements for operators to report suspected historic and prehistoric archaeological resources to BOEM and BSEE and take precautions to protect the resource. The requirements are expected to be similar to NTL 2005-G07 (“Archaeological Resource Surveys and Reports”) (USDOI, MMS, 2005), the enforcement for which is shared between BOEM and BSEE. BOEM and BSEE also require reporting and avoidance for any previously undiscovered suspected archaeological resource and precautions to protect the resource from operational activities while appropriate mitigation measures are developed. Regulations have been promulgated based on the National Historic Preservation Act (NHPA) (16 U.S.C. §§ 470 *et seq*.), especially Sections 106 and 110; the Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. § 470), which prohibits the excavation and removal of items of archaeological interest from Federal lands without a permit; and the Antiquities Act of 1906 (16 U.S.C. § 431). Under the oil and gas regulations, archaeological resource surveys are required as by 30 CFR § 550.203(o), 550.204(s), and 550.1007(a)(5), and an archaeological resource report is required by 30 CFR §§ 550.203(b)(15), 550.204(b)(8)(v)(A), and 550.1007(a)(5). These existing regulations are applicable to all G&G operations that involve seafloor-disturbing activities, including coring, grab sampling, and placement of bottom cables or nodes. Equivalent information needs to be provided for renewable energy and marine minerals programs, although equivalent regulations do not expressly exist for renewable energy or for marine minerals. The equivalent is provided through guidance, supported by regulation and/or statutory authority (see NHPA Section 106, OCSLA, and 30 CFR parts 585 and 580).

If an operator discovers any archaeological resource while conducting operations authorized under a lease or pipeline right-of-way, operations within or that may affect the discovery must be immediately halted the discovery reported to BOEM and BSEE. If BOEM determines that the resource is significant, based on criteria under the NHPA, BSEE, in consultation with BOEM, will direct how the resource is to be protected during operations and activities. If BOEM determines that the resource is not significant, BOEM will so advise BSEE. BSEE informs the operator when operations may resume (30 CFR § 250.194).

3.1.3.2. Avoidance of Sensitive Benthic Communities

BOEM will require site-specific information regarding sensitive benthic communities (including hard/live bottom areas, deepwater coral communities, and chemosynthetic communities) prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom-founded equipment or structures in the AOI. All authorizations for seafloor-disturbing activities will be subject to restrictions to protect corals and hard/live bottom resources, including requirements for mapping and avoidance, as well as pre-deployment photographic surveys of areas where bottom-founded instrumentation and appurtenances are to be deployed. BOEM Renewable Energy Program has developed biological survey protocols that would provide guidance for these site-specific surveys.

BOEM has not designated specific benthic locations for avoidance in the AOI. However, likely areas for avoidance would include known hard/live bottom areas; known deepwater coral locations including *Lophelia* and *Oculina* coral sites; deepwater coral Habitat Areas of Particular Concern (HAPC); deepwater Marine Protected Areas (MPA); Monitor and Gray's Reef National Marine Sanctuaries (NMS); the Charleston Bump area; and the walls of submarine canyons. These benthic features are discussed in **Chapter 4.2.1.1.2** of the Programmatic EIS. All authorizations for G&G surveys proposed within or near these areas would be subject to the review noted above to facilitate avoidance.

BOEM has not developed specific buffer zones for sensitive benthic communities in the Atlantic, but it is expected that they would at a minimum include those currently required by BOEM in the Gulf of Mexico, where the locations of many sensitive bottom communities are known and there is a long history of bottom surveying in association with oil and gas exploration and production. In the Gulf of Mexico, sensitive benthic features in water depths less than 300 m (~1,000 ft) are protected by NTL 2009-G39 ("Biologically-Sensitive Underwater Features and Areas") (USDOI, MMS, 2009a) and features in greater water depths are protected by NTL 2009-G40 ("Deepwater Benthic Communities") (USDOI, MMS, 2009b). Large topographic features, such as the Flower Garden Banks and similar offshore "banks" are defined by "No Activity Zones" where no bottom-disturbing activity may take place within 152 m (500 ft). No seafloor-disturbing activities can occur within 30 m (100 ft) of "pinnacle trend" hard/live bottom features that have vertical relief of 2.4 m (8 ft) or more. Avoidance of low-relief hard/live bottom features is required but no buffer distance is specified; plans proposing activities near these areas must include survey coverage extending to 1,000 m (3,280 ft) from the location of proposed bottom-disturbing activity. For high-density deepwater benthic communities (including chemosynthetic and deepwater coral communities), setbacks of 610 m (2,000 ft) are required for drilling discharge locations and 76 m (250 ft) from the location of all other proposed seafloor disturbances. The application of similar setbacks as default buffer zones would be expected when G&G activities take place in the AOI.

3.1.4. Guidance for Activities In or Near National Marine Sanctuaries

There are two NMSs within the AOI: Monitor and Gray's Reef (see **Chapter 4.2.11.1.1** of the Programmatic EIS for brief descriptions). BOEM would not authorize seafloor-disturbing activities within the boundaries of an NMS. Seafloor-disturbing activities proposed near the boundaries of an NMS would be assigned a setback distance as a condition of permit approval to be determined at the time the action is before BOEM and in consultation with the Sanctuary Manager. Setbacks of 152 m (500 ft) for seafloor-disturbing activities would be expected that could be modified by consultations with NOAA under the NMSA for specific activities in proximity to an NMS. **Chapter 1.6.15** of the Programmatic EIS provides information about the NMSA consultation process.

All BOEM authorizations for G&G activities would include instructions to minimize impacts on NMS resources. Operators proposing to conduct activities within or near the boundaries of Monitor NMS or Gray's Reef NMS would be instructed to exercise caution to help ensure that such activities do not endanger any other users of the Sanctuary. Additionally, if proposed activities involve seafloor-disturbing activities near an NMS or moving the surface marker buoys for the Sanctuary, the operator would be required to contact the Sanctuary Manager for instructions. In addition, as part of the process for site-specific activities BOEM and BSEE's Environmental Enforcement Division will conduct future coordination with NOAA's Office of National Marine Sanctuaries (ONMS). These coordination activities will include the discussion on notification of divers and boaters in the region, beyond the Notice to Mariners, discussion of setback from the Monitor and Gray's Reef NMSs and environmental monitoring and enforcement efforts.

Existing Federal regulations for Monitor NMS (15 CFR § 922.61) prohibit certain activities including (but not limited to) anchoring, stopping, remaining, or drifting without power at any time; any type of subsurface salvage or recovery operation; diving of any type, whether by an individual or by a submersible; lowering below the surface of the water any grappling, suction, conveyor, dredging or wrecking device; detonating below the surface of the water any explosive or explosive mechanism; drilling or coring the seabed; lowering, laying, positioning or raising any type of seabed cable or cable-laying device; trawling; or discharging waste material into the water in violation of any Federal statute or regulation.

Existing Federal regulations for Gray's Reef NMS (15 CFR § 922.92) prohibit certain activities including (but not limited to) anchoring; dredging; drilling; using explosives; breaking, damaging, or removing any bottom formation; constructing structures; constructing, placing, or abandoning any structure, material, or other matter on the submerged lands of the Sanctuary; and discharging or depositing any material or other matter except fish or fish parts, bait, or chumming materials, effluent from marine sanitation devices, and vessel cooling water. Under a new regulation that went into effect December 4, 2011, the southern third of the NMS is now a research area where fishing and diving is prohibited but vessels are allowed to travel across the area as long as they do not stop (*Federal Register*, 2011; USDOC, ONMS, 2011).

3.1.5. Guidance for Military and NASA Coordination

Guidance for Military Coordination

On February 1, 2013, BOEM met with representatives of the DoD to discuss pre-notification for BOEM-permitted G&G activities (oil and gas) or G&G activities authorized by an OCS plan or negotiated lease (renewable energy and marine minerals) within the AOI. The armed services expressed no fundamental objections with respect to the compatibility of the G&G activity required for oil and gas resource development on the OCS and the operations conducting by DoD within their Atlantic range complexes (**Figure 4-37**) (U.S. DoD, 2010). The proposed action at issue was limited to G&G activity and BOEM sought to acquaint DoD with the impacting factors for such activity and to discuss them in relation to DoD operations. In 2010 (U.S. DoD, 2010, Appendix 2) the DoD composed stipulations for an OCS lease sale in areas where DoD activities currently take place. Although an OCS lease sale is not part of the proposed action in this Programmatic EIS, BOEM accepts the coordination afforded by these stipulations and will adapt the proposed stipulations into conditions for approval for G&G permits or authorizations sought in the AOI. They are fundamentally similar to those used in the Gulf of Mexico for permitted activities or those authorized by OCS plans in NTL 2009-G06 (Military Warning and Water Test Areas).

Stipulation No. 1 - Evacuation

(a) The permittee or authorized operator, recognizing that oil and gas resource exploration, renewable energy development, or marine mineral development may occasionally interfere with military testing, training, and operations, hereby recognizes and agrees that the United States reserves and has the right to temporarily suspend operations and/or require evacuation of an area where BOEM permitted or authorized activities may be scheduled or underway in the interest of national security. Every effort will be made by the appropriate military agency to provide as much advance notice as possible of the need to suspend operations and/or evacuate. Advance notice of fourteen (14) days shall normally be given before requiring a suspension or evacuation, but in no event will the notice be less than four (4) days. Temporary suspension of operations may include the evacuation of personnel, and appropriate sheltering of personnel not evacuated. Appropriate shelter shall mean the protection of all personnel for the entire duration of any Department of Defense activity from flying or falling objects or substances and will be implemented by a written order from the BSEE Regional Supervisors, after consultation with the appropriate command headquarters or other appropriate military agency, or higher authority. The appropriate command headquarters, military agency or higher authority shall provide information to allow the lessee to assess the degree of risk to, and provide sufficient protection for, lessee's personnel and property. Such suspensions or evacuations for national security reasons will not normally exceed seventy-two (72) hours; however, any such suspension may be extended by order of BSEE. Upon cessation of any temporary suspension, the BSEE will immediately notify the lessee such suspension has terminated and operations on the permitted or authorized area can resume.

(b) The permittee or authorized operator shall inform the BSEE of the persons/offices to be notified to implement the terms of this stipulation.

(c) The permittee or authorized operator is encouraged to establish and maintain early contact and coordination with the appropriate command headquarters, in order to avoid or minimize the effects of conflicts with potentially hazardous military operations.

(d) The permittee or authorized operator shall not be entitled to reimbursement for any costs or expenses associated with the suspension of operations or activities or the evacuation of property or personnel in fulfillment of the military mission in accordance with subsections (a) through (c) above.

(e) Notwithstanding subsection (d), the permittee or authorized operator reserves the right to seek reimbursement from appropriate parties for the suspension of operations or activities or the evacuation of property or personnel associated with conflicting commercial operations.

Stipulation No. 2 - Coordination

(a) The placement, location, and planned periods of operation by the permittee or authorized operator are subject to approval by the BOEM Regional Director (RD) after the review of an operator's exploration plan (EP). Prior to approval of the permit or issuance of the authorization, the operator shall consult with the appropriate command headquarters regarding the location, density, and the planned periods of operation to minimize conflicts with Department of Defense activities. When determined necessary by the appropriate command headquarters, the permittee will enter into a formal Operating Agreement with such command headquarters that delineates the specific requirements and operating parameters for a particular action. If it is determined that the final operations will result in interference with scheduled military missions in such a manner as to possibly jeopardize the national defense or to pose unacceptable risks to life and property, then BOEM may approve the permit or issue the authorization with conditions, disapprove it, or require modification in accordance with 30 CFR Part 550. The RD will notify the lessee in writing of the conditions associated with plan approval, or the reason(s) for disapproval or required modifications. Moreover, if there is a serious threat of harm or damage to life or property, or if it is in the interest of national security or defense, pending or approved operations may be suspended in accordance with 30 CFR 550. Such a suspension may extend the term of a permit by an amount equal to the length of the suspension, except as provided in 30 CFR § 550.169(b), or BOEM may require a new permit or authorization be issued to the operator. The BOEM RD will attempt to minimize such suspensions within the confine of related military requirements.

(b) The permittee or authorized operator is encouraged to establish and maintain early contact and coordination with the appropriate command headquarters, in order to avoid or minimize the effects of conflicts with potentially hazardous military operations.

(c) If national security interests are likely to be in continuing conflict with an existing operating agreement, the BOEM RD will direct the lessee to modify any existing operating agreement or to enter into a new operating agreement to implement measures to avoid or minimize the identified potential conflicts.

Stipulation No. 3 - Electromagnetic Emissions

The permittee or authorized operator agrees to control its own electromagnetic emissions and those of its agents, employees, invitees, independent contractors or subcontractors emanating from individual designated defense operating areas, warning areas, and water test areas in accordance with requirements specified by the commander of the command headquarters (list applicable requirements in a table) to the degree necessary to prevent damage to, or unacceptable interference with, Department of Defense flight testing, training, or operational activities, conducted within individual designated defense operating areas, warning areas, and water test areas. Prior to entry into the particular operating area, warning area, or water test area, the permittee or authorized operator, its agents, employees, invitees, independent contractors or subcontractors, must coordinate electromagnetic emissions with the appropriate command headquarters.

Guidance for NASA Coordination

BOEM and NASA have been engaged in ongoing coordination related to NASA's concerns about mission compatibility with BOEM-managed activities. In particular NASA has been concerned about activities that have the potential to impact the Wallops Flight Facility (WFF). NASA's concerns about BOEM-managed activities on the sea surface in the Range Hazard Area fell into three categories: (1) risk to private or state investment and personnel from competing space-use in an active and hazardous rocket and target launch range; (2) impact of private or state investment that leads to unacceptable restrictions on NASA and DoD operations in order to meet safety requirements that will likely result in WFF no longer being one of the Nation's few viable launch and test sites; and (3) adverse impacts on NASA's partnership with the commercial space sector represented at WFF by the Mid-Atlantic Regional Spaceport.

NASA provided comments on the Atlantic G&G Draft Programmatic EIS. Those comments have been addressed and where appropriate incorporated into the Final Programmatic EIS as stipulations below. They also can also be found in **Chapter 3.6.7**. NASA's recommendations for G&G activities occurring within the WFF Range and Hazard Area include (**Figure 4-37**):

Stipulation No. 1 - Evacuation

(a) The permittee or authorized operator, recognizing that oil and gas resource exploration, renewable energy development, or marine mineral development may occasionally interfere with NASA testing and operations, hereby recognizes and agrees that the NASA reserves and has the right to temporarily suspend operations and/or require evacuation of an area where BOEM permitted or authorized activities may be scheduled or underway. Every effort will be made by the NASA to provide as much advance notice as possible of the need to suspend operations and/or evacuate. Advance notice of fourteen (14) days shall normally be given before requiring a suspension or evacuation, but in no event will the notice be less than four (4) days. Temporary suspension of operations may include the evacuation of personnel, and appropriate sheltering of personnel not evacuated. Appropriate shelter shall mean the protection of all personnel for the entire duration of any NASA activity from flying or falling objects or substances and will be implemented by written order from the BSEE Regional Supervisors, after consultation with NASA Safety Office Chief or higher authority. The NASA Safety Office Chief or higher authority shall provide information to allow the lessee to assess the degree of risk to, and provide sufficient protection for, lessee's personnel and property. Such suspensions or evacuations will not normally exceed twenty four (24) hours;

however, any such suspension may be extended. Upon cessation of any temporary suspension, BSEE will immediately notify the lessee such suspension has terminated and operations on the permitted or authorized area can resume.

(b) The permittee or authorized operator shall inform BSEE of the persons/offices to be notified to implement the terms of this stipulation.

(c) The permittee or authorized operator is encouraged to establish and maintain early contact and coordination with the Wallops Test Director, in order to avoid or minimize the effects of conflicts with potentially hazardous NASA operations.

(d) The permittee or authorized operator shall not be entitled to reimbursement for any costs or expenses associated with the suspension of operations or activities or the evacuation of property or personnel in fulfillment of the NASA mission in accordance with subsections (a) through (c) above.

Stipulation No. 2 - Coordination

(a) The placement, location, and planned periods of operation by the permittee or authorized operator are subject to approval by the BOEM RD after the review of an operator's exploration plan (EP). Prior to approval of the permit or issuance of the authorization the operator shall consult with the Wallops Test Director regarding the location, density, and the planned periods of operation to minimize conflicts with NASA activities. When determined necessary by the Wallops Test Director, the permittee shall submit a formal Operating Plan to the Wallops Test Director. The Operating Plan shall delineate the specific requirements and operating parameters of the planned activities. If it is determined that the Final operations will result in interference with scheduled NASA missions in such a manner as to possibly jeopardize the NASA's activities at the Wallops Range or to pose unacceptable risks to life and property, then BOEM may approve the permit or issue the authorization with conditions, disapprove it, or require modification in accordance with 30 CFR Part 550. The BOEM RD will notify the lessee in writing of the conditions associated with plan approval, or the reason(s) for disapproval or required modifications. Moreover, if there is a serious threat of harm or damage to life or property, or if it is in the interest of NASA, pending or approved operations may be suspended. Such a suspension may extend the term of a permit by an amount equal to the length of the suspension, or BOEM may require a new permit or authorization to be issue to the operator. The BOEM RD will attempt to minimize such suspensions.

(b) The permittee or authorized operator is encouraged to establish and maintain early contact and coordination with the Wallops Test Director, in order to avoid or minimize the effects of conflicts with potentially hazardous NASA operations.

(c) If national security interests are likely to be in continuing conflict with an existing operating agreement, the BOEM RD will direct the permittee or authorized operator into a new operating agreement to implement measures to avoid or minimize the effects of conflicts with potentially hazardous NASA operations.

Stipulation No. 3 - Electromagnetic Emissions

The permittee or authorized operator agrees to control its own electromagnetic emissions and those of its agents, employees, invitees, independent contractors or subcontractors emanating from individual designated operating areas, warning areas, and water test areas in accordance with requirements specified by the Wallops Frequency Manager to the degree necessary to prevent damage to, or unacceptable interference with, Wallops (including NASA and Tenant) flight testing, training, or operational activities, conducted within individual designated operating areas, warning areas, and water test areas. Prior to entry into the particular operating area, warning area, or water test area, the permittee or authorized operator, its agents, employees, invitees, independent contractors or subcontractors, must coordinate electromagnetic emissions with the Wallops Frequency Manager.

BOEM will continue to coordinate with NASA to help ensure future spatial use conflicts are avoided.

3.2. MITIGATION FOR SEISMIC AIRGUN SURVEYS

Additional mitigation specifically applicable to seismic airgun surveys includes (1) a time-area closure for NARWs and (2) a Seismic Airgun Survey Protocol. The time-area closure is intended to avoid most impacts from ensonification of the water column on marine mammals and sea turtles. Incidentally, the expanded area would prevent impacts to other species found in these areas. The protocol specifies mitigation measures including an acoustic exclusion zone, ramp-up requirements, visual monitoring by protected species observers (PSOs) prior to and during seismic airgun surveys, and array shutdown requirements. The purpose of the Seismic Airgun Survey Protocol is to minimize the potential for injury to marine mammals and sea turtles and to avoid most Level A harassment of marine mammals.

3.2.1. Time-Area Closure for North Atlantic Right Whales

Although NARWs could occur anywhere within the AOI, they are most likely to be found in the calving/nursery areas offshore the southeastern U.S. coast during the winter months and near the South Atlantic and Mid-Atlantic coast during their seasonal migrations (see **Chapter 4.2.2**). Alternative A includes a time-area closure in this region that is intended to avoid most impacts from ensonification of the water column on NARWs.

The locations and timing of the time-area closure under Alternative A are shown in **Figure C-3**. No seismic airgun surveys would be authorized within the NARW critical habitat area from November 15 through April 15 nor within the Mid-Atlantic and Southeast U.S. SMAs from November 1 through April 30. Additionally, G&G surveys using airguns would not be allowed in active DMAs. A DMA is a temporary management zone that is created by NMFS in response to a reliable sighting of a NARW and expires after 15 days unless extended (*Federal Register*, 2002). Airgun surveys conducted outside of the NARW critical habitat, SMAs, or DMAs during the time-area closures would be required to remain at a distance such that received levels at those boundaries do not exceed the threshold for Level B harassment, as determined by field verification or modeling.

Under the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105), the Southeast U.S. SMA is identified with seasonal restrictions in effect from November 15 to April 15, this is a continuous area that extends from St. Augustine, Florida, to Brunswick, Georgia, extending 37 km (20 nmi) from shore (**Figure C-3**). This time-area closure area for the Southeast U.S. SMA has been expanded with seasonal restrictions from November 1 to April 30. The Mid-Atlantic U.S. SMA, with seasonal restrictions from November 1 through April 30, is a combination of both continuous areas and half circles drawn with 37-km (20-nmi) radii around the entrances to certain bays and ports. Within the AOI, the Mid-Atlantic U.S. SMA includes a continuous zone extending between Wilmington, North Carolina, and Brunswick, Georgia, as well as the entrance to Delaware Bay (Ports of Wilmington [Delaware] and Philadelphia), the entrance to Chesapeake Bay (Ports of Hampton Roads and Baltimore), and the Ports of Morehead City and Beaufort, North Carolina (**Figure C-3**).

The total closure area under Alternative A would be 7,589,594 acres (ac) (30,714 square kilometers [km^2]), or approximately 4 percent of the AOI. As explained in **Appendix E**, the time-area closure is estimated to avoid about two-thirds of the incidental takes of NARWs by active acoustic sound sources over the period of the Programmatic EIS.

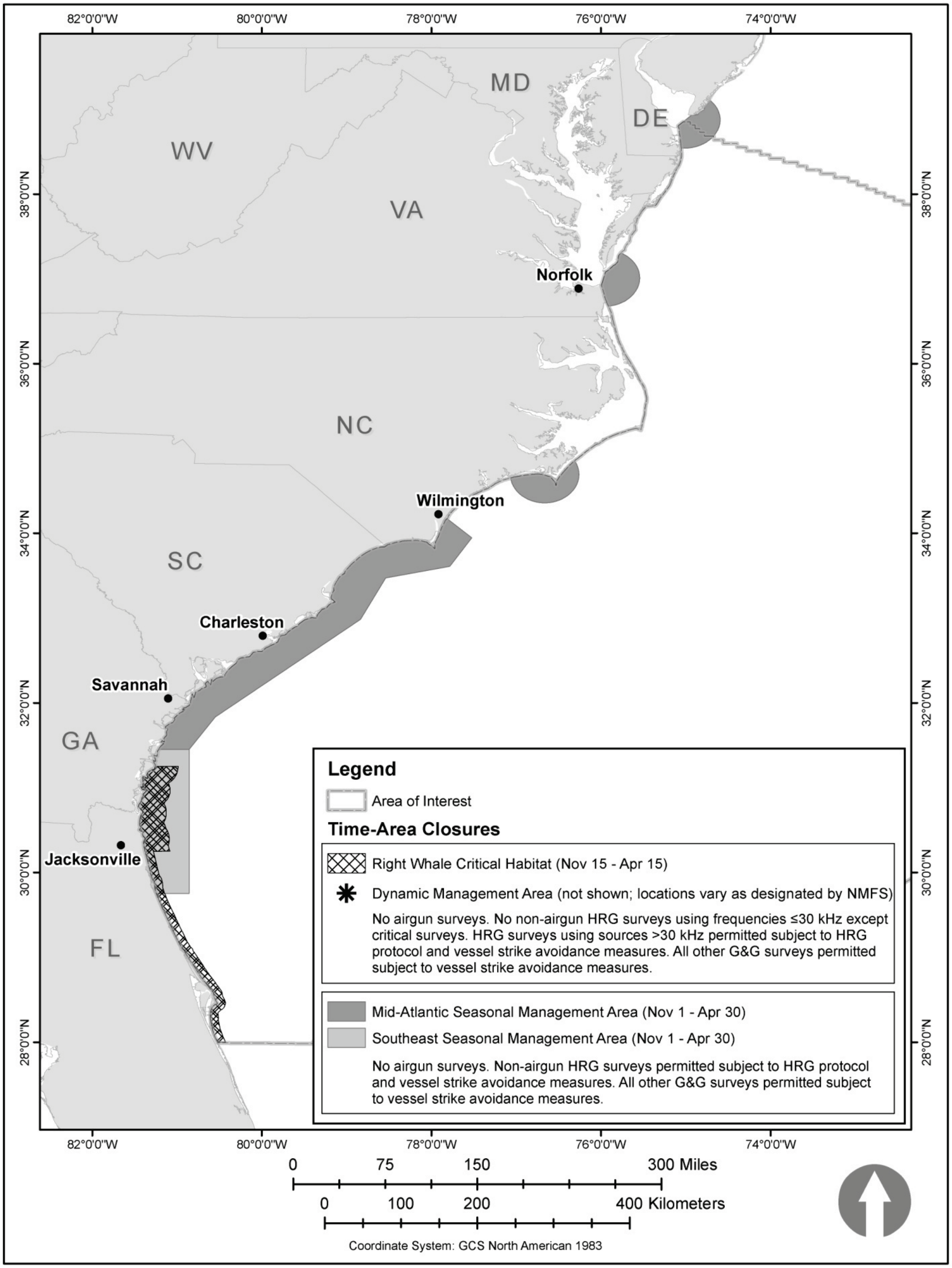


Figure C-3. Time-Area Closures under Alternative A.

If there are changes made to either the Southeast or the Mid-Atlantic U.S. SMAs by NOAA in the future, the closure areas would be modified to align the closure areas with the new boundaries of the SMAs.

3.2.2. Seismic Airgun Survey Protocol

All authorizations for seismic airgun surveys (those involving airguns as an acoustic source) would include a survey protocol that specifies mitigation measures for protected species, including an acoustic exclusion zone, ramp-up requirements, visual monitoring by PSOs prior to and during seismic airgun surveys, and array shutdown requirements. The protocol specifies the conditions under which airgun arrays can be started and those under which they must be shut down. It also includes the recommended but optional use of passive acoustic monitoring (PAM) to help detect vocalizing marine mammals. The protocol requirements apply specifically to airguns, not electromechanical sources such as side-scan sonars; boomers, sparkers, and chirp subbottom profilers; and single beam or multibeam depth sounders that may be operating concurrently during seismic airgun surveys.

The Seismic Airgun Survey Protocol is provided as **Attachment 1** to this Appendix. The protocol is similar to Joint BOEM-BSEE NTL 2012-G02 ("Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program") (USDOI, BOEM and BSEE, 2012b), with key exceptions as noted in the protocol. Each specific permit for seismic activities within the AOI will require additional analyses where BOEM may adjust mitigation based on the best available information at that time.

3.2.2.1. Rationale

The purpose of the operational measures included in the Seismic Airgun Survey Protocol is to minimize the potential for injury to marine mammals and sea turtles and to avoid most Level A harassment of marine mammals.

There are 39 species of marine mammals potentially occurring in the Area of Interest (AOI), as described in **Chapter 4.2.2** of the Programmatic EIS. They include 34 species of cetaceans, 4 species of pinnipeds, and one sirenian (the Florida manatee). The pinnipeds (gray seal, harbor seal, harp seal, and hooded seal) are considered to be extralimital in the AOI and are unlikely to be exposed to underwater sound from seismic airgun surveys under the proposed action. Manatees are present only in inland and near-coastal waters along the southeast coast and are unlikely to be exposed to underwater sound from seismic airgun surveys under the proposed action. Incidental take calculations in **Appendix E** based on abundance data for the AOI predict zero incidental takes of pinnipeds or manatees, even without considering operational mitigation measures included in the Seismic Airgun Survey Protocol.

For the analysis in the Programmatic EIS, two sizes of airgun arrays were modeled, based on current usage in the Gulf of Mexico, and considered representative for potential Atlantic G&G seismic surveys: large airgun array (5,400 in^3) – this array was used to represent sound sources for deep penetration seismic surveys, including 2D, 3D, WAZ, and other variations; and small airgun array (90 in^3) – this array was used to represent sound sources for HRG surveys that use airguns.

Detailed acoustic characteristics of airguns are discussed in **Appendix D**. Broadband source levels are 230.7 dB re 1 µPa for the large airgun array and 210.3 dB re 1 µPa for the small array (**Table C-3**). Although airguns have a frequency range from about 10 to 2,000 Hz, most of the acoustic energy is radiated at frequencies below 200 Hz.

Table C-3

Acoustic Characteristics of Airgun Arrays Included in the Proposed Action

Source	Usage	Operating Frequencies	Broadband Source Level (dB re 1 µPa at 1 m)
Large Airgun Array (5,400 in^2)	Deep penetration seismic surveys, oil and gas exploration (2D, 3D, WAZ, VSP, 4D, etc.)	10-2,000 Hz (most energy at <200 Hz)	230.7
Small Airgun Array (90 in^2)	HRG surveys	10-2,000 Hz (most energy at <200 Hz)	210.3

Abbreviations: 2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional; WAZ = wide azimuth; VSP = vertical seismic profile; HRG = high-resolution geophysical.
Source: **Appendix D**.

Acoustic pulses from airguns are within the hearing range of all marine mammals in the AOI (**Appendix H**). All of the mysticetes occurring in the AOI are low-frequency cetaceans (7 Hz-22 kHz), and most of the odontocetes are mid-frequency cetaceans (150 Hz-160 kHz), with the exception of the harbor porpoise (a high-frequency cetacean, 200 Hz-180 kHz). Manatees have hearing capabilities that are generally similar to phocid pinnipeds, with functional hearing between about 250 Hz and ~90 kHz. Airgun pulses are also within the hearing range of sea turtles, whose best hearing is mainly below 1,600 Hz (**Appendix I**).

To reduce the risk of injury and Level A harassment, the Seismic Airgun Survey Protocol would establish an exclusion zone based on the predicted range at which animals could be exposed to a received sound pressure level of 180 dB re 1 µPa, which is the current NMFS criterion for Level A harassment of cetaceans. The radius of the exclusion zone would be calculated on a survey-specific basis, but would not be less than 500 m (1,640 ft). This exclusion zone applies specifically to airguns, not electromechanical sources such as side-scan sonars; boomers, sparkers, and chirp subbottom profilers; and single beam or multibeam depth sounders that may be operating concurrently during seismic airgun surveys. Although there are no NMFS noise exposure criteria for sea turtles, the mitigation measures are expected to similarly reduce the risk of temporary or permanent hearing loss in sea turtles. The operational mitigation measures would reduce the extent of, but not prevent, behavioral responses including Level B harassment of marine mammals. Other measures such as the time-area closure for NARWs (**Section 3.2.1**) would help to reduce the risk of those impacts. Key elements of the protocol are discussed in the following sections.

3.2.2.2. Ramp-Up

Ramp-up (also known as “soft start”) entails the gradual increase in intensity of an airgun array over a period of 20 min or more until maximum source levels are reached. The intent of ramp-up is to either avoid or reduce the potential for instantaneous hearing damage to an animal (from the sudden initiation of an acoustic source at full power) that might be located in close proximity to an airgun array. Increasing sound levels are designed to warn animals of pending seismic operations, and to allow sufficient time for those animals to leave the immediate area. Increasing sound levels (e.g., from an airgun array) are thought to be annoying or aversive to marine mammals. Under optimal conditions, sensitive individuals are expected to move out of the area, beyond the range where hearing damage might occur. The procedural design and quantitative limits for ramp-up, however, are not based on rigid analytical or empirical evidence, and it is not certain if marine mammals indeed interpret a survey ramp-up as a warning of a stressor to come, as a human might interpret. Therefore, it is used mainly as a “common sense” procedure, although there is little information on its effectiveness (Weir and Dolman, 2007; Parsons et al., 2009).

Nonetheless, ramp-up has become a standard mitigation measure in the U.S. and worldwide. The International Association of Geophysical Contractors (IAGC) recommends ramp-up in its seismic survey guidelines (IAGC, 2011). BOEM requires ramp-up procedures for seismic airgun surveys operating in the Gulf (USDOI, BOEM and BSEE, 2012b).

3.2.2.3. Acoustic Exclusion Zone

The Seismic Airgun Survey Protocol includes an acoustic exclusion zone centered on the sound source to minimize the potential for injury to marine mammals and sea turtles and to avoid Level A harassment of marine mammals to the maximum extent practicable.

The radius of the exclusion zone would be based on the predicted range at which animals could be exposed to a received sound pressure level of 180 dB re 1 µPa, which is the current NMFS criterion for Level A harassment of cetaceans. The radius of the exclusion zone would be calculated on a survey-specific basis, but would not be less than 500 m (1,640 ft). This exclusion zone applies specifically to airguns, not electromechanical sources such as side-scan sonars; boomers, sparkers, and chirp subbottom profilers; and single beam or multibeam depth sounders that may be operating concurrently during seismic airgun surveys.

Although the NMFS also uses a criterion of 190 dB re 1 µPa for Level A harassment of pinnipeds, based on the rare occurrence of pinnipeds in the AOI it is unlikely that a smaller exclusion zone based on the 190-dB criterion would be appropriate for any seismic airgun survey there. There are no noise exposure criteria for sea turtles, but a 180-dB exclusion zone is expected to prevent mortalities, injuries, and most auditory impacts on sea turtles as well.

Based on calculations in **Appendix D** and summarized in **Table C-4**, the 180-dB zone for a large airgun array (5,400 in^3) ranges from 799 to 2,109 m (2,622 to 6,920 ft), with a mean of 1,086 m (3,563 ft). Marine mammals can be detected at distances of up to several kilometers, depending on sea state and the animal's size and behavior. Sea turtles are not likely to be detected beyond 500 m (1,640 ft).

For HRG surveys using a small airgun array (90 in^3), the 180-dB zone ranges from 76 to 186 m (249 to 610 ft), with a mean of 128 m (420 ft) (**Table C-4**). A 500-m (1,640-ft) radius exclusion zone can be effectively monitored and would encompass the zone where Level A harassment could occur.

Table C-4

Estimated Ranges (m) for Level A Harassment of Cetaceans by Airgun Arrays
Based on the NMFS Level A Criterion

Equipment	Usage	Number of Scenarios Modeled	Statistics	NMFS Level A Criterion 180 dB re 1 µPa (rms)	
				R_{max}	$R_{95\%}$
5,400-in^3 Airgun Array	Deep penetration seismic surveys, oil and gas exploration (2D, 3D, WAZ, VSP, 4D, etc.)	21	Min (m)	799	737
			Max (m)	2,109	1,677
			Mean (m)	**1,086**	**930**
90-in^3 Airgun Array	HRG surveys	21	Min (m)	76	74
			Max (m)	186	177
			Mean (m)	**128**	**124**

R_{max} is the maximum received sound pressure level.
$R_{95\%}$ is the received level over 95 percent of the energy of the pulse.
Source: **Appendix D**.

3.2.2.4. Acoustic Exclusion Zone Monitoring by Protected Species Observers

The Seismic Airgun Survey Protocol includes visual monitoring of the exclusion zone by trained PSOs. At least two PSOs will be required on watch aboard seismic vessels at all times during daylight hours (dawn to dusk – i.e., from about 30 min before sunrise to 30 min after sunset) when seismic operations are being conducted, unless conditions (fog, rain, darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that the sea surface observations are halted, visual observations must resume as soon as conditions permit. Ongoing activities may continue but may not be initiated under such conditions (i.e., without appropriate pre-activity monitoring). Operators may only engage trained third-party observers. Training requirements are specified in the Seismic Airgun Survey Protocol (**Attachment 1**).

The main tasks of PSOs are to monitor the acoustic exclusion zone for protected species and to observe and document their presence and behavior. Observers search the area around the vessel using high-powered, pedestal-mounted, “Big Eye” binoculars, hand-held binoculars, and the unaided eye. For larger monitoring programs with a specified visual observation platform, two observers survey for protected species generally using the high-powered binoculars, while a third observer searches with the unaided eye and occasionally hand-held binoculars, and serves as data recorder. Established visual monitoring methods are effective but may not be foolproof in locating every marine mammal or sea turtle within the designated exclusion zone (Barkaszi et al., 2012). These mitigation methods rely on trained and experienced observers to conscientiously work to the required protocols. If the vessel is utilizing a PAM system, a fourth observer will be assigned to monitor that station and communicate with the third observer on the visual observing platform. Data are recorded on paper sheets and/or a laptop computer that has direct input from the vessel’s global positioning system navigation system. Observers rotate among the duty stations at regular intervals, and alternate work and rest periods based upon a pre-determined schedule. In the event a marine mammal or sea turtle is sighted or otherwise detected within the impact zone, seismic operations are suspended until the animal leaves the area (see **Attachment 1**).

Visual, shipboard monitoring is affected by limitations on sightability of individuals due to poor visibility (fog, elevated Beaufort sea state, nighttime operations), species detectability (cryptic species), and/or observer fatigue. Routine activities of marine mammals (e.g., diving duration patterns, pod size, overt behaviors) show considerable variability between species, thereby affecting whether or not animals are sighted (i.e., availability bias). During nighttime operations or during periods of reduced visibility, several options are available to allow for continual monitoring of the impact zone (e.g., shipboard lighting of waters around the vessel, use of enhanced vision equipment, night-vision equipment, and acoustic monitoring [both active and passive]). However, the efficiency of visual monitoring during nighttime hours, using shipboard lighting or enhanced vision equipment, is limited when compared with visual monitoring during daylight hours.

3.2.2.5. Shutdown Requirements

The Seismic Airgun Survey Protocol and HRG Survey Protocol require shutdown of the airgun array or electromechanical equipment any time a marine mammal or sea turtle is observed within the acoustic exclusion zone, whether due to the animal’s movement, the vessel’s movement, or because the animal surfaced inside the exclusion zone. In the event of a shutdown, seismic operations and ramp-up of airguns would recommence only when the sighted animal has cleared the acoustic exclusion zone and no other marine mammals or sea turtles have been sighted within the exclusion zone for at least 60 min. Shutdown would not be required for delphinids approaching the vessel (or vessel’s towed equipment) that indicates a “voluntary approach” on behalf of the delphinid. A “voluntary approach” is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the PSO. If the PSO determines that the delphinid(s) is actively trying to avoid the vessel or the towed equipment, the acoustic sources must be immediately as per his/her instruction. The PSO must record the details of any non-shutdowns in the presence of a delphinid, including the distance of the delphinid(s) from the vessel at the first sighting of the delphinid(s), their heading, where the delphinid positions itself relative to the vessel, how long they stay near the vessel, and any identifiable behaviors. After a shutdown, the operator may recommence seismic operations with a ramp-up of airguns only when the exclusion zone has been visually inspected for at least 60 min to help ensure the absence of all marine mammals and sea turtles.

3.2.2.6. Optional Passive Acoustic Monitoring

Under Alternative A, the Seismic Airgun Survey Protocol strongly encourages, but does not require, the use of PAM to supplement visual observations during monitoring of the acoustic exclusion zone (see **Attachment 1**). This provision is similar to Joint BOEM-BSEE NTL 2012-G02 (*Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program*) (USDOI, BOEM and BSEE, 2012b). PAM can be used to allow ramp-up during low visibility conditions when ramp-up would otherwise not be allowed. Canada and New Zealand have similar provisions (Blue Planet Marine, 2010).

Marine mammals are at the greatest risk of potential injury from seismic airguns when they are submerged and within proximity of the airgun array. Visual monitoring methods are not fully effective for detecting the presence of submerged animals, and detecting surfaced animals during the night and during periods of high sea state and poor visibility. PAM may serve as an effective tool for detecting submerged and vocalizing marine mammals when they are not detectable by visual observation (Hedgeland et al., 2012). Inclusion of PAM does **not** relieve an operator of any of the mitigations (including visual observations) in the seismic airgun protocol with the following exception: use of PAM will allow ramp-up and the subsequent start of a seismic survey during times of reduced visibility (darkness, fog, rain, etc.) when such ramp-up otherwise would not be permitted using only visual observers.

There are two types of PAM systems in current use: fixed systems and towed systems. Fixed PAM systems have the capability to monitor underwater sounds over a wide range of spatial and temporal scales. There are three categories of fixed systems: autonomous recorders, radio-linked hydrophones, and fixed cable hydrophones. Autonomous recorders acquire and store acoustic data internally and are deployed semi-permanently underwater via a mooring or buoy and must be retrieved to access the data. They are capable of continuous recording, automatic detection/classification of sounds, and collection of non-acoustic data. Radio-linked hydrophone systems consist of hydrophones that are moored or fixed to the bottom and transmit the audio signal via radio waves to a receiving station on shore. The acoustic data can be monitored and processed in real or near-real time, or post-processed; however, these data are limited by bandwidth, range of transmission, and data transfer rates. Fixed cable hydrophone systems are typically located on the seafloor in a permanent configuration and can continuously send data to a receiving station. Fixed PAM systems are typically used for monitoring of marine mammals prior to a noise-generating activity (i.e., pile driving, offshore liquefied natural gas facility operation) at a fixed location (Bingham, 2011). For example, the Navy uses a fixed PAM system to monitor their test ranges.

Towed PAM systems were an early configuration applied to monitoring of marine mammals and are used with seismic airgun surveys and for close-range mitigation of the effects of other mobile activities. Towed systems consist of a hydrophone array, tow cable, deck cable, and data processing and monitoring system that processes, displays, and stores selected data. Hydrophone signals are processed for output to the operator with specialized pre-loaded software that has been designed to detect marine mammal click and whistle vocalizations (Hedgeland et al., 2012). Towed arrays have the advantage of mobility and large spatial coverage, and therefore can be used for monitoring when the active source is mobile or covering a large spatial area. However, these systems have limited directional capabilities and challenges from both sound sources and the receivers (e.g., an animal) being mobile. In addition, the towed systems have short time coverage, limited detection range, and are prone to masking problems from vessel noise, flow noise, and seismic source noise, including reverberation in shallow water. They also have limitations from ship availability, can be readily damaged, have difficulties localizing whale calls, and are difficult for use for detection in front of the vessel. Some of these limitations can be overcome, and new technology is being developed (e.g., vector sensors that can measure angles from a single point and assist with determining a more precise bearing of the animal) (Bingham, 2011). Every installation must be designed on a case-by-case basis given the requirements, environment, and resources available, and will need to consider the technological limitations to determine the best method for PAM, which will still need to be used in conjunction with visual observers, as PAM can be conducted at night when visual observations are not possible.

The PAM software and hardware technologies for PAM currently exists that can perform many marine mammal monitoring and mitigation requirements under a wide range of operational conditions. However, these existing systems were not designed specifically for monitoring and mitigation for the offshore industrial application. No single technical approach has the ability to satisfy all or even most of the marine mammal monitoring and mitigation requirements of the offshore industry, and most likely an integrated approach is necessary. In addition, one of the limitations of PAM is that it works only if the animals produce sound that can be detected by the system; there are cryptic species of marine mammals that do not vocalize much or at all. Also, PAM is unable to simultaneously listen to all species in an area due to the wide range of frequencies of vocalizations. The PAM operators must be trained and experienced in order to successfully operate the systems. Fixed PAM technologies are more mature than towed PAM for mitigation and monitoring of marine mammals for the offshore industry. However, towed PAM has been used with some success to supplement visual monitoring of exclusion zones

(Bingham, 2011). Towed arrays have been used primarily for sperm whale work, although they have the disadvantage of not being able detect presence straight ahead or through the ship unless the array is towed deeper than the bottom of the vessel.

Although the technology for detecting and locating underwater sounds and their sources in general is well developed, integrated hardware and software systems using acoustics specifically designed to locate and track marine mammals as mitigation for seismic airgun surveys are relatively new and have only been commercially available in recent years.

3.3. HRG SURVEY PROTOCOL

The HRG Survey Protocol is for surveys that use only electromechanical sources such as side-scan sonar; boomers, sparkers, chirp subbottom profilers; and single beam and multibeam depth sounders. HRG surveys using airguns operating concurrently with electromechanical acoustic sources would be subject to the Seismic Airgun Survey Protocol described in **Section 3.2**.

Mitigation applicable to non-airgun HRG surveys is specified in the HRG Survey Protocol (see **Attachment 2**). In reviewing each specific application for HRG surveys, BOEM will use the site-specific review to adjust mitigation based on the best available information at that time. The HRG Survey Protocol requirements under Alternative A can be summarized as follows:

- All HRG operators must comply with separate guidance for vessel strike avoidance (see **Section 3.1.1**).
- If active acoustic sources will operate above 200 kHz, no additional mitigation for acoustic exclusion zones, PSO requirements, startup or shutdown requirements, or time-area closures would be conditioned to authorizations.
- If at least one acoustic source will operate at frequencies at and below 200 kHz, an acoustic exclusion zone is required, with visual monitoring by trained PSOs and startup and shutdown requirements as described in the protocol.
- Acoustic sources operating at and below 30 kHz are assumed to be within the audibility range of NARWs. Therefore, only HRG surveys using frequencies greater than 30 kHz would be allowed to operate within NARW critical habitat from November 15 through April 15 and in NARW DMAs (see **Section 3.3.1**). All other non-airgun HRG surveys would be permitted or authorized year-round throughout the AOI.

3.3.1. Time-Area Closure for North Atlantic Right Whales

Only HRG surveys using frequencies greater than 30 kHz would be allowed to operate within NARW critical habitat from November 15 through April 15, and those surveys would only occur during daylight hours. Surveys in NARW critical habitat using sources operating at and below 30 kHz would be evaluated by BOEM on a critical need basis, considering whether survey planning could have scheduled survey activities outside of the calving and nursing season and how the particular survey fills a critical need.

A DMA is a temporary management zone that is created by NMFS in response to a reliable sighting of a NARW and expires after 15 days unless extended (*Federal Register*, 2002). If a DMA is established during the course of an HRG survey, further use of all sound sources operating at and below 30 kHz in that DMA must be discontinued within 24 hr of its establishment. Any surveys authorized by BOEM outside, but in proximity of, DMA boundaries are required to remain at a distance such that received levels at these boundaries are no more than the Level B threshold.

Except as noted above for HRG surveys using frequencies at and below 30 kHz, all other non-airgun HRG surveys would be permitted or authorized year-round throughout the AOI.

3.3.2. HRG Survey Protocol

3.3.2.1. Rationale

The purpose of the HRG Survey Protocol is to reduce the potential for acoustic impacts to marine mammals and sea turtles due to active acoustic sources. Based on the information reviewed in

Appendix H and **Appendix I**, acoustic sources operating at frequencies greater than 200 kHz are not likely to be within the hearing range of marine mammals or sea turtles. Therefore, there are no acoustic exclusion zones, PSO requirements, time-area closures, or other additional mitigation requirements for such surveys.

For non-airgun HRG surveys using sources operating at and below 200 kHz, the HRG Survey Protocol would establish an acoustic exclusion zone, require visual monitoring by trained PSOs, and specify startup and shutdown requirements. Ramp-up is not expected to be an effective mitigation measure for non-airgun HRG surveys because electromechanical sources typically are either on or off and are not powered up gradually. PAM would not be included as recommended mitigation in the HRG Survey Protocol under Alternative A.

3.3.2.2. Acoustic Exclusion Zone

An acoustic exclusion zone is required for non-airgun HRG surveys in which at least one acoustic source will operate at frequencies at and below 200 kHz. Important considerations in defining an acoustic exclusion zone (or “safe” range) include the source level, operating frequencies, pulse duration, and directivity of the source as well as the hearing capabilities of the receiving animals. Acoustic characteristics of electromechanical sources are discussed in detail in **Appendix D** and summarized in **Table C-5**.

Table C-5

Acoustic Characteristics of Representative Electromechanical Sound Sources Included in the Programmatic EIS

Source	Broadband Source Level (dB re 1 μPa at 1 m)	Operating Frequencies	Within Hearing Range	
			Cetaceans	Sea Turtles
Boomer	212	200 Hz–16 kHz	Yes	Yes
Side-Scan Sonar	226	100 kHz	Yes	No
		400 kHz	No	No
Chirp Subbottom Profiler	222	3.5 kHz	Yes	No
		12 kHz	Yes	No
		200 kHz	No	No
Multibeam Depth Sounder[a]	213	240 kHz	No	No

[a] Single beam depth sounders may also be used for seafloor mapping, and the frequencies and source levels may differ. The multibeam depth sounder was selected as a representative source and is conservative from the standpoint of acoustic impacts.

______ = no auditory impacts expected because frequency is beyond hearing range.

Source: **Appendix D**.

Based on a review of marine mammal hearing, **Appendix H** recognizes three cetacean groups: low-frequency cetaceans (7 Hz to 22 kHz), mid-frequency cetaceans (150 Hz to 160 kHz) and high-frequency cetaceans (200 Hz to 180 kHz). Boomer pulses are within the hearing range of all three cetacean groups. However, the operating frequency of the representative multibeam system (240 kHz) is above the hearing range of all three groups. For side-scan sonar, the 100 kHz operating frequency is within the hearing range of mid- and high-frequency cetaceans, but the 400 kHz frequency is above the range of all groups. For the chirp subbottom profiler, the 3.5 kHz and 12 kHz frequencies are within the hearing range of all three cetacean groups, but the 200 kHz frequency is above the range of all groups. Frequencies emitted by individual equipment may differ from these representative systems selected for programmatic analysis.

Sea turtles are low-frequency specialists whose best hearing is mainly below 1,600 Hz (**Appendix I**). Acoustic signals from electromechanical sources other than the boomer are not likely to be detectable by sea turtles. Because of the relatively low source level of the boomer as discussed below, sea turtles are unlikely to hear these pulses unless they are very near the source.

3.3.2.2.1. Injury Ranges Calculated Using the 180-dB NMFS Criterion

To reduce the risk of injury and Level A harassment of marine mammals, the HRG Survey Protocol would establish an acoustic exclusion zone based on the predicted range at which animals could be exposed to a received sound pressure level of 180 dB re 1 µPa, which is the current NMFS criterion for Level A harassment of cetaceans. The operational mitigation measures would not prevent all Level A harassment and would reduce the extent of, but not prevent, behavioral responses including Level B harassment.

Table C-6 lists the maximum 180-dB range calculated for electromechanical sources, based on acoustic modeling in **Appendix D**. The range of values reflects the various geographic and seasonal scenarios modeled. The 180 dB radius ranged from 38 to 45 m (125 to 148 ft) for the boomer from 32 to 42 m (105 to 138 ft) for the chirp subbottom profiler. The 180-dB radius was 27 m (89 ft) for the multibeam depth sounder under all scenarios. The side-scan sonar had the largest 180-dB radius, ranging from 128 to 192 m (420 to 630 ft).

Table C-6

Estimated Ranges for Level A and B Harassment of Cetaceans
by Electromechanical Sources Based on the NMFS 180-dB and 160-dB Criteria

Equipment	Number of Scenarios Modeled	Pulse Duration	Adjustment (dB) for Short Pulse Duration[a]	180-dB Radius (m)		160-dB Radius (m)	
				Calculated using Nominal Source Level[b]	Recalculated for Short Pulse Duration[a]	Calculated using Nominal Source Level[b]	Recalculated for Short Pulse Duration[a]
Boomer	14	180 µs	-27.3	38-45	<5	1,054-2,138	16
Side-Scan Sonar	14	20 ms	-7.0	128-192	65-96	500-655	337-450
Chirp Subbottom Profiler	14	64 ms	-1.9	32-42	26-35	359-971	240-689
Multibeam Depth Sounder	7	225 µs	-26.5	27	<5	147-156	12

[a] The nominal source level was adjusted by the amount indicated to recalculate the 180-dB radius in the last column.
[b] The value is the radius (Rmax) for the maximum received sound pressure level (**Appendix D)**.

Source: **Appendix D**.

The initial 180-dB calculations in **Table C-6** are based on nominal source levels and do not take into account the pulse duration. As indicated in the table, the pulses produced by all of the electromechanical sources are much shorter than 1 s. As summarized by Au and Hastings (2008), when receiving tone pulses, the mammalian ear behaves like an integrator with an "integration time constant." Energy is summed over the duration of a pulse until the pulse is longer than the integration time constant. Studies of bottlenose dolphins by Johnson (1968) indicate an integration time constant of approximately 100 ms. A 10 ms pulse with a received SPL of 180 dB would be integrated over a 100 ms period, resulting in a 10-fold (10 dB) reduction. Using the assumption of a 100 ms integration time, the 180 dB radii for side-scan sonar and multibeam depth sounder were recalculated to account for short pulse duration as shown in **Table C-6**. For the boomer, and multibeam depth sounder, the recalculated 180-dB radius was <5 m under all scenarios. The recalculated 180 dB radius ranged from 65 to 96 m (213 to 315 ft) for the side-scan sonar and from 26 to 35 m (85 to 115 ft) for chirp subbottom profiler. Specific considerations for each source are discussed below.

3.3.2.2.1.1. Boomer

The frequency range of the representative boomer (200 Hz to 16 kHz) is entirely within the hearing range of all cetacean groups and is also within the expected hearing range of sea turtles. Based on a source level of 212 dB re 1 µPa, the 180 dB radius is estimated to range from 38 to 45 m (125 to 148 ft) for the various geographic and seasonal scenarios modeled. However, taking into account the short pulse duration (180 µs), the recalculated 180 dB radius is <5 m (16 ft) in all modeled scenarios (**Table C-6**).

3.3.2.2.1.2. Side-Scan Sonar

For the representative side-scan sonar, the 100 kHz operating frequency is within the hearing range of mid- and high-frequency cetaceans, but the 400 kHz frequency is above the range of all groups. Sea turtles are not expected to hear this source. Based on a source level of 226 dB re 1 µPa, the 180-dB radius is estimated to range from 128-192 m (420-630 ft) for the various geographic and seasonal scenarios modeled. Taking into account the short pulse length of 20 ms, the recalculated 180-dB radius ranges from 65 to 96 m (213 to 315 ft) (**Table C-6**).

3.3.2.2.1.3. Chirp Subbottom Profiler

The representative chirp subbottom profiler operates at three frequencies: 3.5 kHz, 12 kHz, and 200 kHz. The highest frequency (200 kHz) is above the hearing range for all cetaceans. Sea turtles are not expected to hear this source. Based on a source level of 222 dB re 1 µPa, the 180-dB radius ranges from 32 to 42 m (105 to 138 ft) for the various geographic and seasonal scenarios modeled. Because the pulse length of 64 ms is relatively close to the 10-ms integration time assumed for the cetacean ear, the correction for pulse length reduces the ranges only slightly to 26-35 m (85-115 ft) (**Table C-6**).

3.3.2.2.1.4. Multibeam Depth Sounder

Based on a source level of 213 dB re 1 µPa, the 180-dB radius calculated for the multibeam depth sounder is 27 m (89 ft) for all of the geographic and seasonal scenarios modeled. Taking into account the short pulse duration (225 µs), the radius is further reduced to <5 m (16 ft) for all modeled scenarios. More importantly, because the operating frequency of the representative multibeam system (240 kHz) is above the hearing range of all three cetacean groups, no auditory impacts are expected. Similarly, sea turtles are not expected to hear this source.

The relatively low risk of auditory impacts on marine mammals from multibeam depth sounders is consistent with a recent analysis by Lurton and DeRuiter (2011) taking into account both the short pulse duration and high directivity of these sources.

3.3.2.2.2. Injury Ranges Calculated Using the Southall Criteria

Based on data for onset of temporary threshold shift (TTS), Southall et al. (2007) proposed dual injury criteria for cetaceans exposed to non-pulse sources. In the Southall et al. (2007) terminology, all of the electromechanical sources evaluated here would be considered non-pulse sources. The first injury criterion is a sound exposure level (SEL) of 215 dB re 1 μPa^2 s and the second is a flat-weighted peak pressure exceeding 230 dB re 1 µPa. Injury is assumed to occur if either criterion is exceeded (or both).

For all of the representative electromechanical sources in this Programmatic EIS, the source level is less than 230 dB re 1 µPa and therefore the pressure criterion would not be exceeded and the injury radius is zero. Calculation of the injury radius using the SEL criterion is complicated because exposure depends on the ping rate and the number of pulses an animal receives; however, in general, predicted injury radii are expected to be less than 10 m (33 ft) for all of the sources.

3.3.2.2.3. Level B Harassment Ranges Calculated Using the 160-dB NMFS Criterion

Table C-6 also lists the maximum 160-dB range calculated for electromechanical sources, based on acoustic modeling in **Appendix D**. The range of values reflects the various geographic and seasonal scenarios modeled. The boomer had the largest 160-dB radius, ranging from 1,054 to 2,138 m (3,458 to 7,015 ft), followed by the chirp subbottom profiler (359-971 m or 1,178-3,186 ft), the side-scan sonar (500-655 m or 1,640-2,149 ft) and the multibeam depth sounder (147-156 m or 482-512 ft).

Values taking into account pulse duration are shown in the last column of **Table C-6**. Due to the very short pulse duration, the boomer, and multibeam depth sounder have radii of 16 m (52 ft) and 12 m (39 ft), respectively. The recalculated 160 dB radius ranged from 240 to 689 m (787 to 2,261 ft) for the chirp subbottom profiler and from 337 to 450 m (1,106 to 1,476 ft) for side-scan sonar.

3.3.2.2.4. Discussion

Among the representative electromechanical sources, boomers, and multibeam depth sounders pose the smallest risk of auditory impacts to marine mammals. Under all scenarios modeled, the 180-dB radius for both sources is estimated to be <50 m (160 ft) for the nominal source level and <5 m (16 ft) when pulse duration is taken into account. Based on the Southall criteria, the predicted injury radius would be zero for both sources. In addition, the operating frequency of the representative multibeam depth sounder is beyond the range of all three cetacean groups. (Some multibeam depth sounders use different frequencies that are within the cetacean hearing range, but the system modeled here is considered representative of the equipment likely to be used during HRG surveys for renewable energy and marine minerals sites.)

Both the representative side-scan sonar and chirp subbottom profiler could be detectable by cetaceans, depending on the operating frequencies selected. The side-scan sonar operating at 100 kHz would be detectable and the 180-dB radius is estimated to be 128-192 m (420-630 ft) based on the nominal source level and 65-96 m (213-315 ft) when the short pulse length is taken into account. The chirp subbottom profiler operating at either 3.5 kHz or 12 kHz would be detectable and the 180-dB radius is estimated to be 32-42 m (105-138 ft) based on the nominal source level and 26-35 m (85-115 ft) when the short pulse length is taken into account. Based on the Southall criteria, predicted injury ranges are less than 10 m (33 ft) for both sources.

Depending on the suite of equipment selected and the operating frequencies selected, there may be no acoustic impacts. For example, if a survey uses side-scan sonar at 400 kHz, chirp subbottom at 200 kHz, multibeam depth sounder at 240 kHz, and no boomer or sparker, then no acoustic impacts on marine mammals would be expected.

For surveys with one or more sources operating at frequencies within the cetacean hearing range, if source levels are low enough, it may be feasible to monitor the entire 160 dB radius. For example, a source level of 206 dB re 1µPa would have a 160 dB radius of 200 m (656 ft) (based on the simplistic assumption of spherical spreading).

3.3.2.2.5. Practical Considerations

BOEM expects that a 200 m (656 ft) radius acoustic exclusion zone can be effectively monitored from the types of coastal survey vessels expected to be used for non-airgun HRG surveys within the AOI. The operational ranges for non-airgun HRG surveys typically conducted for renewable energy and marine minerals projects would be approximately <25 mi from shore and in water <40 m (141 ft) deep. The operational ranges for non-airgun HRG surveys typically conducted for oil and gas would be located throughout the AOI. Unlike the large, dedicated vessels used for seismic airgun surveys, coastal survey vessels may not have an elevated viewing platform that may be used by visual observers, and so their capability for effectively monitoring a radius larger than a few hundred meters would depend on vessel size and configuration. An acoustic exclusion zone radius of 200 m (656 ft) would encompass the 180-dB Level A harassment radius calculated for all of the representative electromechanical sources included in this Programmatic EIS as summarized above. Depending on the source levels of the equipment used on particular surveys, this radius may also encompass the 160 dB Level B harassment zone. Therefore, the protocol would allow an operator to monitor a radius larger than 200 m (656 ft) if the visual observers are able to effectively monitor the designated acoustic exclusion zone.

Geophysical operators report that dolphins frequently approach and chase the side-scan sonar towfish. Therefore, requiring a shutdown for delphinids could significantly increase survey duration or even make it impossible to complete some HRG surveys. The protocol requires that the exclusion zone be initially clear of all marine mammals and sea turtles and specifies shutdown for any marine mammal or sea turtle entering the exclusion zone. Shutdown would not be required for delphinids approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. If a delphinid voluntarily moves into the exclusion zone after the active acoustic sound sources are operating, it is reasoned that the sound pressure level is not negatively affecting that particular animal.

3.3.2.2.6. Conclusions – Acoustic Exclusion Zone

An acoustic exclusion zone would be established for HRG surveys conducted with one or more sound sources operating at a frequency of at or below 200 kHz. An acoustic exclusion zone is not required for HRG surveys in which all active sound sources would operate at frequencies greater than 200 kHz.

The acoustic exclusion zone would be a 200 m (656 ft) radius zone around the sound source which for most cases would encompass the 180-dB re 1 µPa-m (rms) isopleth, which is the current NMFS criterion for Level A harassment of cetaceans. If the calculated radius for a source is greater than 200 m (656 ft), the exclusion zone would be increased and that increase would be quantified through field verification or modeling. In addition, the applicant would be required to demonstrate that the larger exclusion zone could be effectively monitored. Effectiveness can be demonstrated through available monitoring studies or use of a vessel providing sufficient observation deck height to help ensure adequate coverage. Depending on the source levels, operational frequency, and deployment mode of the geophysical equipment used, the 200 m (656 ft) exclusion zone could also encompass the 160-dB Level B harassment zone.

3.3.2.3. Acoustic Exclusion Zone Monitoring by Protected Species Observers

All HRG surveys using one or more active acoustic sources operating at or below 200 kHz must use trained PSOs to monitor an acoustic exclusion zone. If there are no acoustic sources operating at frequencies at and below 200 kHz, there will be no acoustic exclusion zone and there are no requirements for PSOs or other trained visual observers. However, all HRG operators must comply with separate guidance for vessel strike avoidance (see **Section 3.1.1**).

A PSO for an HRG survey is defined as someone who has successfully completed a PSO training course approved by NMFS. The PSOs can be trained crew members and/or third party observers. All PSO resumes must be submitted to NMFS for approval prior to survey operations. Basic training criteria have been established and must be adhered to by any entity that offers PSO training. BOEM will not sanction particular trainers or training programs.

Visual monitoring of the acoustic exclusion zone must be conducted by trained PSOs. At least one PSO would be required on watch aboard HRG survey vessels at all times during daylight hours (dawn to dusk – i.e., from about 30 min before sunrise to 30 min after sunset) when survey operations are being conducted, unless conditions (fog, rain, darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that the sea surface observations are halted, visual observations must resume as soon as conditions permit. Ongoing activities may continue but may not be initiated under such conditions (i.e., without appropriate pre-activity monitoring).

The requirements for PSOs and their roles are as follows:

a. At least one PSO will be required on duty at all times to monitor the acoustic exclusion zone when acoustic sources are operating.

b. The PSO(s) will monitor an acoustic exclusion zone for protected species and observe and document their presence and behavior, searching the area around the vessel using hand-held reticle binoculars, and the unaided eye. If BOEM approves nighttime operations or if operations continue during periods of reduced visibility, operators would monitor the waters around the acoustic exclusion zone using, for example, shipboard lighting, enhanced vision equipment, night-vision equipment and/or PAM.

c. The following schedule limitations shall apply to PSOs during HRG survey activities:

   1. Other than brief alerts to bridge personnel of maritime hazards, no additional duties shall be assigned to PSOs during their watch.
   2. A watch shall be no longer than four consecutive hours.
   3. A break of at least 2 hr shall occur between 4-hr watches, and no other duties shall be assigned during this period.
   4. A PSO's combined watch schedule shall not exceed 12 hrs during a 24-hr period.

3.3.2.4. Shutdown Requirements

Monitoring of the acoustic exclusion zone would begin no less than 60 min prior to start-up and continue until operations cease. Immediate shutdown of the active acoustic sound source(s) would occur if any marine mammal or sea turtle is detected entering or within the acoustic exclusion zone. Subsequent restart of the equipment may only occur following a confirmation that the exclusion zone is clear of all marine mammals and sea turtles for 60 min.

Shutdown would not be required for delphinids approaching the acoustic exclusion zone that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the PSO. If the PSO determines that the delphinid(s) is actively trying to avoid the vessel or the towed equipment, the acoustic sources must be immediately shutdown as per his/her instruction. The PSO must record the details of any non-shutdowns in the presence of a delphinid, including the distance of the delphinid(s) from the vessel at the first sighting of the delphinid(s), their heading, where the delphinid positions itself relative to the vessel, how long they stay near the vessel, and any identifiable behaviors. After a shutdown, HRG operations may recommence only when the exclusion zone has been visually inspected for at least 60 min to help ensure the absence of all marine mammals and sea turtles.

3.3.2.5. Passive Acoustic Monitoring

Passive acoustic monitoring is not included as recommended mitigation in the HRG Survey Protocol for Alternative A. The use of PAM for HRG surveys would be evaluated and approved on an individual project basis, during the activity-specific assessment that is part of the application process. The circumstances specific to each HRG geophysical survey would be considered in determining the utility and cost-effectiveness of PAM. In Alternative B, for non-airgun HRG surveys using sources at or below 200 kHz, if BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility, additional effective monitoring technologies, which could include PAM, would be required (see **Section 4.5**).

High-resolution geophysical surveys typically only involve the use boomer and/or chirp subbottom profiler, side-scan sonar, and multibeam/interferometric/single beam fathometers. The operation and deployment of these sources is different from seismic airguns. Comparatively small vessels are typically deployed for these comparatively small-footprint and short-duration surveys, where sound-producing equipment is vessel-mounted or towed a short distance behind the vessel. Separately towed hydrophone strings are not used unless boomers are deployed. Geophysical surveys associated with marine minerals are typically accomplished within 1-3 daylight-hour days in water depths of 10-30 m (32-98 ft). Surveys in support of renewable energy site development will likely have a larger footprint, take more total time to complete the survey activity, and are conducted further offshore but generally in depths not exceeding 40 m (131 ft). The non-airgun HRG surveys associated with oil and gas exploration and development could be conducted throughout the AOI at all water depths.

Relatively fewer species, but perhaps at greater concentrations (e.g., bottlenose dolphin, NARW), may be present or transiting through these areas. Lower-frequency electromechanical HRG sources (e.g., boomer, sparker, chirp subbottom profilers) are often operated at partial power settings, operated at filtered frequency bandwidth, and towed closer to the bottom, reducing the intensity and zone of ensonification and corresponding likelihood of animal exposure. Night-time surveys are not a standard practice for non-airgun HRG surveys conducted nearshore, however some operators may request the flexibility to work at night in order to save costs associated with returning to port. In such cases an alternative monitoring strategy for night-time operations will be discussed.

3.3.2.6. Other Requirements

BOEM will notify NMFS at least 30 days in advance of the start of the proposed HRG survey activity with a brief determination regarding whether the proposed action is consistent with the activities considered in the Programmatic EIS or associated ESA consultation. If the proposed action is not consistent with the activities and conditions considered in this Programmatic EIS or the associated ESA consultation, then a separate Section 7 consultation may be required.

3.4. SUMMARY OF VISUAL OBSERVER REQUIREMENTS

Several of the preceding sections described requirements for PSOs or other observers. Requirements for observers are summarized in **Table C-7**. All G&G operators must comply with guidance for vessel strike avoidance as explained in **Section 3.1.1**. Regardless of the type of G&G survey being conducted, visual observers monitoring solely for vessel strike avoidance can be crew members and/or trained third party observers. They do not have specific training requirements nor will they need to be approved by BOEM or BSEE.

All seismic airgun surveys must use PSOs to monitor the acoustic exclusion zone. A PSO for a seismic airgun survey must be a third-party observer who has completed a PSO training course meeting the recommendations of the NOAA Fisheries Service's "National Standards for Protected Species Observers and Data Management: A Model for Seismic Surveys." All PSO resumés must be submitted to NMFS for approval prior to survey operations.

All HRG surveys having an acoustic exclusion zone (i.e., those conducted using one or more sound sources operating at and below 200 kHz) must use PSOs to monitor the acoustic exclusion zone. A PSO must be approved by NMFS. The PSOs for HRG surveys can be crew members and/or third party observers. All PSO resumes must be submitted to NMFS for approval prior to survey operations.

Table C-7

Observer Requirements for G&G Survey Types

Survey Type	Protected Species Observer (PSO) Required?	PSO Affiliation (Third Party, Crew, or Combination)	PSO Watch Requirements	No. of PSOs on Duty when Acoustic Sources Operating	Total No. of PSOs Onboard	Vessel Strike Avoidance
Seismic airgun survey with NO PAM	Yes[1]	Third party	1. Other than brief alerts to bridge personnel of maritime hazards, no additional duties during watch. 2. A watch shall be no longer than four consecutive hours. 3. A break of at least 2 hr shall occur between 4-hr watches, with no other duties during this period. 4. A PSO's combined watch schedule shall not exceed 12 hrs in a 24-hr period.	2 visual PSOs (daylight only)	At least 3 (based on watch requirements)	• Handled by PSOs when airguns are operating. • When vessel is in transit or other times when airguns not operating, could be done by PSO or crew member.
Seismic airgun survey with PAM	Yes[1]	Third party	Same as above	2 visual PSOs (daylight only) 1 PAM operator	At least 4 (based on watch requirements; 3 visual PSOs plus PAM operator(s))	Same as above
HRG survey with acoustic exclusion zone NO additional monitoring technologies	Yes[2]	Third party, crew, or combination (but no other duties)	Same as above	1 visual PSO(daylight only)	At least 2 (based on watch requirements)	• Handled by PSOs when acoustic sources are operating. • When vessel is in transit or other times when acoustic source are not operating, could be done by PSO or other crew member.
HRG survey with acoustic exclusion zone and/or additional monitoring technologies	Yes[2]	Third party, crew, or combination (but no other duties)	Same as above	1 visual PSO 1 PAM operator (as applicable)	2 to 4 (based on watch requirements) plus PAM operator(s) as applicable	Same as above
HRG survey with NO acoustic exclusion zone (all freq. >200 kHz)	No	N/A	N/A	None	None	Handled by crew member as part of navigational duties.
Other G&G surveys	No	N/A	N/A	None	None	Handled by crew member as part of navigational duties.

[1] A PSO for a seismic airgun survey is someone who has successfully completed an approved PSO training course meeting the recommendations of the NOAA Fisheries Service "National Standards for Protected Species Observers and Data Management: A Model for Seismic Surveys" (Baker et al., 2013). All PSO résumés must be submitted to NMFS for approval prior to survey operations.

[2] A PSO for an HRG survey is someone who has been approved by NMFS. All PSO resumés must be submitted to NMFS for approval prior to survey operations.

4. ADDITIONAL PROTECTIVE MEASURES INCLUDED IN ALTERNATIVE B

The mitigation measures included in Alternative B and their applicability to G&G survey types is summarized in **Table C-8**. The following protective measures in Alternative B would be identical to those previously described for the Proposed Action (Alternative A):

- guidance for vessel strike avoidance guidance;
- guidance for marine debris awareness;
- avoidance and reporting of historic and prehistoric sites;
- avoidance of sensitive benthic communities;
- guidance for activities in or near NMSs; and
- guidance for military and NASA coordination.

Alternative B would include the additional or revised measures listed below and described in the following subsections:

- an expanded airgun time-area closure for NARWs;
- a time-area closure for nesting sea turtles offshore Brevard County, Florida;
- geographic separation of concurrent seismic surveys;
- a Seismic Airgun Survey Protocol with required use of PAM; and
- HRG Survey Protocol (for non-airgun HRG surveys) with additional monitoring requirements for nighttime or reduced visibility.

4.1. EXPANDED TIME-AREA CLOSURE FOR NORTH ATLANTIC RIGHT WHALES

Under Alternative B, the NARW time-area closure for airgun surveys would be expanded to a continuous 37 km (20 nmi) wide zone extending from Delaware Bay to the southern limit of the AOI (**Figure C-4**). The expanded closure zone would fill gaps in coverage between Delaware Bay and Wilmington, North Carolina where the Mid-Atlantic U.S. SMA is discontinuous. It would also cover areas offshore Florida adjacent to the North Atlantic right whale critical habitat between the Southeast U.S. SMA and the southern boundary of the AOI. The expanded closure area would add 6,823,753 ac (27,615 km^2) to the SMA closure areas described under Alternative A, totaling 14,413,356 ac (58,329 km^2) and representing 7 percent of the total AOI (vs. approximately 4% under Alternative A).

The purpose of the expanded time-area closure is to prevent impacts to NARWs along their entire migration route and calving and nursery grounds. The SMAs do not provide continuous coverage of the NARW migratory route along the Mid-Atlantic coast because they focus on areas of heavy ship traffic (including entrances to certain bays and ports). Sightings data reviewed by NMFS in developing the ship strike rule indicate that approximately 83 percent of NARW sightings occur within 37 km (20 nmi) of the coast. The expanded time-area closure under Alternative B would form a continuous zone of the same width along the coast of the AOI (**Figure C-4**).

Table C-8

Applicability of Time-Area Closures and Other Mitigation to G&G Survey Types under Alternative B

Survey Type	Time-Area Closures							Other Applicable Mitigation	
	NARW Critical Habitat (Nov 15-Apr 15)	Southeast & Mid-Atlantic U.S. SMAs (Nov 1-Apr 30)	Additional 20-nmi Closure Zone North (Nov 1 – April 30)	Additional 20-nmi Closure Zone South (Nov 15 – April 15)	Sea Turtle Closure Off Brevard County (May 1 – Oct 31)	DMAs	Rest of AOI	Seismic Airgun Protocol	HRG Protocol
Seismic Airgun Surveys	X	X	X	X	X	X	--	X	--
Non-airgun HRG Surveys with frequencies >200 kHz	--	--	--	--	--	--	--	--	X (but no Acoustic Exclusion Zone)
Non-airgun HRG Surveys with frequencies ≤200 kHz	--	--	--	--	--	--	--	--	X (including Acoustic Exclusion Zone)
Non-airgun HRG Surveys with at least one source having frequencies ≤30 kHz but no sources <1.6 kHz	X (unless survey is critical)	--	--	--	--	X (unless survey is critical)	--	--	X (including Acoustic Exclusion Zone)
Non-airgun HRG Surveys with at least one source <1.6 kHz	X (unless survey is critical)	--	--	--	X (unless survey is critical)	X (unless survey is critical)	--	--	X (including Acoustic Exclusion Zone)
Other G&G Surveys	--	--	--	--	--	--	--	--	--

An "X" indicates the time-area closure or mitigation measure is applicable.
Shading highlights closures and measures that are unique to Alternative B.

Table C-8. Applicability of Time-Area Closures and Other Mitigation to G&G Survey Types under Alternative B (continued).

Survey Type	Other Applicable Mitigation								
	Vessel Strike Avoidance	Marine Debris Guidance	Avoidance of Historic & Prehistoric Sites	Avoidance of Sensitive Benthic Communities	NMS Guidance	Military & NASA Guidance	Geographic Separation of Concurrent Seismic Surveys	Required use of PAM in Seismic Airgun Protocol	Required use of Additional Monitoring Technologies at Night in HRG Protocol[2]
Seismic Airgun Surveys	X	X	X[1]	X[1]	X	X	X	X	--
Non-airgun HRG Surveys with frequencies >200 kHz	X	X	X[1]	X[1]	X	X	--	--	--
Non-airgun HRG Surveys with frequencies ≤200 kHz	X	X	X[1]	X[1]	X	X	--	--	X
Non-airgun HRG Surveys with at least one source having frequencies ≤30 kHz but no sources <1.6 kHz	X	X	X[1]	X[1]	X	X	--	--	X
Non-airgun HRG Surveys with at least one source <1.6 kHz	X	X	X[1]	X[1]	X	X	--	--	X
Other G&G Surveys	X	X	X[1]	X[1]	X	X	--	--	--

AOI = Area of Interest; DMA = Dynamic Management Area; G&G = geological & geophysical; HRG = high-resolution geophysical; NASA = National Aeronautics and Space Administration; NMS = National Marine Sanctuary; SMA = Seasonal Management Area.

1 Avoidance of historic and prehistoric sites and sensitive benthic communities applies only to surveys that involve seafloor-disturbing activities. Seismic airgun surveys and non-airgun HRG surveys that do not disturb the seafloor are not required to avoid these sites or features. Non-airgun HRG surveys and most seismic airgun surveys (except those in which cables or sensors are placed in or on the seafloor) do not disturb the seafloor.

2 The requirement for additional monitoring for HRG surveys applies only to surveys at night or during conditions of reduced visibility.

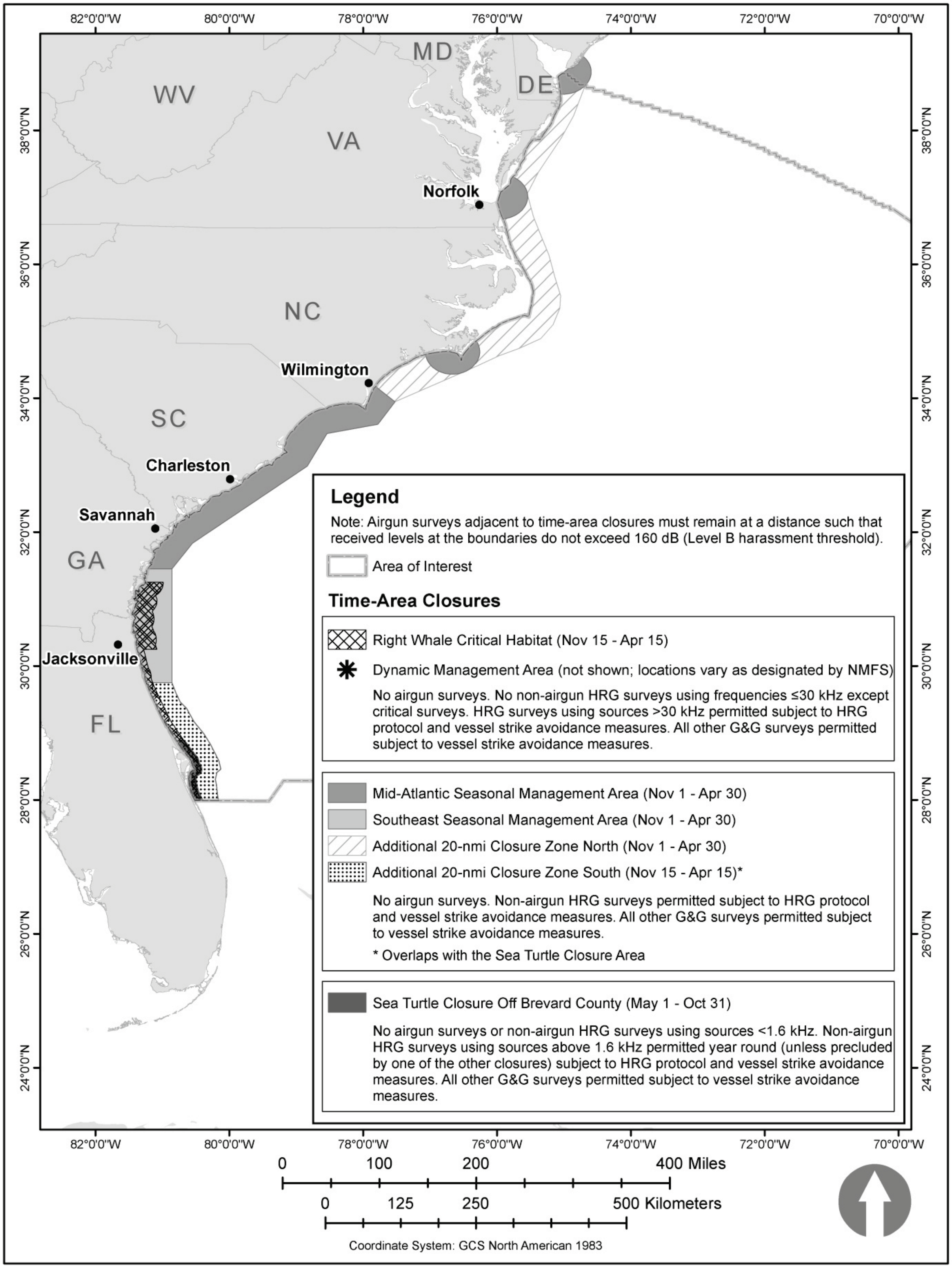


Figure C-4. Time-Area Closures under Alternative B.

Under the expanded time-area closure, no airgun surveys would be authorized within the NARW critical habitat area and additional closure zone south from November 15 through April 15 nor within the Mid-Atlantic and Southeast U.S. SMAs and additional closure zone north from November 1 to April 30, Additionally, airgun surveys would not be allowed in active DMAs. Airgun surveys conducted outside of the continuous expanded 37 km (20 nmi) zone (which incorporates critical habitat and SMAs) or DMAs would be required to remain at a distance such that received levels at those boundaries do not exceed the threshold for Level B harassment, as determined by field verification or modeling.

Under Alternative B, the time-area closure for non-airgun HRG surveys would be the same as under Alternative A. Surveys using acoustic sources operating greater than between 30 and 200 kHz would be authorized year-round throughout the AOI, subject to the HRG protocol, acoustic exclusion zone monitoring, PSO requirements, and guidance for vessel strike avoidance. Surveys using acoustic sources operating greater than 200 kHz would be authorized year-round throughout the AOI, subject to the guidance for vessel strike avoidance. G&G surveys that do not use active acoustic sources would be authorized year-round throughout the AOI, subject to guidance for vessel strike avoidance. Any proposed HRG surveys within the NARW critical habitat and operating at frequencies at and below 30 kHz would be evaluated by BOEM on a critical need basis, considering whether survey planning could have scheduled survey activities outside of the calving and nursing season and how the particular survey fills a critical need. Surveys using acoustic sources operating at and below 30 kHz in areas outside the NARW critical habitat would be authorized year-round, subject to the HRG protocol and guidance for vessel strike avoidance.

4.2. Time-Area Closure for Nesting Sea Turtles Offshore Brevard County, Florida

Alternative B would include a time-area closure in near-coastal waters offshore Brevard County, Florida during the sea turtle nesting season (May 1 to October 31) (**Figure C-4**). No airgun surveys would be authorized within the closure area during this time. Non-airgun HRG surveys using active acoustic sources outside the hearing range of sea turtles, would be allowed year-round, including, between May 1 and October 31, within the Sea Turtle Closure Area. Devices operating above 1.6 kHz would be outside the expected hearing range of sea turtles. Operational or monitoring surveys typically involve a single beam, swath or multibeam and occasional side-scan sonar.

The Brevard County time-area closure would include the portion of Brevard County that is within the AOI and would extend 11 km (5.9 nmi) offshore (**Figure C-5**). The southern border of Brevard County is beyond the southern boundary of the AOI. The closure would also extend radially from the northern county boundary at the shoreline. The extent is based on acoustic modeling of distances that could receive sound pressure levels of 160 dB re 1 µPa from a large airgun array in this area.

The purpose of the closure would be to avoid disturbing the large numbers of loggerhead turtles (and hatchlings) that are likely to be present in nearshore waters of Brevard County during turtle nesting and hatching season. Brevard County includes some of the world's most important nesting beaches for sea turtles. During the 2010 nesting season, there were over 31,000 loggerhead nests in Brevard County. The Archie Carr National Wildlife Refuge (NWR), located mainly within Brevard County, has been identified as the most important nesting area for loggerhead turtles in the western hemisphere. The Archie Carr NWR is critical to the recovery and survival of loggerhead turtles; it has been estimated that 25 percent of all loggerhead nesting in the U.S. occurs in the Archie Carr NWR. Nesting densities have been estimated at 625 nests per km (1,000 nests per mile) within the Archie Carr NWR.

The sea turtle time-area closure would overlap with the NARW time-area closure (**Figure C-5**). The overlapping area would be under closure to seismic airgun surveys (and HRG surveys that use equipment with frequencies less than 1.6 kHz) during most of the year (November 15 – April 15 for NARW and May 1 – October 31 for sea turtles).

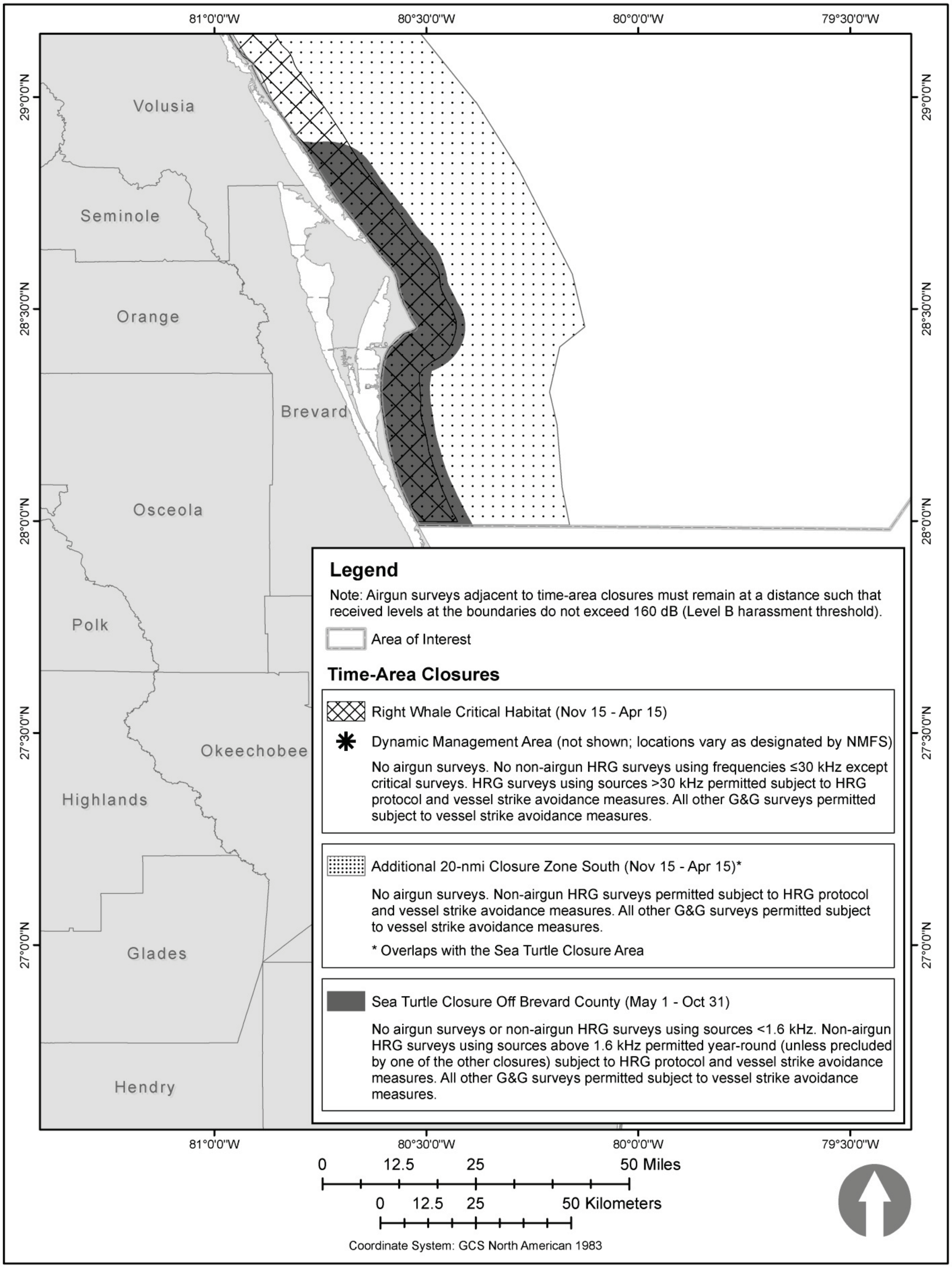


Figure C-5. Time-Area Closures Offshore Brevard County under Alternative B.

4.3. Geographic Separation between Simultaneous Seismic Airgun Surveys

Alternative B would establish a 40-km (25-mi) geographic separation distance between the sources of simultaneously operating seismic airgun surveys. This is in contrast to Alternative A, which does not require any geographic separation of concurrent seismic surveys. The purpose of this measure is to provide a corridor between vessels conducting simultaneous surveys where airgun noise is below Level B thresholds and approaching ambient levels such that animals may pass through rather than traveling larger distances to go around the survey vessels.

The modeling done for this project estimated the largest exposure radii for the 160-dB threshold (Level B) for a large airgun array to be approximately 15 km (8 nmi). This 15 km radii only occurred in less than 10% of the modeled cases, with the more typical radii measured at no more than 10 km (5.4 nmi) (**Appendix D**). In practice, operators typically maintain a separation of about 17.5 km (9.5 nmi) between concurrent surveys to prevent seismic interference. Due to geographic size and activity level, industry has, in certain areas such as the North Sea, developed timeshare guidelines to address interference problems. However, continued development of data processing capabilities has now allowed seismic interference to be addressed, and for the most part, eliminated.

BOEM included a 40-km separation zone within the Draft Programmatic EIS to provide an animal movement corridor between simultaneous surveys where airgun noise is below Level B thresholds and approaching ambient levels. New information suggests that, in some circumstances, airgun noise can be detected at great distances from the sound source, such as across ocean basins (Nieukirk et al., 2012), yet it is unknown if detection of sound at these distances has any effect on marine mammals or other marine species. Therefore, BOEM will consider the value of this measure at the site-specific NEPA and environmental analyses level, as well as any new information available at that time. BOEM may not apply this specific mitigation measure programmatically. These subsequent evaluations will also consider any potential aggregate effects from existing permitted surveys (if any).

4.4. Seismic Airgun Survey Protocol with Required Use of Passive Acoustic Monitoring

Under Alternative B, the use of PAM would be required as part of the Seismic Airgun Survey Protocol (rather than optional or "encouraged" as in Alternative A). The purpose would be to improve detection of marine mammals prior to and during seismic airgun surveys so that impacts can be avoided by shutting down or delaying startup of airgun arrays until the animals are outside the exclusion zone.

Use of PAM would be incorporated into the Seismic Airgun Survey Protocol. The proposed methodology for implementing a PAM survey will require BOEM approval. Survey and sighting reports must include, at a minimum, information specified in the protocol. A description of the PAM system, the software used, and the monitoring plan must be provided to BOEM prior to the survey. The following information must be provided after the survey: an assessment of the usefulness, effectiveness, and problems encountered with the use of PAM as a method of marine mammal detection.

4.5. HRG Survey Protocol with Required Use of Additional Monitoring Technologies During Nighttime Operations

Under Alternative B, if BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility operators must use effective monitoring technologies to monitor the exclusion zone. Possible tools include shipboard lighting, enhanced vision equipment, night-vision equipment and/or PAM. This would apply to surveys with sound sources operating at frequencies at and below 200 kHz during periods of reduced visibility or at night. This provision would apply year-round. **Section 3.2.2.6** discusses PAM monitoring methods and equipment. Approval requirements would be the same as stated in **Section 4.4**. The purpose would be to improve detection of marine mammals prior to and during HRG surveys so that impacts could be avoided by shutting down or delaying startup until the animals are outside the exclusion zone.

5. OTHER MITIGATION AND MONITORING MEASURES CONSIDERED BUT NOT SELECTED

5.1. EXPANDED EXCLUSION ZONE (160 dB) FOR SEISMIC AIRGUN SURVEYS

The Seismic Airgun Survey Protocol (**Attachment 1**) includes an exclusion zone based on the range at which marine mammals could be exposed to a received sound pressure level of 180 dB re 1 µPa, which is the current NMFS criterion for Level A harassment of cetaceans. BOEM also considered establishing an exclusion zone based on a received sound pressure level of 160 dB re 1 µPa, which is the current NMFS criterion for Level B harassment of cetaceans. The purpose of this larger zone would be to avoid most Level B harassment of marine mammals. Based on calculations in **Appendix D** as summarized in **Table C-9**, this zone could extend up to 15 km (9.3 mi) from a large airgun array (5,400 in^3) and up to 3 km (1.9 mi) from a small airgun array (90 in^3) depending on the geographic location and season modeled. The mean distances were 8.5 km (5.3 mi) for a large airgun array and 1.9 km (1.2 mi) for a small airgun array.

Table C-9

Estimated Ranges (m) for Level B Harassment of Cetaceans by Airgun Arrays based on the NMFS 160-dB Criterion

Equipment	Number of Scenarios Modeled	Statistics	Current NMFS Level B Criterion 160 dB re 1 µPa (rms)	
			R_{max}	$R_{95\%}$
5,400 in^3 Airgun Array	21	Min (m)	5,184	4,959
		Max (m)	15,305	9,122
		Mean (m)	**8,679**	**6,856**
90 in^3 Airgun Array	35	Min (m)	1,294	1,100
		Max (m)	3,056	2,519
		Mean (m)	**1,919**	**1,684**

R_{max} is the maximum received sound pressure level.
$R_{95\%}$ is the received level over 95 percent of the energy of the pulse.
Source: **Appendix D**.

BOEM has determined that it is not feasible to routinely require monitoring of a 160 dB exclusion zone for seismic surveys using shipboard PSOs. Effective monitoring of a larger, 160 dB exclusion zone may be feasible for some surveys if the 160 dB radius is small enough, but in many cases it would require a combination of techniques in addition to shipboard PSOs. These could include aerial monitoring using manned or unmanned aircraft. As explained in **Section 5.3**, in current practice those techniques have significant limitations and disadvantages, given the geographic scope of the proposed action. BOEM has determined that it is not currently feasible to require a combination of shipboard and aerial surveys on a routine basis to effectively monitor a 160 dB exclusion zone.

Although 160 dB is the current criterion for Level B harassment of cetaceans by impulsive sources, there is much variability and ongoing research about the levels of received sound that can cause behavioral responses in marine mammals, as well as the biological significance of those responses (National Research Council, 2005; Southall et al., 2007; Ellison et al., 2011). Also, although the exclusion zone included in the proposed action would not prevent Level B harassment of marine mammals, other measures such as the time-area closure for NARWs (**Section 3.2.1**) would help to reduce the risk of those impacts.

5.2. ACTIVE ACOUSTIC MONITORING

Active acoustic monitoring (AAM) is a method of determining the presence of marine mammals that use sonar. The AAM can potentially detect non-vocalizing marine mammals, whereas PAM can detect only vocalizing animals. However, there a number of significant issues with AAM, including that AAM systems transmit acoustic energy that may disturb marine mammals by influencing their behavior, and a separate permit may be necessary for its use (Bingham, 2011).

Active sonar produces a short sound pulse (energy) from a high power source (transducer) that travels through the water, reflects off objects, and travels back to a hydrophone receiver. The time it takes for the sound to travel to and from the target is easily computed from the difference in time that the source "ping" was sent and the time the reflected returning sound is measured. This travel time multiplied by the speed of sound in water divided by two is the approximate distance to the target. Bearing and range from the ship (or some other platform) can be converted to an absolute position on a map, given the ship position and some simple geometry. This is used, for example, to map seabed features, or to discriminate among different objects on the seafloor and in the water.

Potential problems with the use of AAM include standard sonar problems of reverberations and propagation in high-clutter shallow water environments, false alarms, species classification, methods of deployment, and cost (Stein, 2011). In addition, while AAM can identify animals swimming at right angle to the sound source, it is difficult to detect animals that are directly facing toward or away from the AAM sound source. It is also difficult to detect animals swimming at depth or animals swimming close to the surface with AAM. Another operational challenge with AAM is that it does not penetrate beneath thermoclines or haloclines, so animals swimming below them would also not be detected by AAM systems that are hull-mounted. In these situations, towed AAM systems would be required. In addition, AAM is not very useful in very shallow water, especially in rough seas. Currently the use of AAM technology for mitigation and monitoring of marine mammals during offshore industry activities is less advanced than either fixed or towed PAM systems. However, recent testing of the technology indicates that it can be useful in certain circumstances (Bingham, 2011).

There have also been some studies performed using high frequency fisheries sonar for locating marine mammals, killer whales in Norway in particular (Knudsen et al., 2007). These fisheries sonars operate at 20-30 kHz, with some operating at frequencies above 100 kHz. Most whales can detect frequencies in the 20-30 kHz range, but only smaller whales and dolphins can detect frequencies above 100 kHz (Knudsen et al., 2007). One study compared results using two sonars with different operating ranges, one operated at 20-30 kHz and the other operated at 110-122 kHz, and determined that the lower frequency sonar detected killer whales up to at least a 1,500-m (4,921-ft) range, whereas the higher frequency sonar did not give reliable detection at ranges greater than 400 m (1,312 ft) (Knudsen et al., 2007). However, most fish-finding sonars operate at around 30 kHz and would be good for detecting whales out to about 2 km (1.2 mi) and dolphins out to about 1 km (0.6 mi), but due to the frequency they also would be audible to all the small marine mammals and some of the larger whales. If the whale detection sonar is operated at frequencies that the animals might hear, the detection sonar also would need to be assessed as a source of disturbance, and the signal processing for species discrimination and potential cumulative effects would need to be addressed.

BOEM has determined that it is not currently feasible to require AAM on a routine basis because the development of an effective active sonar system will require consideration of the behavioral differences among various types of marine mammals. It may be difficult to develop a single approach that will work well with all species.

5.3. AERIAL SURVEYS

As a mitigation measure, aerial surveys with PSOs provide the ability to observe and monitor large exclusion zones that cannot be adequately monitored from a vessel. As a mitigation measure, aerial surveys can monitor seismic exclusion zones, and if marine mammals are seen from the aircraft within the appropriate exclusion zone around the seismic source vessel or heading toward that zone, the aerial PSO could notify the seismic vessel on-board personnel in order for the sighting to be monitored, tracked, and appropriate mitigation measures initiated as necessary.

Aerial surveys are performed by two primary observers sitting at bubble windows on opposite sides of a small aircraft flying typically at 305-457 m (1,000-1,500 ft) above the surface. The observers search the sea surface visible through the bubble windows with the unaided eye. When a marine mammal is sighted, the observers record the species, number of individuals, size/sex/and age class when possible, activity, heading, and swimming speed category (if traveling). In addition, the observer will recorded the time, sightability (subjectively classified as excellent, good, moderately impaired, seriously impaired, or impossible), sea conditions, and sun glare (none, little, moderate, or severe) at intervals along the transect and at the end of each transect.

Aerial monitoring programs have significant limitations. Practically, they are limited to nearshore waters where there is an airport nearby to allow for adequate survey duration to allow for less transit time to and from the survey vessel location. They also require additional logistical coordination, are sensitive to weather-related interruptions, and carry safety risks to survey personnel. For example, in May 2008 a small aircraft conducting marine mammal surveys for a renewable energy site offshore the Mid-Atlantic coast crashed in New Jersey, killing two people and injuring two others (Spoto, 2008).

Because of the significant limitations for manned aerial surveys in offshore waters due to the long transit times, unmanned aircraft systems (UASs) are a possibility for future use. The UASs have been emerging as a potential monitoring resource for detecting the presence of marine mammals during research as well as to meet mitigation and monitoring requirements during human activities, such as military preparedness exercises (e.g., sonar signals), seismic airgun surveys, and geophysical research. A number of organizations, such as members of the offshore oil and gas industry, NMFS, BOEM, and the U.S. Navy, have been investigating the use of these surveys for a number of reasons, including but not limited to (1) unmanned surveys address safety concerns of putting human pilots and observers in potentially dangerous offshore areas; (2) unmanned aircraft can generally fly up to 20 hr, which is longer than manned surveys; (3) unmanned surveys can provide video data, even with high definition video cameras, which can be carefully reviewed post-flight rather than relying simply on visual observations during the flight; (4) unmanned surveys may provide for more frequent survey effort since securing personnel for flights is not necessary; and (5) aircraft can be launched from seismic ships. Models currently under production, such as the ScanEagle which is used for military and other applications, show potential for use in conducting marine mammal surveys. Preliminary scientific testing has been conducted by NMFS scientists at the National Marine Mammal Laboratory (NMML). However, NMFS has indicated that more testing is necessary before NMFS will give approval to the use of UASs as a mitigation or monitoring tool.

The current process to gain approval to operate an UAS requires the military and non-military (Federal, State, and local government entities, academic institutions, and private entities) to request the FAA to issue a Certificate of Waiver or Authorization (COA) or a special airworthiness certificate. The Federal Aviation Administration (FAA) evaluates these applications on a case-by-case basis. Advances in technology have led to increased demand for UASs resulting in a rise in number of applications which has slowed the review process. In February 2012, Congress enacted the FAA Modernization and Reform Act (P.L. 112-95), which calls for the FAA to accelerate the integration of unmanned aircraft into the national airspace system by 2015. FAA authority extends to airspace over territorial waters from the U.S. coast to 12 miles offshore of the U.S. coast. NMFS and BOEM are following the ongoing efforts to streamline the FAA approval process. Should the FAA grant UAS approval for use in offshore waters of the Atlantic Ocean, NMFS (and BOEM) would then make a determination (informed by the results of additional UAS testing) on whether UASs are a practical tool to detect marine mammals in offshore waters in support of seismic survey monitoring programs.

5.4. AUTONOMOUS UNDERWATER VEHICLES

Autonomous underwater vehicles (AUVs) can be used to aid in PAM. The AUVs are capable of monitoring at vertical and horizontal scales similar to the diving and foraging movements of the whales themselves (Moore et al., 2007). Another advantage of deploying PAM from AUVs or towed platforms is that it provides a good means of detecting vocalizing marine mammals that is less affected by sea state, visibility, or presence of a survey vessel (USDOC, NOAA, 2007).

The Office of Naval Research is sponsoring studies involving five different AUVs using PAM on gliders. However, the results of these studies are not available at this time. One issue with using PAM on AUVs is that they are already slow vessels, and attaching a towed array system creates additional drag that slows them down further. BOEM has determined that it is not currently feasible to use AUVs for monitoring seismic airgun surveys on a routine basis.

5.5. Equipment Power Down

An equipment power down involves decreasing the number of acoustic sources in use such that the radii of the 190 and 180 dB re 1 μPa (rms) zones are decreased to the extent that observed marine mammals or sea turtles are not in the applicable exclusion zone. A power down may also occur when the vessel is moving from one seismic line to another. During a power down, only one acoustic source is operated. The continued operation of one acoustic source is intended to:

a. alert marine mammals or sea turtles to the presence of the seismic vessel in the area, and

b. retain the option of initiating a ramp up to full array under poor visibility conditions.

In contrast, a shutdown is when all acoustic source activity is suspended. In a power down, if a marine mammal or sea turtle is detected outside the exclusion zone but is likely to enter the exclusion zone, and if the vessel's speed and/or course cannot be changed to avoid having the mammal or sea turtle enter the exclusion zone, the acoustic sources may (as an alternative to a complete shutdown) be powered down before the mammal or sea turtle is within the exclusion zone. Likewise, if a mammal is already within the exclusion zone when first detected, the acoustic sources are powered down immediately if this is a reasonable alternative to a complete shutdown. During a power down of the array, the number of acoustic sources operating will be reduced to a single acoustic source. The small acoustic power down sources are measured during acoustic sound source measurements conducted at the start of seismic operations. If a marine mammal or sea turtle is detected within or near the applicable exclusion zone around the power down source, it is deactivated resulting in a complete shutdown.

Following a power down, operation of the full acoustic source array does not resume until all marine mammals and/or sea turtles have cleared the exclusion zone. The animal is considered to have cleared the exclusion zone if it:

- is visually observed to have left the exclusion zone, or
- has not been seen within the zone for 15 min in the case of pinnipeds (excluding walruses) or small odontocetes, or
- has not been seen within the zone for 30 min in the case of mysticetes or large odontocetes.

The operating acoustic source(s) is shut down completely if a marine mammal or sea turtle approaches or enters the then-applicable exclusion zone and a power down is not practical or adequate to reduce exposure to less than 190 or 180 dB re 1 μPa (rms). The operating acoustic sources(s) are also shut down completely if a marine mammal or sea turtle approaches or enters the estimated exclusion zone around the reduced source that is used during a power down. Acoustic source activity does not resume until the marine mammal or sea turtle has cleared the exclusion zone. The animal is considered to have cleared the exclusion zone if it is visually observed to have left the exclusion zone, or if it has not been seen within the zone for 15 min (pinnipeds and small odontocetes) or 30 min (mysticetes and large odontocetes). Ramp up procedures will be followed during resumption of full seismic operations after a shutdown of the acoustic source array.

During the November 2012 BOEM and NMFS Monitoring and Mitigation Workshop, members of industry indicated that a power down may not actually be useful and the end result may be higher and extended levels of sound due to industry's need to circle back and re-shoot that line to prevent gaps in their data. Instead, BOEM and NMFS are requiring a standard shutdown procedure. This mitigation measure, though, may be managed adaptively.

6. NON-AIRGUN ALTERNATIVES AND RELATED MEASURES CONSIDERED BUT NOT SELECTED

The impulsive airgun has been under scrutiny as a sound source for seismic exploration due to the potential impacts of underwater noise on marine life (Weilgart, 2010). Alternative acoustic source technologies generally put the same level of useable energy into the water as airguns, but over a longer period of time with a resulting lower peak sound level, i.e., they are quieter. One alternative, the low frequency passive seismic method, relies on naturally produced sounds and does not introduce any sound into the environment. These alternative acoustic sources are in various stages of development, and none of the systems with the potential to replace airguns as a seismic source are currently commercially available. However, they are discussed in detail in the technical write-up below along with technology-based mitigation measures that attempt to decrease the noise level of airguns.

In February 2013, BOEM hosted a Workshop on "Quieting Technologies for Reducing Noise during Seismic Surveying and Pile Driving." The goals of the Workshop included review and evaluation of recent developments; identification of system and site-specific requirements for operation of new technologies; evaluation of data quality and cost-effectiveness of new technologies; examination of potential changes in environmental impacts from new technologies; and identification of which technologies, if any, provide the most promise.

6.1. Marine Vibroseis (Vibrators)

A seismic vibrator, commonly known as vibroseis, propagates energy into the Earth over an extended period of time as opposed to the near-instantaneous energy provided by airguns (LGL Limited environmental research associates and Marine Acoustics Inc., 2011; OGP, 2011). Vibroseis was developed by scientists at the Continental Oil Company (Conoco) during the 1950s and was a trademark name until the company's patent lapsed.

Vibroseis is used widely for seismic surveys on land, but so far has seen relatively limited use in the marine environment (OGP, 2011). According to OGP (2011), "the geophysical concept of marine vibrators is understood and offers great promise, but further investment and development will be required in order to improve operational efficiency and data imaging capability that is comparable with airgun source arrays." However, marine vibroseis has been cited as "arguably the most likely technology to eventually replace airguns" (Weilgart, 2012a). Two types of marine vibrators have been developed: hydraulic and electromechanical. Hydraulic and electromechanical marine vibrators can be towed in the same configuration as airgun arrays or operated in a stationary mode much like land vibrators; marine vibrator's may have fewer elements and better source characteristics, and will have lower source signal rise times, lower peak pressures, and less energy above 100 Hz (Thorson et al., 2005).

The Marine Vibroseis Joint Industry Program, sponsored by ExxonMobil, Shell, and Total, is pursuing development of new marine vibroseis technologies in a phased approach. Phase I, which was completed in September 2009, consisted of scoping, casting a wide net, outside of oil/gas industry to identify a broad range of technologies, and developing specifications. Phase II, which was completed in March 2013, consisted of contacting vendors, receiving and evaluating proposals, and selecting 3 proposals to fund and move forward. Phase III, which is underway, is pursuing 3 different technologies and expects that the first prototype will be tested and evaluated in 18 months. Phase IV will be to build and field test commercial systems from the technologies tested and evaluated in Phase III. Phase IV is anticipated to be complete in 2016 (Rosenbladt et al., 2013).

Marine Vibroseis is considered currently as the most promising alternative for airguns in select settings and applications (i.e., shallow water, sensitive habitat, near biological resources). Nonetheless, vibroseis will not be a wholesale replacement for airguns.

6.1.1. Hydraulic

In 1981, Industrial Vehicles International, Inc. (IVI) signed an agreement with Britoil to develop a marine vibrator seismic source. In 1983, after scrapping the first design, IVI began developing a new system with the goal of producing a marine source able to emit a broad band, high amplitude, modulating frequency output. In 1985, the first commercial system was offered (IVI, 2003). The developed system consists of a marine vibrator, vibrator controller, and a power unit. The marine vibrator contains a piston within a housing with power supplied to the electrical, pneumatic and hydraulic systems by the power unit. An alternator, air compressor, and two pressure-driven hydraulic pumps are driven by an air-cooled diesel engine. The source is capable of generating modulated frequencies between 10 and 250 Hz and can be used in water depths as shallow as 1 m (3 ft). Signals are generated by conventional land vibrator controllers (IVI, 2010).

The system has been tested in various environments from transition zones to deepwater. Acoustic performance tests conducted at the Seneca Lake Facility of the Naval Underwater Systems Center in 1988 evaluated the system and determined that the marine vibrator was deficient in the low frequencies (Johnston, 1989; Walker et al., 1996). A comparison of marine vibrator, dynamite, and airgun sources in southern Louisiana concluded that the marine vibrator was a viable source for environmentally sensitive areas (Potter et al., 1997; Smith and Jenkerson, 1998). In transition zones, when coupled with the seafloor, marine vibrators operate like a land vibrator (Christensen, 1989). The best performance is on a seafloor which distributes the vibrator's forces.

Initial deepwater tests were conducted in the Gulf of Mexico by Geco-Prakla using a vibrator with an energy output approximately equivalent to a 1,000-in^3 airgun. Despite limitations of low frequency energy, good definition of reflectors down to 3 s indicated that the system was viable (Haldorsen et al., 1985). In 1996, a commercial field test comparing a six-marine-vibrator array with a single 4,258 in^3 airgun was undertaken in the North Sea by Geco-Prakla with the objectives of evaluating cost, reliability, production rate and quality of the geophysical data. After 2 weeks of data collection, a comparison between the marine vibrator and the airgun data indicated that the marine vibrator data contained more frequency content above 30 Hz and less frequency content below 10 Hz than the airgun data, but overall the data were comparable. Marine vibrator production rates were slightly lower than those of the airgun, but by the end of the survey, the technical downtime of the marine vibrator was similar to the airgun (Johnson et al., 1997).

Geco-Prakla, a subsidiary of Schlumberger, operated the marine vibrator program, conducting surveys and tests until 2000 when the exclusive-use agreement between IVI and Schlumberger expired (Bird, 2003). Industrial Vehicles International, Inc. continued to further develop the system into the early 2000's, but they are no longer actively marketing the product because there is no client base for the system. The significant expense to retrofit the marine exploration companies' ships to support marine vibrators is not offset by reduced operation costs or better data quality. Industrial Vehicles International, Inc. presently has marine vibrator systems that could be used for seismic data collection, but they would require renovation prior to deployment, which could take 3 months to a year (E. Christensen, Vice President IVI, pers. comm. with J. Lage, BOEM, 2010).

Stephen Chelminski, the inventor of the airgun and primary founder of Bolt Technology Corporation, has also developed a design for a marine vibrator prototype that he calls a "seavibe" (Weilgart, 2012a). It is 53 cm in diameter, 3.5 to 6 m in length, streamlined, and towable at any speed or depth. The signal can be pulse-coded or a swept signal or even a mix, without any high frequencies (5-100 Hz, although frequencies can range from 2 to 200 Hz). The signal duration can be changed in real-time. According to Weilgart (2012a), the prototype system is reliable, more efficient than airguns, and requires less horsepower to tow than airgun arrays. A significant amount of the engineering and design for the Chelminski Research Marine Vibratory Sound Source (the Source) has been completed on the marine vibrator prototype, patents have been applied for, but assembly and testing have not begun (Chelminski, 2013).

6.1.2. Electric

Petroleum Geo-Services (PGS) began developing an electro-mechanical marine vibrator in the late 1990's. The original system consists of two transducers: the lower frequency (6-20 Hz) "Subtone" source and the higher frequency (20-100 Hz) "Triton" source (Tenghamn, 2005, 2006). Each vibrator is composed of a flextensional shell that surrounds an electrical coil, a magnetic circuit and a spring element. The sound in the water column is generated by a current in the coil, which causes the spring elements and shell to vibrate. Mechanical resonances from the shell and spring elements allow very efficient, high power generation (Tenghamn, 2005, 2006; Spence et al., 2007). The source tow-depth, generally between 5 and 25 m (16 and 82 ft) below the sea surface, is selected depending on the frequency and enhancement from the surface reflection which, to a certain degree, directs the acoustic signal downwards.

An electrical marine vibrator offers several advantages over hydraulic vibrators (Tenghamn, 2006, 2010). The reduction of the overall sound level and, specifically, the frequencies above 100 Hz that are beyond the useful seismic range is a major advantage of the system. Another is the reduction of acoustic power in comparison with conventional seismic sources, which occurs because the net source energy is spread over a long period of time (Tenghamn, 2005, 2006). Because highly controllable and repeatable signals can be produced, pseudo random noise (PRN) sequences can be generated, which make it possible to reduce the peak power even more (the PRN sequences not only spread the source energy over time, but also spread the frequencies over time). Finally, there is no need for heavy equipment and hydraulic systems that can cause hydraulic oil spills. As the electrical vibrator requires only an electrical power supply, it can be easily transported to different vessels.

This system was compared to a 760 in^3 airgun along a 2D line in shallow water. A comparison of the data demonstrates that the marine vibrator equals the penetration of the airgun down to 5.5 s two-way travel time while emitting less acoustic energy into the water. A second test comparing dynamite to the vibrators was run in the transition zone (1.2-1.8 m [4-6 ft] of water). The transducers were mounted in a frame that was placed on the seabed. The vibrators lost the low frequency component due to attenuation of the signal, limiting the depth of penetration to approximately 2 s two-way travel time. However, in the shallower sections imaged by the vibrator, the two sources compared favorably (Tenghamn, 2005, 2006). Most of the trials have been conducted in shallow water (<100 m [<328 ft]); deeper water tests need to be run to determine performance depth range of the system (Tenghamn, 2010).

During the early period of development, the system proved the concept that it worked as a source for seismic data. However, unreliability prevented it from becoming a commercial system. Petroleum Geo-Services spent 2006 and 2007 conducting a feasibility study to improve reliability and testing a newly developed prototype. New sources have since then been tested for reliability and acoustic performance during 2008 and 2009 (Rune Tenghamn, VP Innovation and Business Development, PGS, pers. comm. to K. Olsen 6/4/13).

In 2007, PGS took over the commercialization and used this system in onshore and shallow water regions. In 2010, Geokinetics purchased the onshore Division of PGS which included the onshore and shallow water marine vibroseis system and have developed a more robust vibrator to withstand the rigors of seismic operations in their commercialization of the marine vibrator out to 200 m. PGS continues to own the intellectual property for the marine vibrator development in use in deep water (>200 m). This design has replaced the electromagnetic voice coil drivers with more reliable drivers and has made refinements of the springs and pressure equalization systems, as well as implementing a feedback control system that can drive the vibrator. This system has been through calibration tests in 2011 and was tested in both vertical and horizontal positions. Currently, the design is awaiting sea trials to test for data quality, field ability, and endurance. Once completed, commercial deployment could potentially begin by the end of the 2013.

The Geokinetics marine vibrator is a collaborative project with PGS and is a significant design departure from previous marine vibrator units. The proof of concept was demonstrated offshore Texas in 1999. It follows specific design specifications of a frequency range between 6 to 100 Hz and an output level of approximately 2 bar meters peak-to-peak. The advantages of the Geokinetics marine vibrator include potentially lower environmental impacts with lower amplitude levels, capability of specialized sweeps using pseudo-noise technology, and no in-water hydraulics with a completely electric-mechanical system for drivers and controls. With the efficient flextensional shell design, which minimizes water flow and maximizes pressure wave generation, this design is more efficient at generating low frequencies. Another advantage of the Geokinetics system is the two intentional resonances within the seismic bandwidth making it easier to generate the desired frequency band. The two resonant frequencies show up as peaks in amplitude spectrum. The subtones have a resonant frequency of 8 and 24 Hz. The tritons have a resonant frequency of 28 and 80 Hz. If the two spectrums are combined, there is an overall high amplitude spectrum completely inside the useable bandwidth for seismic activity.

Currently the Geokinetics marine vibrator is the one closest to being ready for commercial use. For the most part other alternative impulse sources are currently experimental. Information collected to date indicate that marine vibroseis is less environmentally damaging than airguns, but this evaluation needs to be expanded to a full EA to accurately evaluate the impacts and determine if there are tradeoffs in the types of impacts among the different technologies. Special attention needs to be given to potential unintended consequence of the control of phase spectrum of marine vibroseis, which allows for the proliferation of a number of sources over a large area all being fired at the same time. This approach effectively increases the size of the area impacted; and a PRN sweep of marine vibrators in this configuration may result in marine mammal masking effects at higher frequencies than currently employed, with unknown consequences (CSA Ocean Sciences Inc., 2013).

6.2. LOW-FREQUENCY ACOUSTIC SOURCE (PATENTED)

Originally designed as a ship sound simulator for the Norwegian navy, the low level acoustic combustion source (LACS) is being promoted as an alternative source for seismic acquisition (Weilgart, 2010). The LACS system is a combustion engine with a cylinder, spark plug, two pistons, two lids, and a shock absorber. It creates an acoustic pulse when two pistons push lids vertically in opposite directions; one wave reflects from the sea surface and combines with the downward moving wave. There is no bubble noise from this system as all air is vented and released at the surface, not into the underwater environment. The absence of bubble noise allows the system to produce long sequences of acoustic pulses at a rate of 11 shots per second; this allows the signal energy to be built up in time with a lower amount of energy put into the water (Askeland et al., 2007, 2009). The system design also controls the output signal waveform, which can reduce the amount of non-seismic (>100 Hz) frequencies produced (Spence et al., 2007). The transmitted pulses are recorded by a near-field hydrophone and seafloor and sediment reflections are recorded by a far-field streamer (Askeland et al., 2007, 2009).

Two LACS systems are being offered commercially. The LACS 4A has a diameter of 400 mm (15.7 in), a height of 600 mm (24 in), and a weight of approximately 100 kg (220 lb) in air. Pulse peak-peak pressure is 218 dB re 1µPa @ 1 m. Field test results of the LACS 4A system demonstrate that the system is capable of accurately imaging shallow sediments (~230 m [755 ft]) within a fjord environment (Askeland et al., 2008, 2009). This system is suitable for shallow penetration towed-streamer seismic surveys or vertical seismic profiling (Askeland et al., 2008).

The second system, the LACS 8A, theoretically has the potential to compete with a conventional deep penetration airgun seismic array. The LACS 8A system has pulse peak-peak pressure of 3 Bar meter or 230 dB re 1µPa @ 1 m. The weight is 400 kg (880 lb), and the diameter is 800 mm (31.5 in).). Several LACS units may be operated together to provide an increased pulse pressure (Bjørge Naxys AS, 2010). This system currently does not exist, and the project is presently on hold. It would take at least 18 months to build and field test one of these systems if money came available to do so (J. Abrahamsen, Managing Director Bjørge Naxys, pers. comm. to J. Lage, BOEM, 2010).

The LACS system may prove to be a suitable substitute. but it currently exists only as a design and there is no known interest in further development of this system.

6.3. DEEP-TOWED ACOUSTICS/GEOPHYSICS SYSTEM

The Navy developed a deep-towed acoustics/geophysics system (DTAGS) to better characterize the geoacoustic properties of abyssal plain and other deepwater sediments. The system was tested and modified in the early 1990's and used in various locations around the world until it was lost at sea in 1997 (Gettrust et al., 1991; Wood et al., 2003).

The second generation DTAGS is based on the original design but with more modern electronics. It uses the same Helmholtz resonator source consisting of five concentric piezoelectric ceramic rings sealed in an oil-filled rubber sleeve to generate a broadband signal greater than 2 octaves. The optimum frequency performance range is between 220 and 1,000 Hz with a source level of 200 dB re 1 µPa @ 1 m, which is a major improvement over the original DTAGS. The source is extremely flexible, allowing for changes in waveform and decrease in sound level to produce a source amplitude, waveform, and frequency to suit specific requirements (Wood et al., 2003; Wood, 2010).

The DTAGS is towed behind a survey vessel usually at a level of 100 m (328 ft) above the seafloor and a vessel speed of 2 kn (3.7 km/hr); it can operate at full ocean depths (6,000 m [19,685 ft]). A 450-m (1,476-ft), 48-channel streamer array is towed behind the source to record the reflected signals. Seismic signals are digitized at each hydrophone and recorded in SEG Y format in a top-side unit (Wood et al., 2003; Wood, 2010). The DTAGS can also be configured with an aluminum landing plate, which transmits the acoustic energy directly into the seafloor. With this configuration, vertical bottom founded hydrophone arrays are used to receive reflections (Breland, 2010).

Proximity of the acoustic source to the seafloor is an advantage of the DTAGS. The system has a limit of 1 km (0.6 mi) penetration in most marine sediments (Wood et al., 2003). It has been used very successfully to map out gas hydrates in the Gulf of Mexico (Wood et al., 2008), Canadian Pacific (Wood and Gettrust, 2000; Wood et al., 2002), and Blake Ridge (Wood and Gettrust, 2000).

There is only one DTAGS in existence at this time. While it has imaged shallow sediments and gas hydrate environments extremely well, the current tool design could not replace a deep penetration airgun array for oil and gas exploration at this time; DTAGS was not designed for this purpose. However, there is no physical limitation to designing a resonant cavity source to simulate the frequency band of airguns.

According to Weilgart (2012b), DTAGS was tested in the Gulf of Mexico in the summer of 2011 and will undergo another trial off the coast of Oregon in September 2012. Though the frequency range of DTAGS is currently 200 to 4,000 Hz, it may be extended down to about 100 Hz (Warren Wood, pers. comm. cited in Weilgart, 2012b).

6.4. Low-Frequency Passive Seismic Methods for Exploration

Low-frequency passive seismic methods utilize microseisms, which are faint earth tremors caused by the natural sounds of the earth, to image the subsurface. A typical survey consists of highly sensitive receivers (usually broadband seismometers) placed in the area of interest to collect data over a period of time. Upon completion of the survey, the data are analyzed and filtered to remove all non-natural sounds, which is most efficiently completed using an automated process (Hanssen and Bussat, 2008).

All of the current methods use one of following three sources of natural sounds: natural seismicity, ocean waves, or microseism surface waves.

Natural seismicity uses the earth's own movements as a source of energy. Two techniques have been developed to utilize this energy source.

Daylight imaging (DLI) uses the local seismicity of an area to produce reflection seismic profiles, similar to those recorded in active seismic surveys (Claerbout, 1968). As in active reflection seismic operations, geophones are deployed; the target can be imaged using a regularly spaced 2D line geometry (Hohl and Mateeva, 2006; Draganov et al., 2009). The seismicity of the area, geologic complexity, and receiver sensitivity control the record length. The DLI can augment active seismic data, where it is difficult to collect data.

Local earthquake tomography (LET) also uses local seismicity of a region to map on the reservoir scale (Kapotas et al., 2003). However, it is used to calculate the velocity structure of the subsurface in 3D by analyzing each earthquake on multiple receivers and generating ray paths instead of cross-correlating the recorded signals. This method requires a longer period of data collection than the other methods to produce results.

Ocean waves are used as a sound source for the sea floor compliance technique. The method requires that ocean bottom seismometer (OBS) stations with highly-sensitive, broadband seismometers and differential or absolute pressure gauges be installed in water several hundred meters deep. In the right setting, a coarse one-dimensional (1D) S-wave velocity model of the subsurface down to the Moho can be generated using the measured water pressure and vertical movement of the seabed caused by large passing ocean waves (Crawford and Singh, 2008).

Ambient-noise (surface-wave) tomography [AN(SW)T] uses low frequency (between 0.1 and 1 Hz) ambient noise records to estimate shear wave velocities and structural information about the earth. The ambient noise used consists mainly of microseism surface waves (Rayleigh and Love waves) (Bussat and Kugler, 2009). This technique requires the use of broadband seismometers to record the low frequency surface waves, which can penetrate to depths of several kilometers (Bensen et al., 2007, 2008). Because the marine environment produces abundant, high-energy surface waves, a few hours or days of acquisition can produce good quality data. The AN(SW)T can be used in areas where seismic data are difficult to collect or in environmentally sensitive areas. While this technology is new and still in need of further testing, the lateral resolution at several kilometer depths may reach a few hundred meters, and the resolution may be better than gravimetric or magnetic data, which is promising for oil and gas exploration (Bussat and Kugler, 2009).

Surface-wave amplitudes (SWAs) is a 1D method that images the geological structure of the subsurface by analyzing passive acoustic data that have not been geophysically processed. The transformation of incoming micro-seismic surface waves, scattered at vertical discontinuities, into body waves may produce these data, but the process is not well understood (Gorbatikov et al., 2008).

Low-frequency spectroscopy (LFS), also known as low frequency passive seismic (LFPS) or hydrocarbon microtremor analysis (HyMAS), tests for an indication of subsurface hydrocarbon accumulation using spectral signatures gathered from the ambient seismic wave field recorded by broadband seismometers. The cause of the spectral anomalies, often called direct hydrocarbon indicators, is presently unknown, but the following reasons have been proposed: standing wave resonance, selective attenuation, resonant amplification (Graf et al., 2007), and pore fluid oscillations (Frehner et al., 2006; Holzner et al., 2009). Energy anomalies in the frequency range between 1 and 6 Hz have been observed in known hydrocarbon areas including Mexico (Saenger et al., 2009), Abu Dhabi (Birkelo et al., 2010), Brazil, Austria (Graf et al., 2007), and southern Asia (West et al., 2010). However, this methodology is highly dependent on the ability to process out all anthropogenic noise and topography (Hanssen and Bussat, 2008). This method is still in the early stage of development and has not been confirmed in the field during all studies (Ali et al., 2007; Al-Faraj, 2007).

The most successful use of low frequency passive micro-seismic data has been on land, where it is easier to isolate the extraneous noise from the natural signal. The technique is also promising in the marine environment. To ensure success of a marine survey: (1) it is imperative that the recording instruments are in proper contact with the substrate (the natural signal may not be accurately recorded in unconsolidated material) and (2) the increase in both anthropogenic and naturally produced noise in the marine environment is correctly filtered so that it does not mask the signal of interest.

Passive seismic surveys cannot replace active seismic acquisition. However, passive acoustic data have the potential to enhance oil recovery at a better resolution than magnetic or gravimetric methods (Bussat and Kugler, 2009), especially in areas that are environmentally sensitive or where active seismic operations are difficult.

6.5. Low-Impact Seismic Array

Nedwell (2010) describes the concept of a low impact seismic array (LISA) based on the use of inexpensive but powerful and rugged electromagnetic projectors to replace airgun arrays. The prospective benefit was that since the signal could be well controlled, both in frequency content and in the direction in which the sound propagated, the possibility existed of undertaking seismic surveys in environmentally sensitive areas with little or no collateral environmental impact.

The LISA project embodies the idea of using a large array of small but powerful electromagnetic projectors to replace airgun arrays. Initial measurements were made on a small (n=4) array of existing electromagnetic transducers. It was found that a source level of about 142 dB re 1 μPa per volt @ 1 m was achieved, at a peak frequency of 25 Hz. The operating frequency could be reduced to below 10 Hz with reasonable modifications, allowing use of an array for seismic exploration. The results indicate that it would be possible to achieve an array source level of about 223 dB re 1 μPa @ 1 m, which is adequate for seismic surveying.

6.6. Fiber Optic Receivers

Short of replacing seismic airguns, improvements in fiber optic sensing and telemetering could allow use of smaller airguns and airgun arrays in the future (Nash and Strudley, 2010). Fiber optic receivers are receivers that incorporate optical fibers to transmit the received acoustic signal as light. They are most frequently used in the petroleum industry for seismic permanent reservoir monitoring, a four-dimensional (4D) reservoir evaluation application. The optical receivers are permanently placed on the seafloor, ensuring consistency and repeatability of the 4D surveys, better signal to noise ratios, and quality of subsequently collected data. Fiber optic systems are not new. Fiber optical components have been used by the military for years in similar applications for antisubmarine warfare and area surveillance, and they have proven to be highly reliable.

Fiber optic receivers are more sensitive than standard receivers, which allows for smaller airgun arrays to be used. While these receivers offer a benefit to the environment through a decrease in airgun noise, this technology is not presently available for towed-streamer surveys.

Fiber optic receivers typically are used in areas with large-scale oil and gas production requiring 4D monitoring. They would not be expected to be used in the Atlantic OCS during the time period of the Programmatic EIS because there are no active leases and only very limited exploration activities could occur between 2018 and 2020 if leasing is allowed (**Chapter 3** of the Programmatic EIS).

6.7. AIRGUN MODIFICATIONS TO LESSEN IMPACTS

In addition to alternative methods for seismic data collection, industry and the public sector have actively investigated the use of technology-based mitigation measures to lessen the impacts of airguns in the water.

6.7.1. Airgun Silencers

One such measure, an airgun silencer, which has acoustically absorptive foam rubber on metal plates mounted radially around the airgun, has demonstrated 0-6 dB reductions at frequencies above and 0-3 dB reductions below 700 Hz. This system has been tested only on low pressure airguns and is not a viable mitigation tool because it needs to be replaced after 100 shots (Spence et al., 2007).

Spence et al. (2007) characterized the airgun silencer as a "proof-of-concept" that would require further development to become a commercial product. During a workshop conducted for the Spence et al. (2007) report, participants suggested that placing the absorbent material farther from the airgun may increase the life of the silencer and allow it to be used for larger airguns and arrays. However, a later review by Spence (2009) characterized the airgun silencer treatment as "impractical" for the same reasons noted above.

6.7.2. Bubble Curtains

Bubble curtains generally consist of a rubber hose or metal pipe with holes to allow air passage and a connector hose attached to an air compressor. They have successfully been tested and used in conjunction with pile driving and at construction sites to frighten away fishes and decrease the noise level emitted into the surrounding water (Würsig et al., 2000; Sexton, 2007; Reyff, 2009). They have also been used as stand-alone units or with light and sound to deflect fishes away from dams or keep them out of specific areas (Pegg, 2005; Weiser, 2010).

The use of bubbles as a mitigation for seismic noise has also been pursued. During an initial test of the concept, the sound source was flanked by two bubble screens; it demonstrated that bubble curtains were capable of attenuating seismic energy up to 28 dB at 80 Hz while stationary in a lake. This two-bubble curtain configuration was field tested from a moving vessel in Venezuela and Aruba where a 12-dB suppression of low frequency sound and a decrease in the sound level of laterally projecting sound was documented (Sixma, 1996; Sixma and Stubbs, 1998). A different study in the Gulf of Mexico tested an "acoustic blanket" of bubbles as a method to suppress multiple reflections in the seismic data. The results of the acoustic blanket study determined that suppression of multiples was not practical using the current technology. However, the acoustic blanket measurably suppressed tube waves in boreholes and has the capability of blocking out thruster noises from a laying vessel during an ocean bottom cable survey, which would allow closer proximity of the shooting vessel and increase productivity (Ross et al., 2004, 2005).

A recent study "Methods to Reduce Lateral Noise Propagation from Seismic Exploration Vessels" was conducted by Stress Engineering Services Inc. under BOEM's Technology Assessment & Research Program (Ayers et al., 2009, 2010). The first phase of the project was spent researching, developing concepts for noise reduction, and evaluating the following three concepts: (1) an air bubble curtain; (2) focusing arrays to create a narrower footprint; and (3) decreasing noise by redesigning airguns. The air bubble curtain was selected as the most promising alternative, which led to more refined studies the second year (Ayers et al., 2009). A rigorous 3D acoustic analysis of the preferred bubble curtain design, including shallow-water seafloor effects and sound attenuation within the bubble curtain, was conducted during the second phase of the study. Results of the model indicated that the bubble curtains performed poorly at reducing sound levels and are not a viable option for mitigation of lateral noise propagation during seismic operations from a moving vessel (Ayers et al., 2010).

6.7.3. E-source Airguns

Weilgart (2012b) notes that "Bolt Technology Corporation and WesternGeco have attempted to design an airgun, the E-source airgun, which reduces the output of high-frequency energy while optimizing it in the seismic band of interest, in order to minimize the effects on marine animals. This approach may be too piecemeal and not comprehensive enough, however, as other potentially damaging characteristics of airgun pulses remain." The E-Source airgun is still under development and no additional information is available in the public domain at this time (Robert Laws, Schlumberger Cambridge Research Ltd., pers. comm. to Bill Streever BP 1/17/13).

7. ADAPTIVE MANAGEMENT

Adaptive management is a flexible decision-making process that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. "Other events" include additions to the body of knowledge for where and when species use the ocean and how the impacting factors from our potentially permitted actions affect them. **Chapter 1.7.7** identifies a number of potential sources for future information.

The National Research Council defines adaptive management as follows:

> Adaptive management is a decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders (USDOI Technical Guide – Adaptive Management Working Group, 2009 updated edition) (USDOI Adaptive Management Technical Guide; Williams et al., 2009).

BOEM, as the decision maker, in conjunction with interested stakeholders, will begin to develop a more specific and detailed adaptive management process to include the following:

1. framing of objectives;
2. analytical tools;
3. methods to achieve those objectives;
4. management options and strategies; and
5. overall structured decision-making approach.

The goal will be to seek the most appropriate way to manage resources, minimize impacts, and allow for the activity to take place while remaining flexible and transparent. BOEM's adaptive management approach begins with the preparation of a "programmatic" EIS as a baseline that broadly covers the likely range of protective measures that may be taken to avoid or minimize impacts. Later, any site-specific NEPA compliance needed for subsequent shifts in how protective measures are fielded can "tier" off of the initial programmatic EIS. The programmatic evaluation, therefore, needs to ensure that a robust collection of the potential protective measures have been treated in the alternatives that are defined. This approach is endorsed by the technical manual (Williams et al., 2009).

The outline for how BOEM and BSEE intend to realize adaptive management in the AOI follows the USDOI technical guide's philosophy and meets the measures of success defined in it: (1) preparation of an EIS is a public process; (2) BOEM's management goals are to reduce and avoid impacts from OCS activities approved by BOEM while still allowing the goals and intent of the OCSLA for exploration and development of the OCS; (3) results from monitoring (BOEM/BSEE NTL-required operator reports) and assessment (BOEM Environmental Studies Program) are inputs to adjust and improve management decisions for the protective measure available and assigned as conditions of permit approval; and (4) implementation remains consistent with applicable laws.

The Programmatic EIS has identified three Alternatives: Alternative A – The Proposed Action; Alternative B – The Preferred Alternative; and Alternative C – the No Action Alternative, and has analyzed the possible impacts associated with those Alternatives (see **Chapters 2** and **4** of the Programmatic EIS). Mitigation measures have also been identified as part of Alternatives A and B. These mitigation measures have been created and designed with a goal to both minimize impacts and avoid impacts on the marine environment. Additional or different mitigation measures may be required in the future as part of the MMPA authorization process to avoid/minimize impacts to marine mammals. Once activities and management actions are underway, BOEM and BSEE will be actively monitoring whether the mitigations measures identified and implemented are sufficient to protect the environment while still allowing for the activities authorized to take place. Adaptive management is a learning-based process. By monitoring the mitigations associated with the management decisions that may follow for completion of G&G activities, an improved understanding about which actions and mitigations work and why will be gained. In other words, a feedback loop will be created between BSEE and BOEM so that a better understanding of how a resource system works is gained, thus promoting improved subsequent decision-making allowing for management objectives to be achieved.

Once a better understanding of the effectiveness of assigned mitigations is achieved, BOEM, as the decision maker, will be able to better assess and adjust future management decisions and design more effective mitigations if warranted. This adaptation will take place by using this Programmatic EIS as a baseline; an ongoing process of BSEE examining monitoring data and periodic assessments performed on it in BOEM's Environmental Studies Program; and using models to predict outcomes with the comparative results of these analyses feeding back into the decision-making process to produce more effective future decisions. BOEM understands and acknowledges that there are many uncertainties regarding ecosystems and that actual and expected results of the mitigation measures associated with the Alternatives in this document can vary greatly. By creating and applying an adaptive management process, however, aspects of mitigation and management that are not working can be isolated and adjustments can be made to allow for improved management of the activity and the resource.

BOEM also understands that successful adaptive management of a program and activities within that program requires stakeholder participation. Participation and pre-decisional input from interested parties such as other Federal, State, and local agencies, non-governmental organizations, industry, tribal governments and the public is key to designing and creating an adaptive management process that will be successful at all stages of its iterative course. This in turn will result in the goal of protecting the resource(s) at issue while allowing for the program and its activities to continue.

There are many and varied types of new information BOEM will use to inform its adaptive management process (several of these areas are discussed in **Chapter 1.7.7**). The ability to analyze the new information and adjust measures based on this analysis is then built into the site-specific NEPA and other internal and external environmental review processes. The question then becomes what types of additional measures may be considered. Additional measures would need to be analyzed in terms of not only effectiveness in mitigating the intended effect but also practicability in being implemented in the field. Although BOEM cannot determine the full suite of potential measures in advance of the site-specific analysis or completion of an adaptive management plan, the list below provides some examples. BOEM does not consider this list exhaustive (new ideas or measures may also emerge) and is not implying that any or all of them would be implemented.

- Additional time-area closures (potentially related to biologically important areas or multi-use conflicts);
- Limits to seismic surveys and/or additional separation requirements – spatially or temporally (e.g., larger separation distances between concurrent surveys operating in same acoustical framework or restrictions in number of seismic surveys operating in a specific geographic location);
- Consolidation of surveys in specified geographic area to achieve multiple user information needs while limiting overall noise;
- Use of other alternative seismic technologies such as vibroseis, airgun silencers, bubble curtains (as technology develops) or requiring existing but less impactful acoustic sources in biologically important areas;
- Buffer zones around critical habitat and biological areas of importance; or
- Expanded exclusion zones and enhanced monitoring to cover those zones.

Examples for illustrative purposes only include:

1. An applicant submits an application to conduct a seismic survey using a large airgun array in an area that the latest NOAA CetMap information indicates is biologically important to cetaceans. BOEM would analyze the potential for effects and consider

alternatives that would limit this potential (e.g., time closures during periods of highest density, required use of quieter technologies).

2. New information is obtained that indicates there is a multiple use conflict between the operation times of a type of survey BOEM authorizes and another ocean activity (e.g., specific, time-sensitive fishing period or military activity period). In this case, BOEM would analyze site-specific NEPA alternatives that consider expanded separation distances between activities or even avoidance of an area until the conflict passes or having the survey start elsewhere in its survey plan and return once the conflict has passed.
3. New information is gained through government-to-government consultations with federally-recognized tribes on site-specific requests that lead to additional mitigation to avoid impacts to important cultural resources.

The above are some examples of the application of adaptive management where additional mitigation measures may be implemented based on the analysis using the best available information at the time of the site-specific NEPA analysis. BOEM will also continue to review monitoring data to determine effectiveness of required mitigation measures.

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Attachment 1: Seismic Airgun Survey Protocol

Note: The following protocol has been developed for the Mid- and South Atlantic Planning Areas. The foundation of the protocol is similar to the Joint BOEM-BSEE NTL 2012-G02 (*Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program*) (USDOI, BOEM and BSEE, 2012b) used in the Gulf of Mexico. The ecosystems and diversity of species present within the Mid- and South Atlantic Planning Areas are distinct to this area, therefore protocols presented below may be similar to the types of operational procedures used in the Gulf of Mexico, but there are differences including the following exceptions:

- The protocol would apply to all seismic surveys in the AOI regardless of water depth. Joint NTL 2012-G02 does not apply to water depths less than 200 m (656 ft) in the Gulf of Mexico west of 88º W.
- The protocol includes a time-area closure for airgun surveys in North Atlantic right whale (NARW) critical habitat, Mid-Atlantic and Southeast U.S. Seasonal Management Areas (SMA), and Dynamic Management Areas (DMA).
- The radius of the acoustic exclusion zone would be based on the predicted range at which animals could be exposed to a received sound pressure level of 180 dB re 1 µPa, which is the current NMFS criterion for Level A harassment of cetaceans. The radius would be calculated for each survey but would not be less than 500 m (1,640 ft). In contrast, Joint NTL 2012-G02 specifies a single, fixed radius of 500 m (1,640 ft).
- Shutdown of the airgun array would be required any time a marine mammal or sea turtle is observed within the acoustic exclusion zone, whether due to the animal's movement, the vessel's movement, or because the animal surfaced inside the acoustic exclusion zone. There would be an exception for delphinids approaching the vessel or towed equipment at a speed and vector that indicates voluntary approach to bow-ride or chase towed equipment. In contrast, Joint NTL 2012-G02 requires the exclusion zone to be clear of all marine mammals and sea turtles for startup, but shutdown is required only for <u>whales</u> entering the exclusion zone.
- The "all clear" period to help ensure the absence of any marine mammal or sea turtle within the acoustic exclusion zone has been changed from 30 minutes to 60 minutes.

Background

The use of an airgun or airgun arrays while conducting seismic operations may have an impact on marine wildlife, including marine mammals and sea turtles. Some marine mammals, such as the North Atlantic right whale (*Eubalaena glacialis*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), and Florida manatee (*Trichechus manatus latirostris*), that inhabit the AOI are protected under the ESA, and all marine mammals are protected under the MMPA. All five sea turtle species inhabiting the AOI are protected under the ESA. They are the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), Kemp's ridley turtle (*Lepidochelys kempii*), and leatherback turtle (*Dermochelys coriacea*).

In order to protect marine mammals and sea turtles during seismic operations, NMFS requires seismic operators to use ramp-up and visual observation procedures when conducting seismic surveys. Procedures for ramp-up, Protected Species Observer (PSO) training, visual monitoring, and reporting are described in detail in this protocol. These mitigation measures apply to all seismic survey operations conducted regardless of water depth. Performance of these mitigation measures is also a condition of the approval of applications for geophysical permits. Permittees must demonstrate compliance with these mitigation measures by submitting to BOEM certain reports detailed in this protocol. The measures contained herein would apply to all on-lease surveys conducted under 30 CFR part 550 and all off-lease surveys conducted under 30 CFR part 551 in the AOI. In addition, the measures would apply to any deep penetration seismic surveys conducted to evaluate formation suitability for carbon sequestration in the renewable energy program.

Definitions

Terms used in this protocol have the following meanings:

1. Airgun means a device that releases compressed air into the water column, creating an acoustical energy pulse with the purpose of penetrating the seafloor.
2. Ramp-up means the gradual increase in emitted sound levels from an airgun array by systematically turning on the full complement of an array's airguns over a period of time.
3. Visual monitoring means the use of trained PSOs to scan the ocean surface visually for the presence of marine mammals and sea turtles. These observers must have successfully completed a PSO training program as described below. The area to be scanned visually includes, but is not limited to, the acoustic exclusion zone. Visual monitoring of an acoustic exclusion zone and adjacent waters is intended to establish and, when visual conditions allow, maintain a zone around the sound source and seismic vessel that is clear of all marine mammals and sea turtles, thereby reducing or eliminating the potential for injury.
4. Acoustic exclusion zone means the area at and below the sea surface within a radius to be determined by calculating the maximum range at which animals could be exposed to a received sound pressure level of 180 dB re 1 μPa, which is the current NMFS criterion for Level A harassment of cetaceans. The distance is calculated from the center of an airgun array. Each survey vessel must maintain its own unique exclusion zone. The radius of the exclusion zone must be calculated independently for each survey based on the configuration of the airgun array and the ambient acoustic environment, but must not be less than 500 m (1,640 ft).
5. Dolphins mean all marine mammal species in the family Delphinidae. This includes, among others, killer whales, pilot whales, and all of the "dolphin" species.

Time-Area Closure

No seismic airgun surveys will be authorized within the NARW critical habitat area from November 15 through April 15 nor within the Mid-Atlantic and Southeast U.S. SMAs from November 1 to April 30. Additionally, seismic airgun surveys will not be allowed in active DMAs. A DMA is a temporary management zone that is created by NMFS in response to a reliable sighting of a North Atlantic right whale and expires after 15 days unless extended (*Federal Register*, 2002). Airgun surveys conducted outside of the critical habitat, SMAs, or DMAs would be required to remain at a distance such that received levels at those boundaries do not exceed the threshold for Level B harassment, as determined by field verification or modeling.

The Southeast U.S. SMA, with seasonal restrictions in effect from November 1 to April 30, is a continuous area that extends from St. Augustine, Florida, to Brunswick, Georgia, extending 37 km (20 nmi) from shore. The Mid-Atlantic U.S. SMA, with seasonal restrictions from November 1 through April 30, is a combination of both continuous areas and half circles drawn with a 37-km (20-nmi) radii around the entrances to certain bays and ports. Within the AOI, the Mid-Atlantic U.S. SMA includes a continuous zone extending between Wilmington, North Carolina, and Brunswick, Georgia, as well as the entrance to Delaware Bay (Ports of Wilmington [Delaware] and Philadelphia), the entrance to Chesapeake Bay (Ports of Hampton Roads and Baltimore), and the Ports of Morehead City and Beaufort, North Carolina.

If there are changes made to either the Southeast or the Mid-Atlantic U.S. SMA's by NMFS in the future, the closure areas would be modified to align the closure areas with the new boundaries of the SMAs.

Acoustic Exclusion Zone

The acoustic exclusion zone is the primary mechanism to minimize the potential for injury (Level A harassment) of marine mammals to the maximum extent practicable. The radius of the acoustic exclusion zone would be based on the predicted range at which animals could be exposed to a received sound pressure level (SPL) of 180 dB re 1 μPa, which is the current NMFS criterion for Level A harassment of cetaceans by pulsed (and continuous) sources. The radius of the acoustic exclusion zone would be calculated on a survey-specific basis but would not be less than 500 m (1,640 ft). Based on calculations in the Acoustic Modeling Report (**Appendix D**), the 180-dB zone for a large airgun array (5,400 in^3) ranges from 799 to 2,109 m (2,622 to 6,920 ft), with a mean of 1,086 m (3,563 ft). For oil and gas surveys using a small airgun array (90 in^3), the calculated 180-dB zone ranges from 76 to 186 m (249 to 610 ft), with a mean of 128 m (420 ft).

Although NMFS also uses a criterion of 190 dB re 1 μPa for Level A harassment of pinnipeds by pulsed (and continuous) sources, it is unlikely that a smaller acoustic exclusion zone based on the 190-dB criterion would be appropriate for any seismic airgun survey, based on the rare occurrence of pinnipeds in the AOI.

While there are no noise exposure criteria for sea turtles, the protocol is expected to similarly reduce the risk of injury in sea turtles. With these measures in place, no mortalities or injuries of marine mammals or sea turtles are expected.

Ramp-Up Procedures

The intent of ramp-up is to warn marine mammals and sea turtles of pending seismic operations and to allow sufficient time for those animals to leave the immediate vicinity. Under normal conditions, animals sensitive to these activities are expected to move out of the area. For all seismic surveys, including airgun testing, use the ramp-up procedures described below to allow marine mammals and sea turtles to depart the exclusion zone before seismic surveying begins.

Measures to conduct ramp-up procedures during all seismic survey operations, including airgun testing, are as follows:

1. Visually monitor the acoustic exclusion zone and adjacent waters for the absence of all marine mammals and sea turtles for at least 60 min before initiating ramp-up procedures. If none are detected, you may initiate ramp-up procedures. <u>Do not initiate</u> ramp-up procedures at night or when you cannot visually monitor the exclusion zone for all marine mammals and sea turtles if your minimum source level drops below 160 dB re 1 μPa-m (rms) (see measure 5).
2. Initiate ramp-up procedures by firing a single airgun. The preferred airgun to begin with should be the smallest airgun, in terms of energy output (dB) and volume (in^3).
3. Continue ramp-up by gradually activating additional airguns over a period of at least 20 min, but no longer than 40 min, until the desired operating level of the airgun array is obtained.
4. Immediately shutdown all airguns, if any marine mammal or sea turtle are detected entering the defined exclusion zone. However, shutdown would not be required for dolphins approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the dolphin. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the dolphin(s) with a speed and vector that indicates that the dolphin(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the dolphin(s) would be subject to the determination of the PSO. If the PSO determines that the dolphin(s) is actively trying to avoid the vessel or the towed equipment, the acoustic sources must be immediately as per his/her instruction. The PSO must record the details of any non-shutdowns in the presence of a dolphin, including the distance of the dolphin(s) from the vessel at the first sighting of the dolphin(s), their heading, where the dolphin positions itself relative to the vessel, how long they stay near the vessel, and any identifiable behaviors. After a shutdown, you may recommence seismic operations with a ramp-up of airguns only when the exclusion zone has been visually inspected for at least 60 min to help ensure the absence of all marine mammals and sea turtles.
5. You may reduce the source level of the airgun array, using the same shot interval as the seismic survey, to maintain a minimum source level of 160 dB re 1 μPa-m (rms) for the duration of certain activities. By maintaining the minimum source level, you will not be required to conduct the 60-min visual clearance of the exclusion zone

before ramping back up to full output. Activities that are appropriate for maintaining the minimum source level are (1) all turns between transect lines, when a survey using the full array is being conducted immediately prior to the turn and will be resumed immediately after the turn; and (2) unscheduled, unavoidable maintenance of the airgun array that requires the interruption of a survey to shut down the array. The survey should be resumed immediately after the repairs are completed. There may be other occasions when this practice is appropriate, but use of the minimum source level to avoid the 60-min visual clearance of the exclusion zone is only for events that occur during a survey using the full power array. The minimum sound source level is not to be used to allow a later ramp-up after dark or in conditions when ramp-up would not otherwise be allowed.

Protected Species Observer Program

Basic Requirements

PSOs will be required onboard seismic survey vessels to monitor the acoustic exclusion zone around the sound source to help ensure it is free of all marine mammals and sea turtles during operation of the survey equipment. All PSOs must be third-party observers and must have completed a PSO training program, described in the following section. The following guidelines shall be followed by PSOs on seismic survey vessels:

1. At least two PSOs will be required on duty at all times during daylight hours (dawn to dusk) when seismic operations are being conducted, unless conditions (fog, rain, darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that the sea surface observations are halted, visual observations must resume as soon as conditions permit.
2. Other than brief alerts to bridge personnel of maritime hazards, no additional duties shall be assigned to PSOs during their watch.
3. No PSO will be allowed more than 4 consecutive hours on watch as a visual observer.
4. A break of at least 2 hr shall occur between 4-hr watches, and no other duties shall be assigned during this period.
5. A PSO’s combined watch schedule shall not exceed 12 hr during a 24-hr period.

Training

All PSOs must have completed a PSO training program. The training program, shall be in accordance with the recommendations described in NOAA Fisheries Service 2012 National Standards for a Protected Species Observer and Data Management Program: A Model for Seismic Surveys (Baker et al., 2013). All training programs offering to fulfill the observer training requirement must (1) furnish to BOEM a course information packet that includes the name and qualifications (i.e., experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material; (2) furnish each trainee with a document stating successful completion of the course; and (3) provide BOEM with names, affiliations, and dates of course completion of trainees.

The training course must include the following elements:

I. Brief overview of the MMPA and the ESA as they relate to seismic acquisition and protection of marine mammals and sea turtles in the Atlantic Ocean.
II. Brief overview of seismic acquisition operations.
III. Overview of seismic mitigation measures and the PSO program.
IV. Discussion of the role and responsibilities of the PSO, including
    a) Legal requirements (why you are here and what you do);
    b) Professional behavior (code of conduct);
    c) Integrity;
    d) Authority of PSO to call for shutdown of seismic acquisition operations;

e) Assigned duties;
   1) What can be asked of the observer;
   2) What cannot be asked of the observer; and
f) Reporting of violations and coercion;

V. Identification of Atlantic marine mammals and sea turtles.
VI. Cues and search methods for locating marine mammals and sea turtles.
VII. Data collection and reporting requirements:
   a) Forms and reports to BOEM via email on the 1st and 15th of each month; and
   b) Marine mammal or sea turtle in exclusion zone/shutdown report within 24 hr.

Basic training criteria have been established and must be adhered to by any entity that offers observer training. BOEM will not sanction particular trainers or training programs.

All seismic survey vessels must comply with separate guidance for vessel strike avoidance issued by BOEM and the Bureau of Safety and Environmental Enforcement (BSEE). Visual observers monitoring solely for vessel strike avoidance (e.g., during transit or other times when airguns are not operating) can be crew members, trained third party observers, or a combination of both. They do not have specific training requirements nor will they need to be approved by BOEM or BSEE.

Visual Monitoring Methods

The PSOs on duty will look for marine mammals and sea turtles using the naked eye and hand-held binoculars provided by the seismic vessel operator. The observers will stand watch in a suitable location that will not interfere with navigation or operation of the vessel and that affords the observers an optimal view of the sea surface. The observers will provide 360º coverage surrounding the seismic vessel and adjust their positions appropriately to help ensure adequate coverage of the entire area. These observations must be consistent, diligent, and free of distractions for the duration of the watch.

Visual monitoring will begin no less than 60 min prior to the beginning of ramp-up and continue until seismic operations cease or sighting conditions do not allow observation of the sea surface (e.g., fog, rain, darkness). If any marine mammal or sea turtle is observed, the observer should note and monitor the position (including latitude/longitude of the vessel and relative bearing and estimated distance to the animal) until the animal dives or moves out of visual range of the observer. Make sure you continue to observe for additional animals that may surface in the area, as often there are numerous animals that may surface at varying time intervals. At any time a marine mammal or sea turtle is observed within the exclusion zone, whether due to the animal's movement, the vessel's movement, or because the animal surfaced inside the exclusion zone, the observer will call for the immediate shutdown of the seismic operation, including airgun firing (the vessel may continue on its course but all airgun discharges must cease). Shutdown would not be required for dolphins approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the dolphin. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the dolphin(s) with a speed and vector that indicates that the dolphin(s) is approaching the vessels and remains near the vessel or towed equipment. The vessel operator must comply immediately with such a call by an on-watch visual observer. Any disagreement or discussion should occur only after shutdown. After a shutdown, when no marine mammals or sea turtles are sighted for at least a 60-min period, ramp-up of the source array may begin. Ramp-up cannot begin unless conditions allow the sea surface to be visually inspected for marine mammals and sea turtles for 60 min prior to commencement of ramp-up (unless the method described in the section entitled "Passive Acoustic Monitoring" is used). Thus, ramp-up cannot begin after dark or in conditions that prohibit visual inspection (fog, rain, etc.) of the exclusion zone. Any shutdown due to a marine mammal or sea turtle sighting within the exclusion zone must be followed by a 60-min all-clear period and then a standard, full ramp-up. Any shutdown for other reasons, including, but not limited to, mechanical or electronic failure, resulting in the cessation of the sound source for a period greater than 20 min, must also be followed by full ramp-up procedures. In recognition of occasional, short periods of the cessation of airgun firing for a variety of reasons, periods of airgun silence **not exceeding 20 min** in duration will not require ramp-up for the resumption of seismic operations if (1) visual surveys are continued diligently throughout the silent period (requiring daylight and reasonable sighting conditions), and (2) no marine mammals or sea turtles are observed in the exclusion zone. If marine mammals or sea turtles are observed in the exclusion zone during the short silent period, resumption of seismic survey operations must be preceded by ramp-up.

Reporting

The importance of accurate and complete reporting of the results of the mitigation measures cannot be overstated. Only through diligent and careful reporting can BOEM, and subsequently the NMFS, determine the need for and effectiveness of mitigation measures. Information on observer effort and seismic operations is as important as animal sighting and behavior data. In order to accommodate various vessels' bridge practices and preferences, vessel operators and observers may design data reporting forms in whatever format they deem convenient and appropriate. Alternatively, observers or vessel operators may adopt the United Kingdom's Joint Nature Conservation Committee forms (available at their website, www.jncc.gov.uk). At a minimum, the following items should be recorded and included in reports to BOEM:

Observer Effort Report: BOEM requires the submission of observer effort reports to BSEE on the 1st and the 15th of each month for each day seismic acquisition operations are conducted. These reports must include the following:

1. vessel name;
2. observers' names and affiliations;
3. survey type (e.g., site, 3D, 4D);
4. BOEM permit number (for "off-lease seismic surveys") or OCS lease number (for "on-lease seismic surveys");
5. date;
6. time and latitude/longitude when daily visual survey began;
7. time and latitude/longitude when daily visual survey ended; and
8. average environmental conditions while on each visual survey rotation and session as well as when any conditions change during the rotation, each session, including:
   a. wind speed and direction;
   b. sea state (glassy, slight, choppy, rough, or Beaufort scale);
   c. swell (low, medium, high, or swell height in meters); and
   d. overall visibility (poor, moderate, good).

Survey Report: BOEM requires the submission of survey reports to BSEE on the 1st and the 15th of the month for each day seismic acquisition operations are conducted and airguns are discharged. These reports must include the following:

1. vessel name;
2. survey type (e.g., site, 3D, 4D);
3. BOEM permit number (for "off-lease seismic surveys") or OCS lease number (for "on-lease seismic surveys"), if applicable;
4. date;
5. time pre-ramp-up survey begins;
6. observations of marine mammals and sea turtles seen during pre-ramp-up surveys;
7. time ramp-up begins;
8. observations of marine mammals and sea turtles seen during ramp-up;
9. time sound source (airguns or HRG equipment) is operating at the desired intensity;
10. observations of marine mammals and sea turtles seen during surveys;
11. if marine mammals or sea turtles were seen, was any action taken (i.e., survey delayed, guns shut down)?
12. reason that marine mammals and sea turtles might not have been observed (e.g., swell, glare, fog); and
13. time sound source (airgun array or HRG equipment) stops firing.

Sighting Report: BOEM shall require the submission of reports to BSEE for marine mammals and sea turtles sighted during seismic and HRG surveys on the 1st and the 15th of each month except as indicated below. These reports are in addition to any reports required as a condition of the geophysical permit and must include the following:

1. vessel name;
2. survey type (e.g., site, 3D, 4D);
3. BOEM permit number (for "off-lease seismic surveys") or OCS lease number (for "on-lease seismic surveys");
4. date;
5. time;
6. watch status (Were you on watch or was this sighting made opportunistically by you or someone else?);
7. observer or person who made the sighting;
8. latitude/longitude of vessel;
9. bearing of vessel; (true compass direction);
10. bearing (true compass direction) and estimated range to animal(s) at first sighting;
11. water depth (meters);
12. species (or identification to lowest possible taxonomic level);
13. certainty of identification (sure, most likely, best guess);
14. total number of animals;
15. number of juveniles;
16. description (as many distinguishing features as possible of each individual seen, including length, shape, color and pattern, scars or marks, shape and size of dorsal fin, shape of head, and blow characteristics);
17. direction of animal's travel – compass direction;
18. direction of animal's travel – related to the vessel (drawing preferably);
19. behavior (as explicit and detailed as possible; note any observed changes in behavior);
20. activity of vessel;
21. airguns firing? (yes or no); and
22. closest distance (meters) to animals from center of airgun or airgun array (whether firing or not).

Note: If this sighting was of a marine mammal or sea turtle within the exclusion zone that resulted in a shutdown of the airguns, include in the sighting report the observed behavior of the animal(s) before shutdown, the observed behavior following shutdown (specifically noting any change in behavior), and the length of time between shutdown and subsequent ramp-up to resume the seismic survey (note if seismic survey was not resumed as soon as possible following shutdown). Send this report to BOEM **within 24 hr of the shutdown**. These sightings should also be included in the first regular semi-monthly report following the incident.

Additional information, important points, and comments are encouraged. All reports will be submitted to BOEM on the 1st and the 15th of each month (with one exception noted above). Forms should be scanned (or data typed) and sent via email to BOEM.

Please note that these marine mammal and sea turtle reports are in addition to any reports required as a condition of the geophysical permit.

Borehole Seismic Surveys

Borehole seismic differs from conventional exploration seismic by the placement of the acoustic receivers in the borehole of a well as opposed to towed streamers or ocean bottom placement of receivers, i.e., nodes or cables. (Note: A complete description of borehole surveys can be found in **Chapter 3.2.2.1.7**.) Because of this key difference, the following mitigation measures apply only to borehole surveys:

- During daylight hours, when visual observations of the exclusion zone are being performed as required in this protocol, borehole seismic operations will not be required to ramp-up for shutdowns of 60 min or less in duration, as long as no marine mammals or sea turtles are observed in the exclusion zone during the shutdown. If a marine mammal or sea turtle is sighted in the exclusion zone, ramp-up is required and may begin only after visual surveys confirm that the exclusion zone has been clear for 60 min.

- During nighttime or when conditions prohibit visual observation of the exclusion zone, ramp-up will not be required for shutdowns of 20 min or less in duration. For borehole seismic surveys that utilize passive acoustics during nighttime and periods of poor visibility, ramp-up is not required for shutdowns of 30 min or less.
- Nighttime or poor visibility ramp-up is allowed only when passive acoustics are used to help ensure that no marine mammals are present in the exclusion zone (as for all other seismic surveys). Operators are strongly encouraged to acquire the survey in daylight hours when possible.
- PSOs must be used during daylight hours, as required in this protocol, and may be stationed either on the source boat or on the associated drilling rig or platform if a clear view of the sea surface in the exclusion zone and adjacent waters is available.
- All other mitigations and provisions for seismic surveys as set forth in this protocol will apply to borehole seismic surveys.
- Reports should reference OCS Lease Number, Area/Block and Borehole Number.

Passive Acoustic Monitoring

Whales, dolphins, and porpoises are very vocal marine mammals, and periods of silence are usually short and most often occur when these animals are at the surface and may be detected using visual observers. However, marine mammals are at the greatest risk of potential injury from seismic airguns when they are submerged and under the airgun array. PAM has been shown to be very effective at detecting submerged and diving sperm whales, and some other marine mammal species, when they are not detectable by visual observation. The use of PAM is required as part of the Seismic Airgun Survey Protocol. Inclusion of PAM does **not** relieve an operator of any of the mitigations (including visual observations) in this protocol, **with the following exception**: monitoring for marine mammals with a passive acoustic array by an observer proficient in its use will allow ramp-up and the subsequent start of a seismic survey during times of reduced visibility (darkness, fog, rain, etc.) when such ramp-up otherwise would not be permitted using only visual observers. An assessment of PAM must be included of the usefulness, effectiveness, and problems encountered with the use of that method of marine mammal detection in the reports described in this protocol. A description of the PAM system, the software used, and the monitoring plan must also be reported to BOEM at the beginning of its use.

Attachment 2: HRG Survey Protocol

This protocol was developed by the Bureau of Ocean Energy Management (BOEM) to specify mitigation requirements for high-resolution geophysical (HRG) surveys in the Area of Interest (AOI) for the Atlantic Geological and Geophysical (G&G) Programmatic Environmental Impact Statement (EIS). It applies to HRG surveys conducted using only electromechanical sources such as side-scan sonar; boomers, sparkers, chirp subbottom profilers; and single beam and multibeam depth sounders. Other HRG surveys using airguns are excluded from this protocol and must comply instead with the Seismic Airgun Survey Protocol.

Background

Certain HRG survey equipment, depending on the operating frequency and source level, may have an impact on marine wildlife, including marine mammals and sea turtles. Some marine mammals, such as the North Atlantic right whale (*Eubalaena glacialis*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), and Florida manatee (*Trichechus manatus latirostris*), that inhabit the AOI are protected under the Endangered Species Act (ESA), and all marine mammals are protected under the Marine Mammal Protection Act (MMPA). All five sea turtle species inhabiting the AOI are protected under the ESA. They are the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), Kemp's ridley turtle (*Lepidochelys kempii*), and leatherback turtle (*Dermochelys coriacea*). The mitigation requirements in this protocol will help to avoid and/or reduce the potential for impacts on marine mammals and turtles.

Overview of Protocol Requirements

The HRG Survey Protocol requirements can be summarized as follows:

- All HRG operators must comply with separate guidance for vessel strike avoidance issued by BOEM and the Bureau of Safety and Environmental Enforcement (BSEE).
- If active acoustic sources will operate above 200 kHz, no additional mitigation for acoustic exclusion zones, PSO requirements, startup or shutdown requirements, or time-area closures would be conditioned to authorizations.
- If at least one acoustic source will operate at frequencies at and below 200 kHz, an acoustic exclusion zone is required year-round and throughout the AOI, with visual monitoring by trained PSOs and startup and shutdown requirements as described in the protocol.
- Only HRG surveys using frequencies greater than 30 kHz will be allowed to operate within NARW critical habitat from November 15 through April 15 and in Dynamic Management Areas (DMA). See the "Time-Area Closures" section for details. All other HRG surveys would be permitted or authorized year-round throughout the AOI.
- HRG surveys using frequencies above 1.6 kHz in sea turtle closure area for Brevard County are permitted or authorized year-round. HRG surveys below 1.6 kHz would need additional consultation with NMFS prior to approval or authorization.

A flow chart summarizing HRG Protocol Requirements for Alternative A is presented in **Figure HRG-1**. The corresponding requirements for Alternative B are shown in **Figure HRG-2**.

Time-Area Closures

Only HRG surveys using frequencies greater than 30 kHz would be allowed to operate within NARW critical habitat from November 15 through April 15. Surveys in NARW critical habitat using sources operating at and below 30 kHz would be evaluated by BOEM on a critical need basis, considering whether survey planning could have scheduled survey activities outside of the calving and nursing season and how the particular survey fills a critical need and would be authorized during daylight hours only. Any surveys authorized by BOEM outside, but in proximity to, NARW critical habitat boundaries are required to remain at a distance such, for all sound sources at and below 30 kHz, received levels at these boundaries are no more than the Level B threshold.

A DMA is a temporary management zone that is created by NMFS in response to a reliable sighting of a NARW and expires after 15 days unless extended (*Federal Register*, 2002). If a DMA is established during the course of an HRG survey, further use of all sound sources in that DMA must be discontinued within 24 hr of its establishment. Any surveys authorized by BOEM outside, but in proximity of, DMA boundaries are required to remain at a distance such, received levels at these boundaries are no more than the Level B threshold.

Except as noted above for HRG surveys using frequencies at and below 30 kHz, all other HRG surveys would be permitted or authorized year-round throughout the AOI.

Acoustic Exclusion Zone

All HRG surveys conducted with one or more sound sources operating at frequencies at and below 200 kHz will be required to establish an acoustic exclusion zone. An acoustic exclusion zone is not required for HRG surveys in which all active sound sources would operate at frequencies greater than 200 kHz.

The acoustic exclusion zone would be a 200 m (656 ft) radius zone around the sound source, which for most cases would encompass the 180 dB re 1 μPa-m (rms) isopleth, which is the current NMFS threshold for Level A harassment of marine mammals. If the calculated Level A threshold radius for a source exceeds 200 m (656 ft), the exclusion zone would be increased and that increase would be quantified through field verification or modeling. In addition, the applicant would be required to demonstrate that the larger exclusion zone could be effectively monitored. Effectiveness can be demonstrated through available monitoring studies or use of a vessel providing sufficient observation deck height to help ensure adequate coverage. Depending on the source levels, operational frequency, and deployment mode of the geophysical equipment used, the 200 m (656 ft) exclusion zone could also encompass the Level B harassment zone.

Protected Species Observer Program

All HRG surveys having an acoustic exclusion zone (i.e., those conducted using one or more sound sources operating at and below 200 kHz) must use PSOs to monitor the acoustic exclusion zone. The PSOs can be trained crew members and/or third party observers.

A PSO for an HRG survey is defined as someone who has successfully completed a PSO training course approved by BOEM. All PSO resumes must be submitted to BOEM for approval prior to survey operations. Basic training criteria have been established and must be adhered to by any entity that offers PSO training. BOEM will not sanction particular trainers or training programs.

Visual Monitoring Requirements

The following visual monitoring requirements apply only to non-airgun HRG surveys in which at least one acoustic source will operate at frequencies at and below 200 kHz. If there are no acoustic sources operating at frequencies at and below 200 kHz, there will be no acoustic exclusion zone and there are no requirements for PSOs. However, all HRG operators must comply with separate guidance for vessel strike avoidance issued by BOEM and BSEE.

Visual monitoring of the acoustic exclusion zone must be conducted by trained PSOs. At least one PSO would be required on watch aboard HRG survey vessels at all times during daylight hours (dawn to dusk – i.e., from about 30 min before sunrise to 30 min after sunset) when survey operations are being conducted, unless conditions (fog, rain, darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that the sea surface observations are halted, visual observations must resume as soon as conditions permit. Ongoing activities may continue but may not be initiated under such conditions (i.e., without appropriate pre-activity monitoring).

The requirements for PSOs and their roles are as follows:

a. At least one PSO will be required on duty at all times to monitor the acoustic exclusion zone when acoustic sources are operating.

b. The PSO(s) will monitor an acoustic exclusion zone for protected species and observe and document their presence and behavior, searching the area around the vessel using hand-held reticule binoculars, and the unaided eye. For nighttime operations or if operations continue during periods of reduced visibility, operators would monitor the waters around the acoustic exclusion zone using shipboard lighting, enhanced vision equipment, night-vision equipment and/or Passive Acoustic Monitoring (PAM).
c. The following schedule limitations shall apply to PSOs during HRG survey activities:
    1. Other than brief alerts to bridge personnel of maritime hazards, no additional duties shall be assigned to PSOs during their watch.
    2. A watch shall be no longer than four consecutive hours.
    3. A break of at least two hours shall occur between 4-hr watches, and no other duties shall be assigned during this period.
    4. A PSO's combined watch schedule shall not exceed 12 hr during a 24-hr period.

The PSO(s) on duty will look for marine mammals and sea turtles using the naked eye and hand-held binoculars. They will stand watch in a suitable location that will not interfere with navigation or operation of the vessel and that affords the PSO an optimal view of the sea surface. The PSOs will provide 360º coverage surrounding the survey vessel and adjust their position(s) appropriately to help ensure adequate coverage of the entire area. These observations must be consistent, diligent, and free of distractions for the duration of the watch.

Startup and Shutdown Requirements

Monitoring of the acoustic exclusion zone must begin no less than 60 min prior to start-up and continue until operations cease. Immediate shutdown of the active acoustic sound source(s) would occur if any marine mammal or sea turtle is detected entering or within the acoustic exclusion zone. Subsequent restart of the equipment may only occur following a confirmation that the exclusion zone is clear of all marine mammals and sea turtles for 60 min.

Shutdown would not be required for delphinids approaching the acoustic exclusion zone that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the PSO. If the PSO determines that the delphinid(s) is actively trying to avoid the vessel or the towed equipment, the acoustic sources must be immediately shutdown as per his/her instruction. The PSO must record the details of any non-shutdowns in the presence of a delphinid, including the distance of the delphinid(s) from the vessel at the first sighting of the delphinid(s), their heading, where the delphinid positions itself relative to the vessel, how long they stay near the vessel, and any identifiable behaviors. After a shutdown, HRG operations may recommence only when the exclusion zone has been visually inspected for at least 60 min to help ensure the absence of all marine mammals and sea turtles.

Reporting

The importance of accurate and complete reporting of the results of the mitigation measures cannot be overstated. Only through diligent and careful reporting can BOEM, and subsequently the NMFS, determine the need for and effectiveness of mitigation measures. Information on observer effort and seismic operations is as important as animal sighting and behavior data. In order to accommodate various vessels' bridge practices and preferences, vessel operators and observers may design data reporting forms in whatever format they deem convenient and appropriate. Alternatively, observers or vessel operators may adopt the United Kingdom's Joint Nature Conservation Committee forms (available at their website, www.jncc.gov.uk). At a minimum, the following items should be recorded and included in reports to BOEM:

Protected Species Observer Reports: Data on all protected species observations must be recorded by the PSO based on standard marine mammal observer data collection protocols. This information must include the following:

1. vessel name;
2. observers' names, affiliations and resumes;
3. date;
4. time and latitude/longitude when daily visual survey began;
5. time and latitude/longitude when daily visual survey ended; and
6. average environmental conditions during visual surveys including:
   a. wind speed and direction;
   b. sea state (glassy, slight, choppy, rough, or Beaufort scale);
   c. swell (low, medium, high, or swell height in meters); and
   d. overall visibility (poor, moderate, good).
7. species (or identification to lowest possible taxonomic level);
8. certainty of identification (sure, most likely, best guess);
9. total number of animals;
10. number of calves, and juveniles (if distinguishable);
11. description (as many distinguishing features as possible of each individual seen, including length, shape, color and pattern, scars or marks, shape and size of dorsal fin, shape of head, and blow characteristics);
12. direction of animal's travel – related to the vessel (drawing preferably);
13. behavior (as explicit and detailed as possible; note any observed changes in behavior); and
14. activity of vessel when sighting occurred.

Note: If this sighting was of a marine mammal or sea turtle within the exclusion zone that resulted in a shutdown of survey equipment, include in the sighting report the observed behavior of the animal(s) before shutdown, the observed behavior following shutdown (specifically noting any change in behavior), and the length of time between shutdown and restart of the survey (note if survey was not resumed as soon as possible following shutdown). Send this report to BOEM **within 24 hr of the shutdown**. These sightings should also be included in the first regular semi-monthly report following the incident.

Additional information, important points, and comments are encouraged. All reports will be submitted to BOEM on the 1st and the 15th of each month (with one exception noted above). Forms should be scanned (or data typed) and sent via email to BOEM.

Please note that these marine mammal and sea turtle reports are in addition to any reports required as a condition of the geophysical permit or authorization.

Passive Acoustic Monitoring

PAM is not currently included as recommended mitigation in the HRG Survey Protocol for Alternative A. The use of PAM for HRG surveys would be evaluated and approved on an individual project basis, during the activity-specific assessment that is part of the application process. The circumstances specific to each HRG geophysical survey would be considered in determining the utility and cost-effectiveness of PAM. Operators may request the flexibility to work at night in order to save costs associated with returning to port. In such cases an alternative monitoring strategy for night-time operations will be discussed.

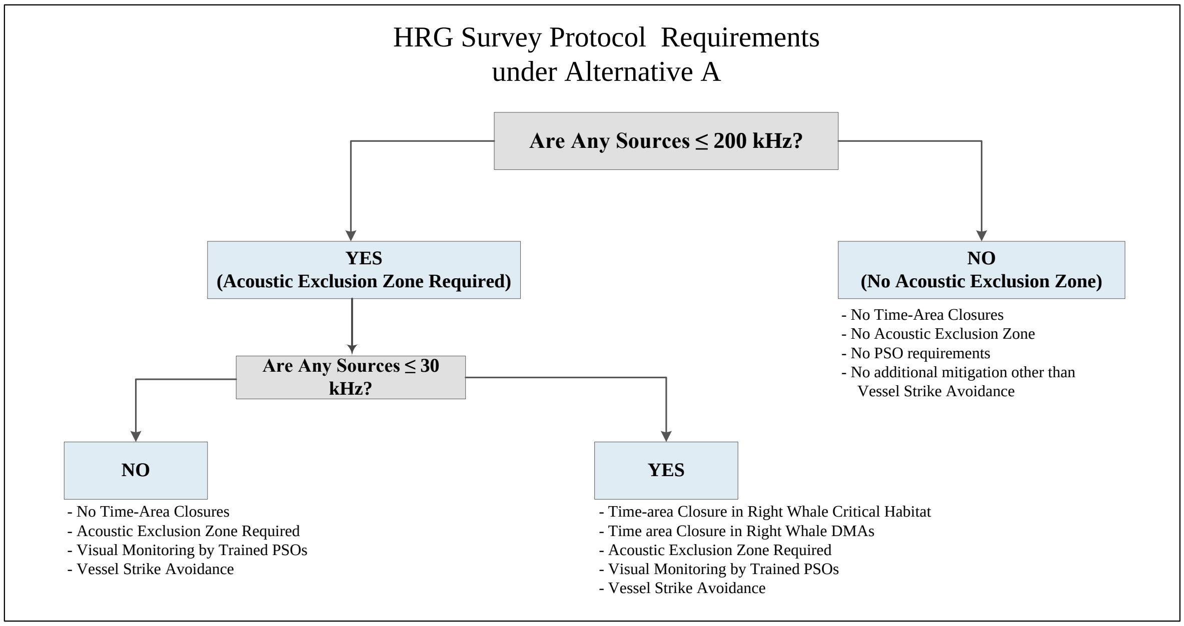

Figure HRG-1. Flow Chart Summarizing HRG Survey Protocol Requirements under Alternative A.

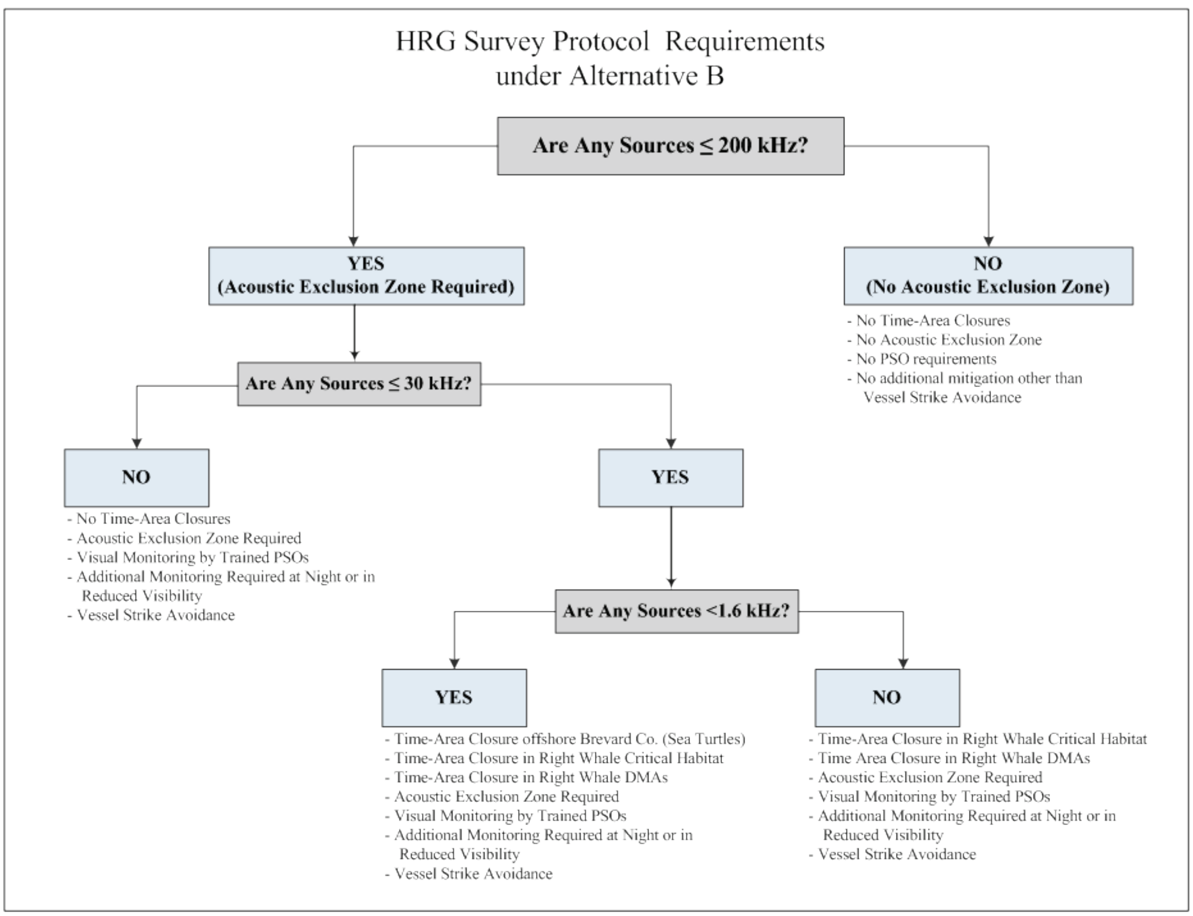

Figure HRG-2. Flow Chart Summarizing HRG Survey Protocol Requirements under Alternative B.

APPENDIX D

ACOUSTIC MODELING REPORT

ACOUSTIC MODELING REPORT

ATLANTIC G&G PROGRAMMATIC EIS

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LIST OF ACRONYMS AND ABBREVIATIONS

2D	two-dimensional
3D	three-dimensional
AASM	Airgun Array Source Model
AIM	Acoustic Integration Model©
ANSI	American National Standard Institute
BOEM	Bureau of Ocean Energy Management
C	Celsius
cm	centimeter
CW	continuous wave
dB	decibel
EIS	Environmental Impact Statement
G&G	geological and geophysical
GDEM	Generalized Digital Environmental Model
GI	generator-injector
HRG	high-resolution geophysical
Hz	hertz
in	inch
J	joule
kHz	kilohertz
kJ	kilojoule
km	kilometer
kV	kilovolt
kW	kilowatt
m	meter
MAI	Marine Acoustics, Inc.
mbsf	meters below seafloor
MMPA	Marine Mammal Protection Act
MONM	Marine Operations Noise Model
MOODS	Master Oceanographic Observational Data Set
NMFS	National Marine Fisheries Service
nmi	nautical mile
OCS	Outer Continental Shelf
ODP	Ocean Drilling Program
PE	parabolic equation
PTS	Permanent Threshold Shift
ppt	parts per thousand
RAM	Range-dependent Acoustic Model
RL	received level
rms	root-mean-square
s	second
SEL	sound exposure level
SL	source level
SPL	sound pressure level
TL	transmission loss
TTS	Temporary Threshold Shift
USGS	U.S. Geological Survey
VSP	vertical seismic profiling

1. INTRODUCTION

This report provides technical information in support of the Programmatic Environmental Impact Statement (EIS) prepared by the Bureau of Ocean Energy Management (BOEM) concerning the potential environmental effects of geological and geophysical (G&G) exploration activities on the mid- and south Atlantic Outer Continental Shelf (OCS). Specifically, this document describes the procedures used to estimate the sound fields that would be generated by airgun arrays and electromechanical sources during said activities. Some background information on acoustic metrics and on the principal factors that affect sound propagation in the water is also provided as a preamble.

The proposed G&G exploration activities encompass a wide range of marine geotechnical studies using acoustic sources including seismic surveying (high-resolution, 2D, 3D, and vertical seismic profiling [VSP]), shallow sediment surveying, and shallow hazard assessment. The activities are to take place in different water depths (shallow water, shelf, slope, and deep ocean environments) and in different seasons of the year.

The description as well as typical acoustic characteristics and specifications were given for seven acoustic sources: large and small airgun arrays, side-scan sonar, boomer subbottom profiler, chirp subbottom profiler, multibeam depth sounder, and sparker. These acoustic sources, with the exclusion of sparker, were considered for the modeling study to provide example acoustic fields for different types of G&G exploration activities.

Twenty-two modeling sites were defined throughout the Area of Interest (AOI). The water depth at the sites varied from 30-5,400 meters (m). Two types of bottom composition were considered: sand and clay, their selection depending on the water depth at the source. Twelve possible sound speed profiles for the water column were used to cover the variation of the sound velocity distribution in the water with location and season. Thirty-five distinct propagation scenarios resulted from considering different sound speed profiles at some of the modeling sites. Multiple sources were modeled for each scenario, yielding a total of 105 acoustic field estimates.

Two acoustic propagation models were employed to estimate the acoustic field radiated by the sound sources. A version of JASCO's Marine Operations Noise Model (MONM), based on the Range-dependent Acoustic Model (RAM) parabolic-equations model, MONM-RAM, was used to estimate the sound exposure levels (SELs) for low-frequency sources (below 2 kilohertz [kHz]) such as the airgun arrays and boomer. A version of MONM based on the BELLHOP ray-trace model, MONM-BELLHOP, was used to model the sound propagation from mid- and high-frequency sources. Both models take into account the geoacoustic properties of the sea bottom, vertical sound speed profile in the water column, range-dependent bathymetry, and the directivity of the source.

The directional source levels (SLs) for the airgun arrays were modeled using the Airgun Array Source Model (AASM) based on the specifications of the source such as the arrangement and volume of the guns, firing pressure, and depth below the sea surface. The directivity function of the high-frequency sources was numerically modeled from technical specifications such as beam width, number of beams, and main beam axis direction; these were obtained from the manufacturer's product specification sheets or through direct contact with the manufacturer. The modeled directional SLs were used as the input for the acoustic propagation model.

2. BASICS OF UNDERWATER ACOUSTICS

2.1. ACOUSTIC METRICS

Various sound level metrics are commonly used to express the loudness of noise and to estimate its effects on marine life. The three primary metrics of importance in this study are peak pressure, root-mean-square (rms) sound pressure level (SPL), and SEL. Some of the criteria used to assess potential bioacoustic impacts on marine species are expressed in terms of sound pressure. Most relevantly, the safety and disturbance thresholds currently applied to marine seismic surveys by the U.S. National Marine Fisheries Service (NMFS) are based on the rms SPL metric as adapted for impulsive sound sources. Other criteria proposed in more recent studies, like Southall et al. (2007), place greater emphasis on sound exposure and define impact thresholds in terms of the SEL metric.

The peak pressure is defined as the maximum absolute value of the amplitude of a pressure time series, *p(t)*.

The rms SPL (dB re 1 µPa, [American National Standard Institute] ANSI symbol L_p) is the rms of the pressure level, *p(t)*, received at a location over a time interval, *T*:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt\right) \tag{1}$$

The rms SPL can be thought of as a measure of the average pressure or as the "effective" pressure over the duration of an acoustic event, such as a single acoustic pulse. Because the time interval, *T*, is used as a divisor, pulses that are more spread out in time have a lower rms SPL for the same total acoustic energy. The time interval, *T*, is conventionally defined as the "90 percent energy pulse duration" rather than a fixed time window (Malme et al., 1986, Greene, 1997, McCauley et al., 1998).

For a pure sine wave the peak pressure (dB re 1 µPa, ANSI symbol L_{pk}) and rms SPL are related through a simple expression (Laughton and Warne, 2003):

$$L_{pk} = 10\log_{10}\left(\sqrt{2}\frac{1}{T}\int_T p^2(t)dt\right) = L_p + 3\text{dB} \tag{2}$$

Sound exposure level (dB re 1 µPa^2·s, ANSI symbol L_E) is the time integral of the square pressure over a fixed time interval, *T*:

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt\right) \tag{3}$$

Sound exposure levels represents the total acoustic energy delivered over the duration of an acoustic event.

Because the rms SPL and SEL are both computed from the integral of square pressure, these metrics are related numerically by a simple expression which depends only on the duration of the integration time interval, *T*:

$$L_p = L_E - 10\log_{10}(T) \tag{4}$$

For continuous sound sources, a time interval of one second is conventionally used, and the rms SPL is equal to the SEL. For impulsive sources, an objective definition of pulse duration is needed when defining the rms SPL. As previously mentioned, the pulse duration is conventionally taken to be the interval during which 90 percent of the pulse energy is received at a location from the source.

2.2. Major Factors Affecting Underwater Sound Propagation

The propagation of sound in the ocean environment is a complex phenomenon to model. Multiple factors can affect the response of the medium to an acoustic wave and the propagation loss of acoustic energy. Some factors, such as geometric spreading, refraction, and absorption are well understood and their influence can be fairly readily calculated. Others, such as scattering, can be difficult to quantify because of their dependence on fine-scale features of the local environment; it is possible, however, to estimate and predict their effect using more empirical approaches. In the sections that follow, the principal factors affecting sound propagation in the ocean are briefly discussed in terms of their numerical estimation.

2.2.1. Geometric Spreading

In a homogeneous free space the wave front moving away from a point-like source has the form of a sphere, whose area (A) increases proportionally to the square of the distance ($A \propto R^2$). In turn, the received pressure is inversely proportional to the square root of the area ($p \propto A^{-1/2}$). Therefore, in a free space the received pressure is inversely proportional to the distance from the source ($p \propto R^{-1}$). In terms of the sound level in decibel, this means that the transmission loss (TL) due to spherical spreading is equal to $20 \cdot \log_{10} R$.

Once the acoustic wave front reaches the seafloor, the spreading can no longer be considered spherical. In the water column, constrained by the sea surface and the sea bottom and at distances greater than the water depth, the acoustic wave front can be approximated more closely as a cylinder. The area of the side of a cylinder is proportional to the radius ($A \propto R$), and the received pressure is thus inversely proportional to the square root of the distance ($p \propto R^{-1/2}$). In decibel terms, the TL due to cylindrical spreading is therefore equal to $20 \cdot \log_{10} R^{1/2}$ or $10 \cdot \log_{10} R$.

In the ocean, the TL due to geometric spreading of the acoustic wave front is generally calculated as spherical spreading for ranges from the source up to the water depth, and as cylindrical spreading beyond that distance.

2.2.2. Absorption

As sound waves propagate they interact at a molecular level with the constituents of sea water through a range of mechanisms, resulting in absorption of some sound energy (Thorp, 1965; Fisher and Simmons, 1977; Francois and Garrison, 1982a,b; Medwin, 2005). This occurs even in completely particulate-free waters in addition to energy losses from scattering by objects such as zooplankton and suspended sediments. The absorption coefficient depends on factors such as temperature, salinity, and pressure and is different for acoustic waves of different frequencies.

The loss of sound energy by absorption is expressed as an attenuation coefficient in units of decibels per kilometer (dB/km). This coefficient is computed from empirical equations and increases generally with the square of frequency.

A representative curve of absorption loss as a function of frequency is shown in **Figure D-1**. The absorption of the acoustic wave energy is virtually nil in the low-frequency range (below 500 hertz [Hz]). It starts having a noticeable effect (at least 1 dB over ranges of 10–20 km) at frequencies above 1 kHz. The absorption loss increases markedly for higher frequencies; for a 100 kHz acoustic signal the absorption loss can exceed 30 dB over just 1 km. In the context of this study, the absorption loss is an important factor for the high-frequency electromechanical sources, whereas it plays virtually no role in the attenuation of sound from airgun sources.

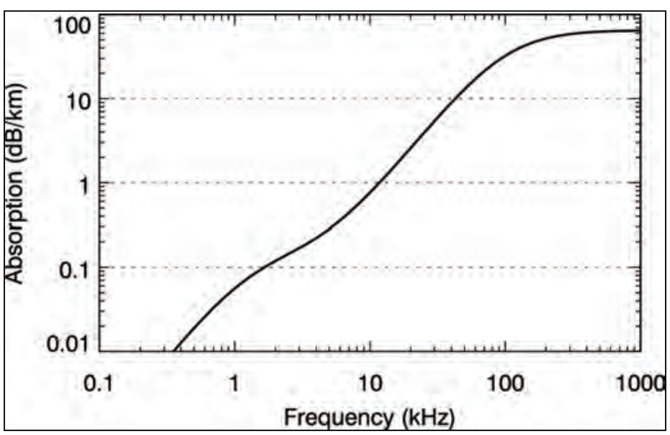

Figure D-1. Sample Plot of Absorption Loss Versus Frequency. T° = 15 °C, Salinity = 33 ppt, z = 50 m.

2.2.3. Refraction

Refraction is a change of direction in a propagating wave caused by spatial variations in sound speed within the medium. As a wave travels across a sound speed interface or gradient, portions of the wave front travel at different speeds, resulting in bending of the ray path (Medwin, 2005). The ray path bends away from a region with a higher sound speed towards a region with a lower sound speed. By affecting travel paths within the medium, refraction can alter the angle of arrival of the sound at a receiver, as well as the angle of incidence upon boundaries (e.g., the seafloor).

In order for refraction to occur, the medium must exhibit a spatial variation of the sound velocity over a scale comparable to the wavelength of the propagating wave. The major variables affecting the sound speed in sea water are the temperature, pressure, and salinity. The dependence is direct for all three variables: with an increase of the parameter the sound speed also increases.

Both temperature and pressure in the ocean have significant variation with depth, resulting in a spread of the sound velocity in the water column that can exceed a 60 meters per second (m/s) differential between maximum and minimum. As the physical parameters of the water can vary with time over a daily or seasonal cycle, so does the sound speed. The longer the period of the variation, the deeper the water layers that can be affected by it. In general, seasonal variations of the sound speed can be observed up to a 300 m depth. Water depths of more than 1,200 m exhibit a uniform sound speed gradient on a global scale.

Figure D-2 presents an example of a sound speed profile that can be observed in the ocean. Seasonal variations occur in the mixed layer, which, depending on ambient conditions, can have either a positive or negative vertical sound speed gradient or none at all. During cold months, when temperature in the upper mixed layer increases with depth, upward refracting conditions can be induced by the positive sound speed gradient in the top water layer. In such conditions sound tends to be channeled in the near-surface layer, referred to as a surface duct, as it is repeatedly reflected downward at the water surface and refracted upward by the positive sound speed gradient (Medwin, 2005). In the underlying thermocline region both temperature and sound speed decline, but below this the temperature is constant and sound speed begins to increase again with depth. The sound velocity minimum results in acoustic refraction from both below and above toward the depth at which the minimum occurs, forming a propagation channel. This allows sound to travel without interaction with the seafloor or the sea surface, significantly reducing TL. The deep sound channel is an important stable channel for long-range propagation, allowing low-frequency sound to travel thousands of kilometers (Medwin, 2005). In shallow continental shelf regions, the water depth is not deep enough to form a deep sound channel. Sound propagation in such regions is, in general, strongly affected by seasonal and daily temperature changes.

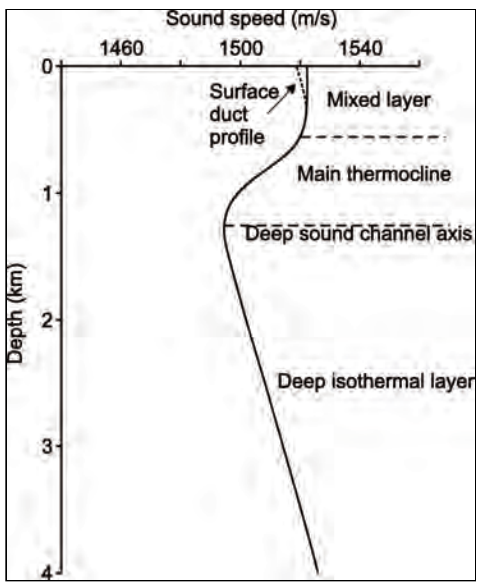

Figure D-2. Generic Sound Speed Profile with Some Common Features Defined.

In deep ocean areas, features of the acoustic field known as convergence zones can be formed because of strong refractive conditions in the deep isothermal layer. Rays emitted from the source at different angles can be focused by refraction in certain volumes, increasing the overall received levels (RLs) compared to the surrounding areas. The increase can be as high as 20 dB; such convergence zones, however, are localized. An example of an acoustic field with convergence zones is shown in **Figure D-3**. In the figure, the convergence zone where the received acoustic level reaches a local maximum can be observed near the surface at 65 and 130 km from the source. In a cross-section view, it would have the form of a ring with a width of several hundred meters and a height of several tens of meters.

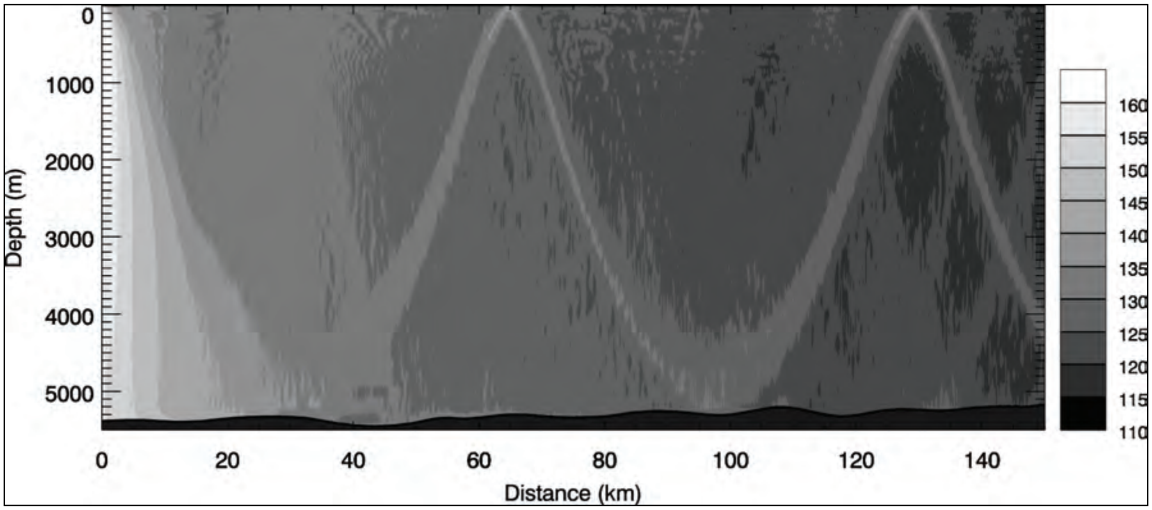

Figure D-3. An Example of an Acoustic Field from an Airgun Array Source with Convergence Zones.

2.2.4. Scattering

Scattering is a general term that covers several types of dispersive phenomena arising from the interaction of a propagating wave front with inhomogeneities in the medium (e.g., suspended particulates, bubbles, buried objects, and air-sea or sea-sediment interfaces). Sound energy arriving at an object may bend around it (diffraction) and/or be scattered back toward the source (backscattering) or other directions. For complex objects (e.g., a rough seafloor), the nature of these interactions can be quite complicated, as individual portions of a wave front are scattered differently (Medwin, 2005). However, if the acoustic wavelength is much greater than the scale of the non-uniformities in the medium (as is most often the case for low-frequency sounds) the effect of scattering on propagation loss is negligible. As the source spectral maximum of airgun arrays is below 200 Hz, sound propagation from such sources is virtually unaffected by scattering. In contrast, scattering loss effects are noticeable for electromechanical sources operating at high frequencies–several kHz and higher.

2.2.5. Bathymetry

Water depth is very influential on sound propagation, particularly at frequencies below a few kilohertz. In shallow water (less than ~100 m depth) acoustic propagation loss is dominated by reflection, transmission, and scattering of sound at the seabed. In deep water (greater than ~ 1 km depth), sound propagation is largely driven by refraction in the water column. At intermediate water column depths, sound propagation is influenced by a combination of these factors.

Low-frequency acoustic waves may not propagate through a shallow water column even in otherwise favorable conditions. If the wavelength of the sound is four times greater than the water depth, mode cut-off does occur (essentially the medium cannot support the oscillation) and the TL increases drastically compared to higher frequency waves (Clay and Medwin, 1977).

Also, as discussed in **Section 2.2.1**, the type of geometric spreading of the acoustic wave front is dependent on the water depth, which defines at which range from the source spherical spreading switches to cylindrical spreading. The TL in the spherical spreading regime is twice as large as in the cylindrical one, so the bathymetry can be very influential on propagation loss for this reason alone.

2.2.6. Source Depth

The radiated power of an underwater sound emitter depends on the position of the source below the sea surface. The propagation model used is designed to fully account for the source depth. The effectiveness of the source at a specific frequency, defined as the ratio of radiated power to the nominal power of the source placed in a free space, increases with depth and depends on the ratio of the source depth to the acoustic wavelength (z_s/λ) (Brekhovskikh and Lysanov, 2003). The effectiveness increases approximately linearly from 0 at $z_s = 0$ to 1.0 at $z_s/\lambda = 1/4$ and 1.2 at $z_s/\lambda = 3/8$. For example, the effectiveness of a broadband source placed at 10 m depth with 1,500 m/s sound velocity will be 1.2 at 56 Hz and only about 0.27 at 10 Hz.

2.2.7. Bottom Loss

Bottom loss is the amount of the original acoustic wave energy that is lost at the water-sediment interface through coupling of the sound into the sediment. Bottom loss, or TL, is the complement of the reflection coefficient, to be defined below.

An acoustic wave travelling in a medium can be reflected from an interface at which abrupt change in geoacoustic parameters is observed. Generally, at the interface only a portion of the total acoustic energy is reflected back, and the rest is transmitted past the interface. The reflection coefficient is the ratio of the amount of the reflected energy to the original energy of an incoming acoustic wave.

The reflection coefficient depends on the discrepancy of the acoustic impedances (defined as the product of density and sound velocity) of the media on each side of the interface. The greater the change of acoustic properties between the media, and hence the mismatch of the impedances, the closer to unity the reflection coefficient is. This coefficient also depends on the incident angle of the acoustic wave; it has its minimal value when the incident angle is 90° (normal to the interface), and it can reach unity at sufficiently glancing angles for certain types of interface.

For the purpose of numerical modeling of sound propagation, the reflection coefficient or bottom loss can be calculated exactly given the properties of the media and the incident angle. In practice, however, there is often uncertainty associated with the estimation of these parameters. The spatial variation of sediment properties can also be significant, which further complicates the estimations. Certain rules of thumb apply to the approximate gauging of bottom loss: since the sound velocity and density of a sediment both increase with grain size, resulting in greater impedance mismatch relative to the water, the bottom loss for sediments with larger grain size is lower than for the sediments with smaller grain size. In general, a sandy bottom is more reflective and thus less acoustically absorptive than a clay bottom.

2.3. Acoustic Impact Criteria

2.3.1. M-Weighting

The potential for anthropogenic underwater noise to affect marine species depends on the species' ability to hear the sounds produced (Ireland et al., 2007). Noises are less likely to disturb animals if they are at frequencies that the animal cannot hear well. An exception is when the sound pressure is so high that it can cause physical injury. For non-injurious sound levels, frequency weighting curves based on audiograms may be applied to weight the importance of sound levels at particular frequencies in a manner reflective of the receiver's sensitivity to those frequencies (Nedwell and Turnpenny, 1998).

An NMFS-sponsored Noise Criteria Committee has proposed standard frequency weighting curves – referred to as M-weighting filters–for use with marine mammal species (Gentry et al., 2004). M-weighting filters are band-pass filter networks that are designed to reduce the importance of inaudible or less-audible frequencies for four marine mammal functional hearing groups:

1. Low-frequency cetaceans;
2. Mid-frequency cetaceans;
3. High-frequency cetaceans; and
4. Pinnipeds.

The amount of discount applied by M-weighting filters for less-audible frequencies is not as great as would be indicated by the corresponding audiograms for these groups of species. The rationale for applying a smaller discount than would be suggested by the audiogram is in part because of an observed characteristic of mammalian hearing that perceived equal loudness curves increasingly have less rapid roll-off outside the most sensitive hearing frequency range as sound levels increase. This is the reason that C-weighting curves for humans, used for assessing very loud sounds such as blasts, are flatter than

A-weighting curves used for quiet to mid-level sounds. Additionally, out-of-band frequencies, though less audible, can still cause physical injury if pressure levels are very high. The M-weighting filters, therefore, are primarily intended to be applied at high sound levels where effects such as temporary or permanent hearing threshold shifts may occur. The use of M-weighting should be considered precautionary (in the sense of overestimating the potential for an effect) when applied to lower level effects such as onset of behavioral response. **Figure D-4** shows the decibel frequency weighting of the four standard underwater M-weighting filters.

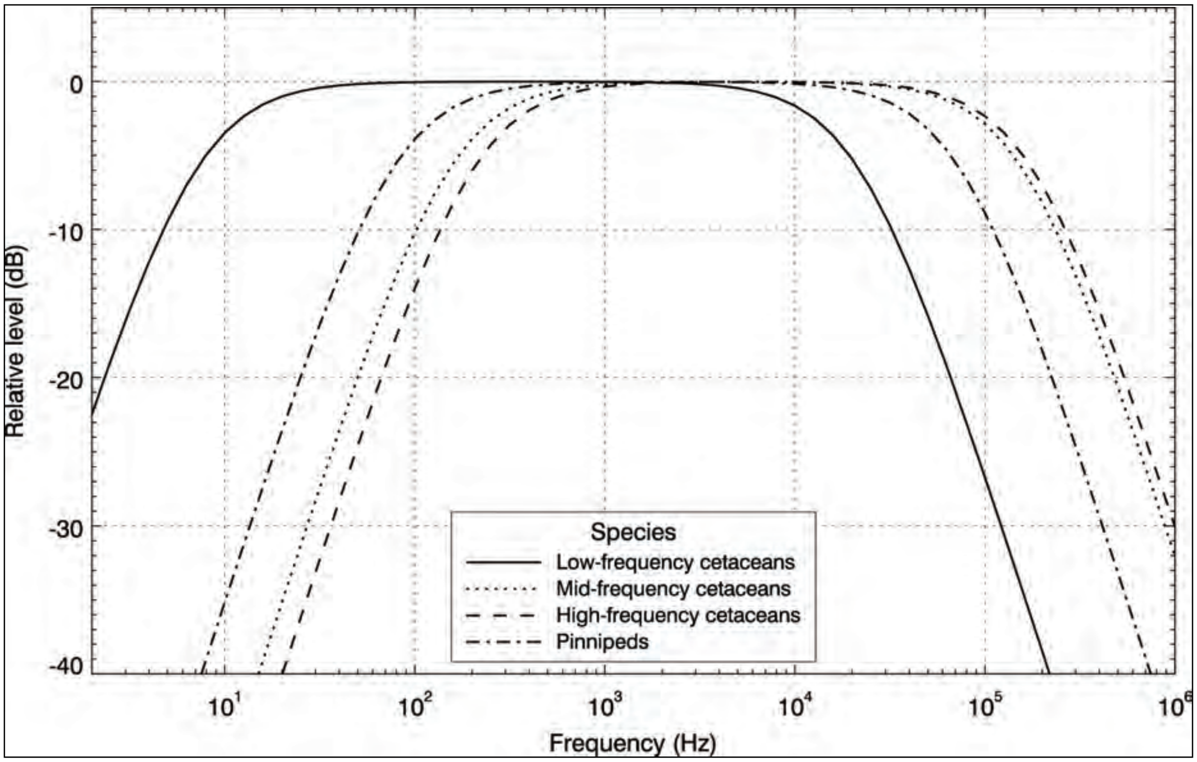

Figure D-4. Standard M-Weighting Curves for Low-, Mid-, and High-Frequency Cetaceans and Pinnipeds Underwater.

The M-weighting filters have unity gain (0 dB) through the pass band, and their high- and low-frequency roll offs are approximately –12 dB per octave. The amplitude response in the frequency domain of the M-weighting filters is defined by:

$$G(f) = -20\log_{10}\left[\left(1+\frac{f_{lo}^2}{f^2}\right)\left(1+\frac{f^2}{f_{hi}^2}\right)\right]\text{dB} \tag{5}$$

The roll off and pass band of these filters are defined by the parameters f_{lo} and f_{hi}. The parameter values of the standard M-weighting curves are presented in **Table D-1**.

The amplitude response of the M-weighting filter is calculated separately for each modeled frequency and added to the received level at that specific frequency to obtain the M-weighted received level:

$$RL_{MW}(f) = RL(f) + G(f) \tag{6}$$

Since the amplitude response of the M-weighting filter calculated using Equation (5) is a negative value, the M-weighted received level is lower than the unweighted one.

Table D-1

Low-Frequency (f_{lo}) and High-Frequency (f_{hi}) Cutoff Parameters for Standard Marine Mammal M-Weighting Curves. Source: Southall et al. (2007).

M-Weighting Filter	f_{lo} (Hz)	f_{hi} (Hz)
Low-frequency cetaceans	7	22,000
Mid-frequency cetaceans	150	160,000
High-frequency cetaceans	200	180,000
Pinnipeds underwater	75	75,000

2.3.2. Consideration of the Minimum Integration Time

The numerical models used for estimating the received levels assume that a virtual receiver does not have a limit on the minimum integration time and therefore the integration time used for the calculation of rms SPL (see Equation [2]) can be as small as the actual length of the pulse emitted by the source. When assessing the impact of the acoustic source on marine mammals, it is important to take the specific properties of the marine mammal hearing apparatus into consideration.

As summarized by Au and Hastings (2008), when receiving tone pulses, the mammalian ear behaves like an integrator with an "integration time constant." Energy is summed over the duration of a pulse until the pulse is longer than the integration time constant. Studies of bottlenose dolphins by Johnson (1968) indicate an integration time constant of approximately 100 ms. Richardson et al. (1995) (Chapter 8.2.4.) summarize a number of studies that compare the effects of short signals (less than 100 ms) with the effect of prolonged signals on marine mammals. It was observed that the thresholds for pulses of 0.2 ms duration were ~ 10–20 dB poorer (i.e., higher). For even shorter pulses, the thresholds can increase by as much as 40 dB.

It can be concluded that the increase in the thresholds with decreasing the signal duration exists because of minimum integration time limitation caused by the specifics of the hearing apparatus of some marine mammals. As such, when calculating the apparent received levels with Equation (2), the minimum integration time should be used for the time interval value T instead of the actual pulse duration. The adjustment for the minimum integration time can be calculated by the following formula:

$$\Delta_{RL} = RL_{app} - RL_{act} = 10\log_{10}\left(\frac{T_{pulse}}{T_{MIT}}\right), \qquad (7)$$

where RL_{app} is the apparent received level that takes into consideration the minimum integration time, RL_{act} is the actual received level calculated using actual pulse duration, T_{pulse} is the pulse length, and T_{MIT} is the minimum integration time. The adjustment is a negative value and should be used only in case $T_{pulse} < T_{MIT}$.

2.3.3. National Marine Fisheries Service Criteria

The NMFS considers two levels of harassment to the marine mammals: Level A (injury) and Level B (disturbance). According to the 1994 Amendments to the Marine Mammal Protection Act (MMPA) of 1972, Level A Harassment is defined as "any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild." Level B Harassment is defined as "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered."

The NMFS (2005) specified that Level A Harassment for pulsed and continuous sources occurs when an animal is exposed to sound pressure levels of 180 dB re 1 µPa rms (for cetaceans) or 190 dB re 1 µPa rms (for pinnipeds). The criterion of 160 dB re 1 µPa rms SPL is considered as Level B Harassment for both mammal groups for pulsed and continuous sources.

The 180–160 dB criteria were thought to be well understood by the public and easily calculated from standard propagation models (*Federal Register*, 2005). Being expressed in rms units, the criteria take into account not only the energy of the pulse, but also the length of the pulse (see Equation [1]). The exposure levels need to be calculated using the unweighted acoustic signal, i.e., they do not take into account different hearing ability of the animals at different frequencies. The disadvantage of such a criterion is that it does not take into account certain important attributes of the exposure such as duration, frequency, or repetition rate (*Federal Register*, 2005).

2.3.4. Southall Criteria

In order to address the shortcomings of the 180–160 dB rms SPL criteria, the Noise Criteria Group was established, which was sponsored by NMFS. The goal of the Noise Criteria Group was to develop updated noise exposure criteria based on solid scientific evidence. In 2007 the findings of the Group, as led by Brandon Southall, were published (Southall et al., 2007). In the publication new noise impact criteria were introduced, now commonly referred to as 'Southall criteria.'

The Southall criteria (**Table D-2**) are based on numerous data collected in the course of controlled and uncontrolled experiments during which different species were exposed to various levels of sound. The observations were made for the occurrence of permanent threshold shift (PTS) or temporary threshold shift (TTS) in animals' hearing. As a result, the criteria for injury were suggested. In terms of behavioral impacts, Southall et al. (2007) did not propose criteria for sources other than a single impulse (e.g., explosion) for the reasons of context-dependence and other complexities in the nature of behavioral responses and available literature.

Table D-2

Southall Criteria for Injury. Source: Southall et al. (2007).

Marine Mammal Group	Injury	
	Peak Pressure	Sound Exposure Level
Low-frequency cetaceans	230 dB re 1 µPa (flat)	198 dB re 1 $\mu Pa^2 \cdot s$ (M_{lf})
Mid-frequency cetaceans	230 dB re 1 µPa (flat)	198 dB re 1 $\mu Pa^2 \cdot s$ (M_{mf})
High-frequency cetaceans	230 dB re 1 µPa (flat)	198 dB re 1 $\mu Pa^2 \cdot s$ (M_{hf})
Pinnipeds underwater	218 dB re 1 µPa (flat)	186 dB re 1 $\mu Pa^2 \cdot s$ (M_{pw})

The injury criteria are based both on peak pressure of the acoustic wave, expressed in dB re 1 µPa, and the total SEL, expressed in dB re 1 $\mu Pa^2 \cdot s$. In order to comply with the criteria, the characteristics of the acoustic wave should not exceed either or both.

Two different levels were established for cetaceans and pinnipeds, with the levels for pinnipeds being lower. Prior to calculation of the sound exposure level appropriate M-weighting filter (see **Section 2.3.1**) would be applied to the acoustic signal to take into account hearing specifics of different mammal groups. During the calculations of the sound exposure level the length of the pulse is not considered, only the total energy released during the pulse event (see Equation [3]).

3. ACOUSTIC SOURCES

The acoustic sources covered in the programmatic modeling study can be subdivided into two major groups:

- airgun sources; and
- electromechanical sources.

An airgun source can consist of a single device, but most often it is made up of an array of airguns. It is considered a low-frequency source since most of its acoustic energy is radiated at frequencies below 200 Hz. Airgun arrays are broadband emitters, with source spectra spanning a number of third-octave bands. A single airgun is an omnidirectional source, i.e. the amplitude of the acoustic wave emitted from the source is uniform in all directions. An airgun array, on the other hand, does exhibit directionality because of the varying delays between signals from the spatially separated airguns in different directions. The main specification of an airgun, which defines its broadband SL and spectral content, is the volume of the air chamber.

Electromechanical sources are considered mid- or high-frequency emitters. They usually have one or two (sometimes three) main operating frequencies, which fall in the range from 2-900 kHz. The acoustic energy emitted outside the main operating frequency band in most of these devices is negligible; they can therefore usually be considered narrow band sources. High-frequency electromechanical sources are highly directive with beam widths as narrow as a few degrees. Electromechanical sources include side-scan sonars, subbottom profilers, single and multibeam depth sounders, boomers, etc.

The list of acoustic sources addressed in this study is presented in **Table D-3**. The operating frequencies and operational application are also provided.

Table D-3

List of Acoustic Source Types Modeled in This Study Indicating Representative Equipment Types, Operating Frequencies, and Survey Application

Type of Acoustic Source	Operating Frequencies	Modeled at Sites		
		Oil and Gas Exploration	Renewable Energy	Marine Minerals
Large airgun array (5,400 in^3)	10-2,000 Hz	●	--	--
Small airgun array (90 in^3)	10-2,000 Hz	●	--	--
Boomer	200-16,000 Hz	●	●	●
Side-scan sonar	100, 400 kHz	●	●	●
Chirp subbottom profiler	3.5, 12,200 kHz	●	●	●
Multibeam depth sounder	240 kHz	●	●	●

A typical hydrographic vessel can be equipped with other survey or auxiliary acoustic sources that were not addressed in this study. Some examples are sparkers and single beam echosounders (also referred to as fathometers). These sources were not considered for modeling, as they either produce an acoustic field similar to another modeled source or the sound field levels are negligible compared to other equipment. The former can be applied to the sparker, as it has acoustic characteristics similar to the boomer and is also used to collect shallow penetration data. The latter can be applied to the single beam echosounder. A typical single beam echosounder has a narrow beam width, less than 20° (Teledyne Odom Hydrographic, Inc., 2011) directed straight down and a low source level 195-205 dB re 1 μPa at 1 m. The lateral extension of the acoustic field from a single beam echosounder would be superceded by the one from other sources with higher source levels and beam directivity closer to the horizontal plane. The description and specifications for a typical sparker source are provided in the report; however, it was not considered for modeling, as the modeling results for the boomer can be used to estimate the acoustic field from a sparker and both are used to collect similar shallow penetration data.

3.1. AIRGUN SOURCES

3.1.1. Seismic Survey Overview

Marine seismic surveys using airgun sources are capable of producing high-resolution, 3D images of geological stratification down to several kilometers depth, and have thus become an essential tool for geophysicists studying the Earth's crust. Seismic airgun surveys can be divided into two types, 2D and 3D, according to the type of data that they acquire. Two-dimensional surveys are so called because they only provide a 2D cross-sectional image of the Earth's structure; they are characterized operationally by large spacing between survey lines, on the order of a kilometer or more. Three-dimensional surveys, on the other hand, rely on very dense line spacing, of the order of a few hundred meters or less, to provide a 3D volumetric image of the underlying geological structures.

The total volume of the airgun array source and the volume of individual airguns for a typical 2D survey are usually larger than for a typical 3D seismic survey. Two-dimensional surveys aim at deeper imaging of the geological structures at the expense of resolution.

A typical seismic survey, either 2D or 3D, is operated from a single survey ship that tows both the seismic source and the receiver apparatus. Up to tens of individual airguns in the source array are fired simultaneously in order to project a high-amplitude seismo-acoustic pulse into the ocean bottom. The receiver equipment usually consists of one or more streamers, often several kilometers in length, that contain hundreds of sensitive hydrophones for detecting echoes of the seismic pulse reflected from subbottom features. In some cases the receiving equipment consists of cabled seismometers placed on the ocean floor. For other seismic surveys, both streamers and ocean-bottom seismometers are used.

The majority of the underwater sound generated by a seismic survey is attributable to the airgun array, the survey vessel itself contributing very little in relative terms to the overall sound field. Airgun arrays are broadband acoustic sources that project energy over a wide range of frequencies, from under 10 Hz to over 5 kHz. Most of the energy, however, is concentrated in the frequency range below 200 Hz. The constituent airguns in the array are geometrically arranged so as to project the maximum amount of seismic energy vertically into the seafloor. A significant portion of the sound energy from the array is, nonetheless, emitted at off-vertical angles and propagated into the surrounding environment. The frequency spectrum of the sound propagating near-horizontally can differ markedly from that of the sound directed downward. There can also be substantial differences in the intensity and frequency spectrum of sound projected in different horizontal directions.

3.1.2. Airgun Operating Principles

An airgun is a pneumatic sound source that creates predominantly low-frequency acoustic impulses by generating bubbles of compressed air in water. The rapid release of highly-compressed air (typically at pressures of ~2,000 psi) from the airgun chamber creates an oscillating air bubble in the water. The expansion and oscillation of this air bubble generates a strongly-peaked, high-amplitude acoustic impulse that is useful for seismic profiling. The main features of the pressure signal generated by an airgun, as shown in **Figure D-5**, are the strong initial peak and the subsequent bubble pulses. The amplitude of the initial peak depends primarily on the firing pressure and chamber volume of the airgun, whereas the period and amplitude of the bubble pulse depend on the chamber volume and firing depth.

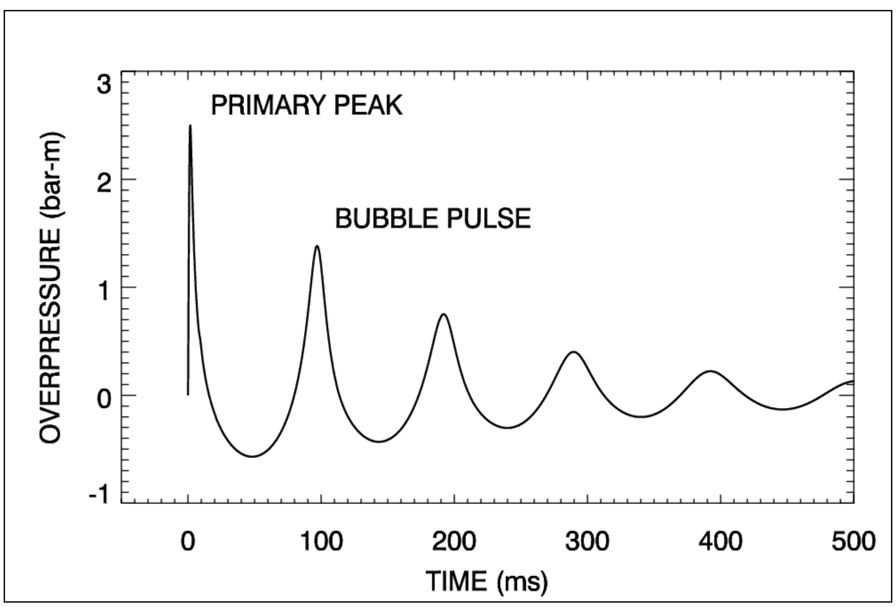

Figure D-5. Overpressure Signature for a Single Airgun, Showing the Primary Peak and the Bubble Pulse.

As mentioned earlier, airguns are designed to generate most of the acoustic energy at frequencies less than ~200 Hz, which are most useful for seismic penetration beneath surficial seabed sediment layers. Because of their impulsive nature, airgun sources inevitably generate sound energy above 200 Hz, although the energy output at those frequencies is substantially less than at low frequencies. In general, the predominant frequency output of an airgun is inversely dependent on its volume.

Zero-to-peak (0-p) SLs for individual airguns range typically between 220 and 235 dB re 1μPa at 1m (~1–6 bar·m), with larger airguns generating higher peak pressures than smaller ones. The peak pressure of an airgun pulse, however, only increases with the cubic root of the chamber volume. Furthermore, the amplitude of the subsequent bubble pulses also increases with the volume of the airgun and constitutes an undesirable feature of the airgun signal as it smears subbottom reflections. In order to increase the pulse amplitude (to "see" deeper into the earth), geophysicists generally combine multiple airguns together into arrays. Airgun arrays provide several advantages over single airguns for deep geophysical surveying:

- the far-field peak pressure of an airgun array in the vertical direction increases nearly linearly with the number of airguns;
- the geometric lay-out of airgun arrays can be optimized to project maximum peak levels toward the seabed (i.e., directly downward), whereas single airguns produce nearly omnidirectional sound; and
- by using airguns of several different volumes, airgun arrays can be "tuned" to increase the amplitude of the primary peak and simultaneously decrease the relative amplitude of the subsequent bubble pulses.

3.1.3. Airgun Array Source Levels

The far-field pressure generated by a seismic airgun array is substantially greater than that of an individual airgun, but is also strongly angle-dependent relative to the array axis. An array of thirty guns, for example, can have a zero-to-peak SL of 255 dB re 1 μPa at 1m (~56 bar·m) in the vertical direction. This apparently high value for the SL can lead to erroneous conclusions about the impact on the marine environment for the following reasons:

- peak SLs for seismic survey sources are usually quoted for the sound propagating vertically downward; because of the directional dependence of the radiated sound field, however, SLs for the sound propagating off to the sides of the array are generally lower; and
- far field SLs do not apply in the near field of the array because an airgun array is a distributed source where the sound from the individual airguns does not add coherently; sound levels in the near field are, in fact, lower than would be expected from far-field estimates.

The acoustic SL of a seismic airgun array varies considerably in both the horizontal and vertical directions because of the complex interaction between the signals from the component airguns. One must account for this variability in order to correctly predict the sound field generated by an airgun array. If the source signatures and relative positions (in 3D) of the individual airguns are known, then it is possible to accurately compute the SL of an array in any direction by summing the contributions of the array elements with the appropriate time delays, according to their relative positions. This is the basis for the airgun array source model discussed in the next section.

3.1.4. Airgun Array Source Model

The current study makes use of a full-waveform AASM, developed by JASCO (MacGillivray, 2006), to compute the SL and directionality of the airgun array. The airgun model is based on the physics of the oscillation and radiation of airgun bubbles, as described by Ziolkowski (1970). The model solves in parallel, using a numerical integration scheme, a set of ordinary differential equations that define the airgun bubble oscillations.

In addition to the basic bubble physics, the source model also accounts for non-linear pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behavior, as described by such authors as Dragoset (1984), Laws et al. (1990), and Landro (1992). The source model includes four empirical parameters that are tuned so that the model output matches observed airgun behavior. These parameters were fitted to a large library of real airgun data using a "simulated annealing" global optimization algorithm. The airgun data were obtained from a systematic study (Racca and Scrimger, 1986) that measured the signatures of Bolt 600/B guns ranging in volume from 5-185 cubic inches (in^3).

The airgun array source model requires several inputs, including the array layout, volumes, towing depths, and firing pressure. The output of the source model is a set of "notional" signatures for the array elements; these are the pressure waveforms of the individual airguns, compensated for the interaction with other airguns in the array, at a standard reference distance of 1 m.

After the source model is executed, the resulting notional signatures are summed together with the appropriate phase delays to obtain the far-field source signature of the array. The far-field array signature, in turn, is filtered into third-octave pass bands to compute the SL of the array as a function of frequency band, f_c, and propagation azimuth, θ: $SL = SL(f_c, \theta)$.

The interaction between the signals from individual airguns creates a directionality pattern in the overall acoustic emission from the array. This directionality is particularly prominent at frequencies from several tens to several hundred Hz; at lower frequencies the array appears omnidirectional, whereas at higher frequencies the pattern of lobes becomes too finely spaced to resolve.

The propagation model, discussed in **Section 4.1**, calculates TL from an equivalent point-like acoustic source to receiver locations at various distances, depths, and bearings. As previously mentioned, however, the point-source assumption is not valid in the near field, where the output from the distinct array elements does not add coherently. The maximum extent of the near field of an array is given by the expression

$$R_{nf} < \frac{L^2}{4\lambda} \tag{8}$$

Here, λ is the frequency dependent sound wavelength and L is the longest dimension of the array (Lurton, 2002, §5.2.4). For example, along the diagonal of the 3-string (18-airgun) array discussed below, L ≈ 22 m and so the maximum near field range is 80 m at 1 kHz (R_{nf} is less for lower frequencies). Beyond these ranges it is assumed that an array radiates like a directional point source and can be treated as such for the purpose of propagation modeling.

3.1.5. Large Airgun Array

A 5,400 in^3 airgun array was taken as a representative example of a large seismic source for oil and gas exploration. The configuration of the array and air gun volumes were suggested in the "MAI Discussion Points about Modeling Assumptions" document.

The array has dimensions of 16 × 15 m and consists of 18 air guns placed in three identical strings of six air guns each (**Figure D-6**). The volume of individual air guns ranges from 105-660 in^3. Firing pressure for all elements is 2,000 psi. The depth below the sea surface for the array was set at 6.5 m.

The array was modeled using the JASCO airgun array source model to compute notional source signatures and from them obtain third-octave band SLs as a function of azimuth angle. The resulting broadside and endfire (relative to the trackline) overpressure signatures and corresponding power spectrum levels are shown in **Figure D-7**. Horizontal third-octave band directionality plots are shown in **Figure D-8**. Specific characteristics of the 5,400 in^3 airgun array pressure signature are provided in **Table D-4**.

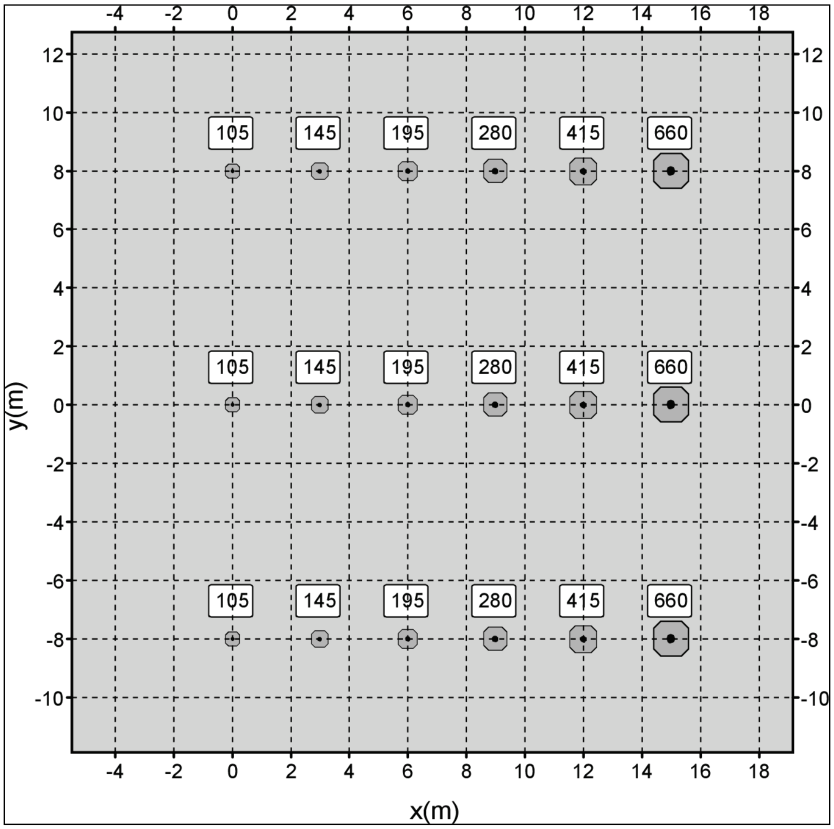

Figure D-6. Layout of the 5,400 in^3 Seismic Array. Symbol Sizes and Labels Indicate the Volume of the Airguns in Cubic Inches.

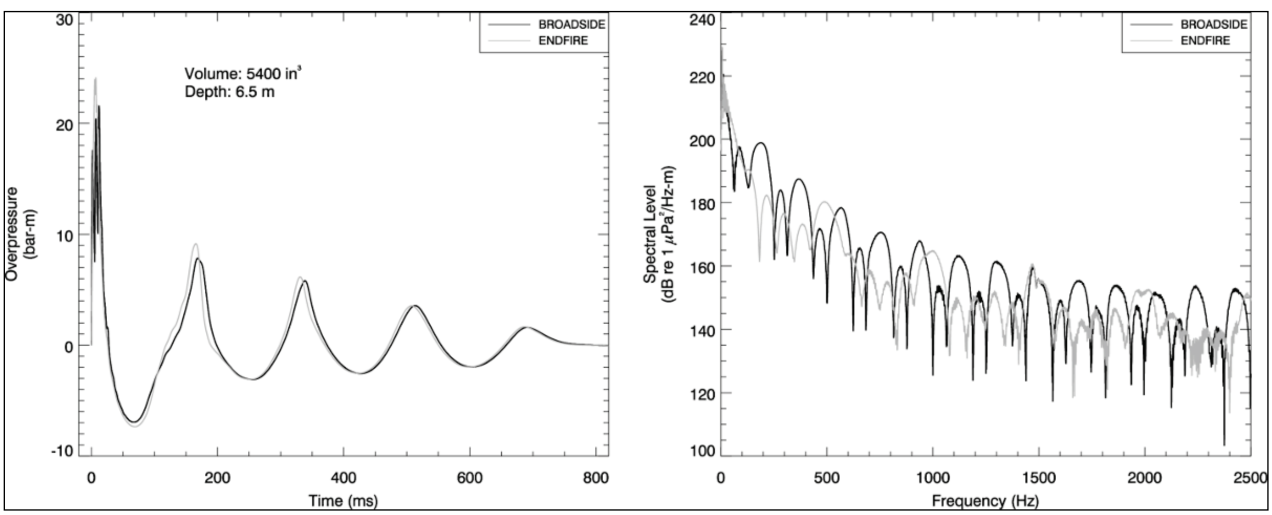

Figure D-7. Predicted Overpressure Signature (left) and Power Spectrum (right) for the 5,400 in^3 Airgun Array in the Broadside and Endfire Directions. Surface Ghosts (Effects of the Pulse Reflection at the Water Surface) Are Not Included in These Signatures.

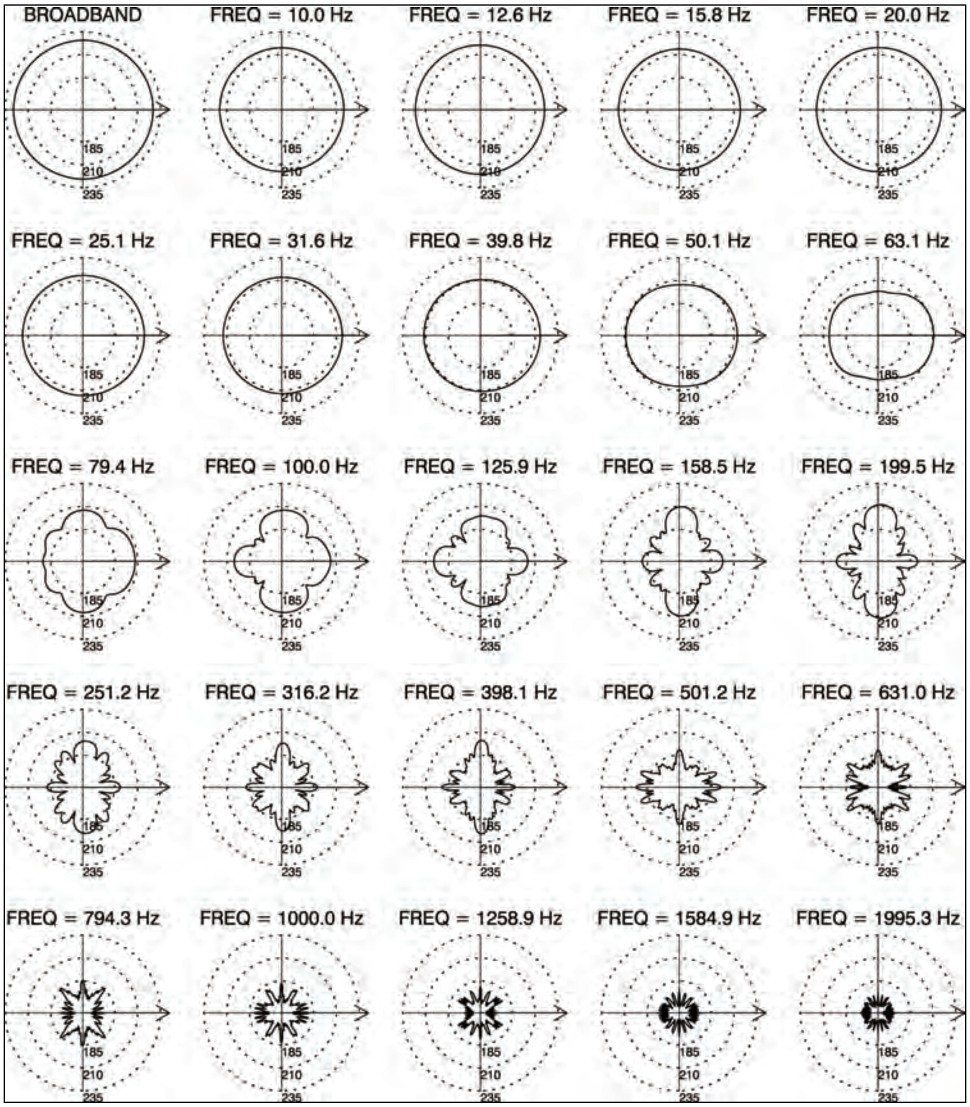

Figure D-8. Azimuthal Directivity Pattern of SLs for the 5,400 in^3 Array at 6.5 m Depth, Shown in Third-Octave Bands by Center Frequency. Arrows Indicate the Front of the Array and the Solid Black Curves Indicate the Source Levels in dB re 1 µPa^2·s as a Function of Angle in the Horizontal Plane, Referenced to a Fixed Radial dB Level Scale (Dashed Circles).

Table D-4

The 5,400 in^3 Airgun Array Pressure Characteristics from the AASM Model at 6.5 m Depth. Surface Ghost Effects Are Excluded

Metric	Forward Endfire	Broadside
Zero-Peak Pressure (dB re 1 µPa at 1 m)	247.7	246.7
90% rms level (dB re 1 µPa at 1 m)	233.3	232.5
90% rms duration (ms)	500	513
SEL 10–2,000 Hz (dB re 1 µPa^2·s at 1 m)	224.7	224.7
SEL 0–1,000 Hz (dB re 1 µPa^2·s at 1 m)	230.7	230.0
SEL 1,000–2,000 Hz (dB re 1 µPa^2·s at 1 m)	181.7	181.8

The directivity of the airgun arrays source is markedly dependent on the array configuration. The maximum pressure levels in each frequency band (over all directions), on the other hand, are less strongly dependent on the configurations and can be considered as a function of the total volume of the array. In view of the generalized nature of this study it was decided to remove the directivity from the source modeling by calculating the maximum level over all azimuths in each third-octave band and using those band levels for all directions. The resulting SLs for the 5,400 in^3 airgun are shown in **Figure D-9**.

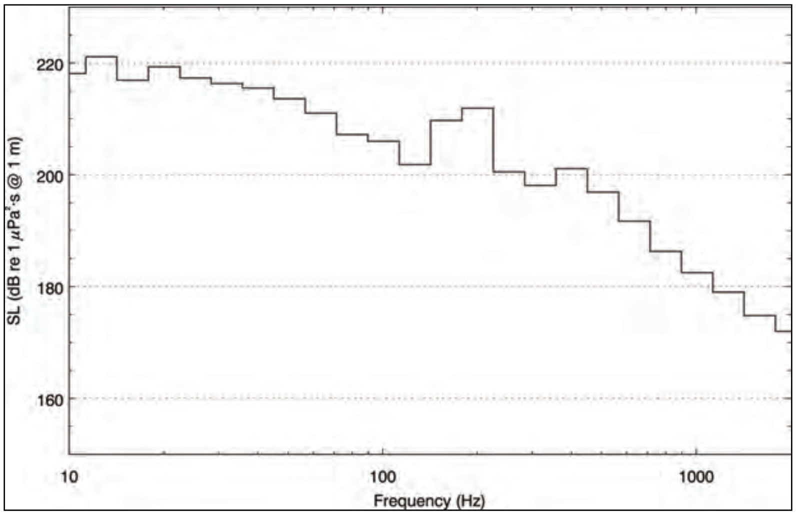

Figure D-9. Maximum Directional SLs in Each Third-Octave Band for the 5,400 in^3 Airgun Array.

3.1.6. Small Airgun Array

A 90 in^3, two airgun array was taken as representative configuration for the purpose of modeling a small seismic source typically used for high-resolution geophysical (HRG) surveys of oil and gas exploration and development sites. The two guns were assumed to be 45 in^3 each, spaced 1 m from each other and deployed at a depth of 6.5 m. The source modeling considerations for the 90 in^3 airgun array were similar to the ones for the large airgun array (see **Section 3.1.5**), including the removal of the directivity from the source function by assuming that the maximum directional acoustic level in each third-octave band is emitted in all directions.

Specific characteristics of the 90 in^3 airgun array pressure signature are provided in **Table D-5**. The observed maximum levels in third-octave bands for the 90 in.^{3} airgun array are shown in **Figure D-10**.

Table D-5

The 90 in^3 Airgun Array Pressure Characteristics from the AASM Model at 6.5 m Depth.
Surface Ghost Effects Are Excluded

Metric	Forward Endfire	Broadside
Zero-peak Pressure (dB re 1 μPa at 1 m)	232.0	231.2
90% rms level (dB re 1 μPa at 1 m)	215.9	215.8
90% rms duration (ms)	247	248
SEL 10–2,000 Hz (dB re 1 μPa^2·s at 1 m)	210.2	210.1
SEL 0–1,000 Hz (dB re 1 μPa^2·s at 1 m)	210.3	210.2
SEL 1,000–2,000 Hz (dB re 1 μPa^2·s at 1 m)	172.6	170.1

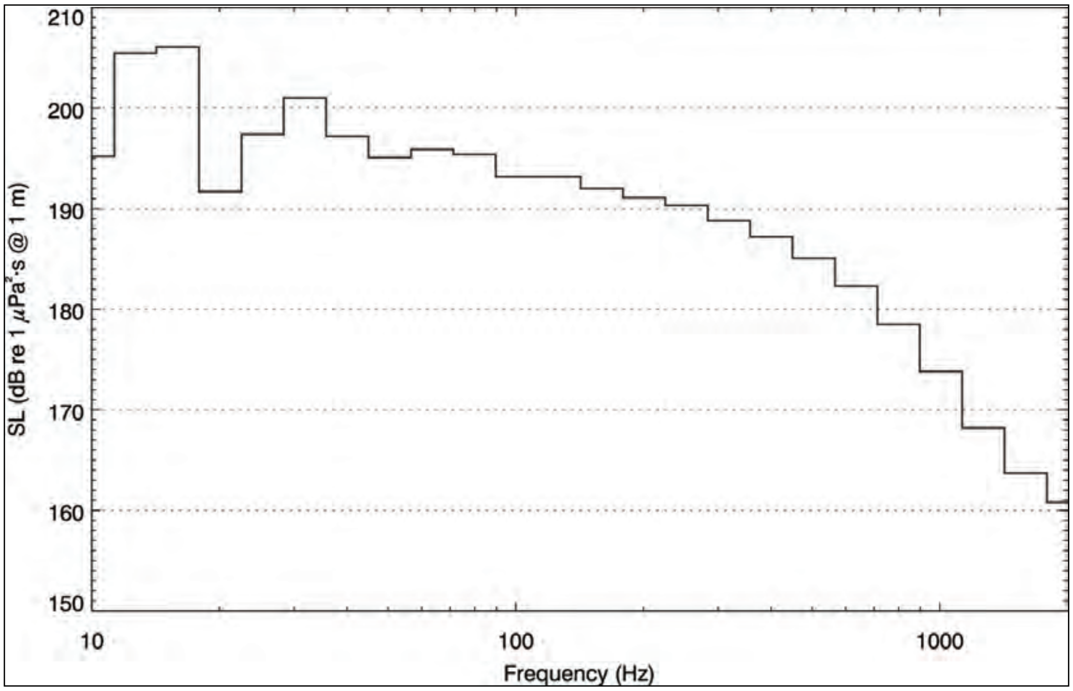

Figure D-10. Maximum Directional SLs in Each Third-Octave Band for the 90 in^3 Airgun Array.

3.2. Electromechanical Sources

Mid- and high-frequency underwater acoustic sources for geophysical measurements create an oscillatory overpressure through rapid vibration of a surface, using either electromagnetic forces or the piezoelectric effect of some materials. A vibratory source based on the piezoelectric effect is commonly referred to as a transducer, and may be capable of receiving as well as emitting functionality.

The transducers are usually designed to excite an acoustic wave of a specific frequency, often in a highly directive beam. The directional capability increases with increasing operating frequency. The main parameter characterizing the directivity is the beam width, defined as the angle subtended by diametrically opposite "half power" (-3 dB) points of the main lobe. For different transducers at a single operating frequency the beam width can vary from 180° (almost omnidirectional) to only a few degrees.

Transducers are usually produced with either circular or rectangular active surfaces. For circular transducers the beam width in the horizontal plane (assuming a downward pointing main beam) is equal in all directions. Rectangular transducers produce more complex beam patterns with variable beam width in the horizontal plane; two beam width values are usually specified for orthogonal axes.

3.2.1. Beam Pattern Calculation

The acoustic radiation pattern, or beam pattern, of a transducer is the relative measure of acoustic transmitting or receiving power as a function of spatial angle. Directionality is generally measured in decibels relative to the maximum radiation level along the central (acoustic) axis perpendicular to the transducer surface. The pattern is defined largely by the operating frequency of the device and the size and shape of the transducer.

Beam patterns generally consist of a main lobe extending along the central axis of the transducer, and multiple secondary lobes separated by nulls. The width of the main lobe depends on the size of the active surface relative to the sound wavelength in the medium, with larger transducers producing narrower beams. **Figure D-11** presents a 3D visualization of a typical beam pattern for a circular transducer.

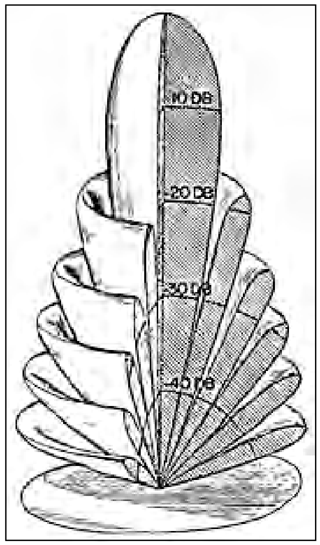

Figure D-11. Typical 3D Beam Pattern for a Circular Transducer. Source: Massa (1999).

The beam width is a key characteristic of transducers. It is generally defined as the total angular range where the sound pressure level of the main beam is within 3 dB of the on-axis peak power (Massa, 1999). The true beam pattern of a transducer can only be obtained by *in situ* measurement of the emitted energy around the device, as shown in the example of **Figure D-12**. Such data, however, are not always readily available, and for modeling purposes it is often sufficient to estimate the beam pattern based on transducer theory.

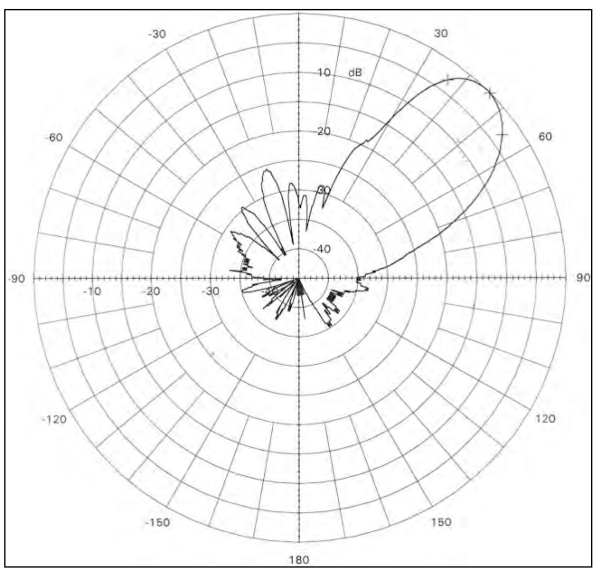

Figure D-12. 2D Polar Representation of a Beam Pattern Obtained by *In Situ* Measurement (Vertical Slice) of a Transducer Used by Kongsberg. These Sample Measurements Were Obtained through Personal Communications with the Manufacturer.

3.2.2. Beam Pattern of a Circular Transducer

The beam of an ideal circular transducer is symmetric about the main axis; the radiated level depends only on the depression angle (off main axis angle). In this study, beam directivities were calculated from the standard formula for the beam pattern of a circular transducer (Kinsler et al., 1950; ITC, 1993). The directivity function of a conical beam, relative to the on-axis pressure amplitude, is given by:

$$R(\phi) = \frac{2 \cdot J_1(\pi\, D_\lambda\, sin(\phi))}{\pi\, D_\lambda\, sin(\phi)} \quad \text{and} \quad D_\lambda = \frac{60}{\theta_{bw}}, \tag{9}$$

where J_1 is the Bessel function of the first order, D_λ is the transducer dimension (e.g., diameter) in wavelengths of sound in the water, θ_{bw} is the beam width in degrees, and ϕ is the beam angle from the transducer axis. The beam pattern of a circular transducer can be calculated from the transducer's specified beam width or from the diameter of the active surface and the operating frequency. The calculated beam pattern for a circular transducer with a beam width of 20° is shown in **Figure D-13**. The gray scale represents the SL (in dB re 1 µPa at 1 m) and the declination angle is relative to a central vector (0°, 0°) pointing directly downward at the seafloor.

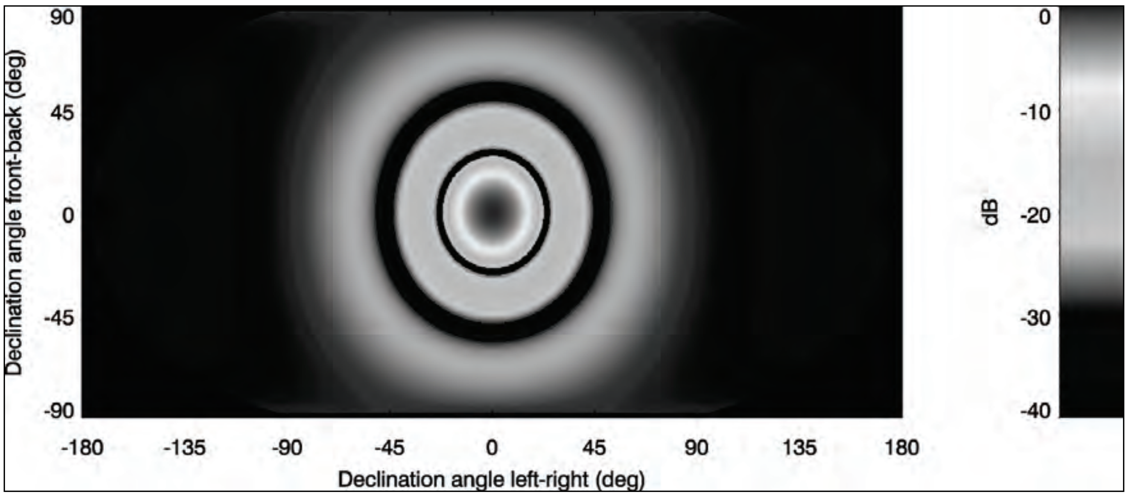

Figure D-13. Calculated Beam Pattern for a Circular Transducer with a Beam Width of 20°. Beam Power Function Shown Relative to the On-axis Level, Using the Robinson Projection.

Although some acoustic energy is emitted at the back of the transducer, the theory only accounts for the beam power in the front half space (ϕ <90°) and assumes no energy directed into the back half space. The relative power at these rearward angles is significantly lower, generally by more than 30 dB, and consequently the emission in the back half space can be estimated by applying a simple decay rate, in dB per angular degree, which reduces the beam power at ϕ = 90° to a value 30 dB lower than at ϕ = 0°. This simple estimate of the beam power in the back half space allows a conservative estimate of the total beam power.

3.2.3. Beam Pattern of a Rectangular Transducer

Rectangular transducer beam directivities were calculated from the standard formula for the beam pattern of a rectangular acoustic array (Kinsler et al., 1950; International Transducer Corporation, 1993). This expression is the product of the toroidal beam patterns of two line arrays, where the directional characteristics in the along- and across-track directions are computed from the respective beam widths. The directivity function of a toroidal beam, relative to the on-axis pressure amplitude, is given by:

$$R(\phi) = \frac{sin(\pi\, L_\lambda\, sin(\phi))}{\pi\, L_\lambda\, sin(\phi)} \quad \text{and} \quad L_\lambda = \frac{50}{\theta_{bw}}, \tag{10}$$

where L_λ is the transducer dimension in wavelengths, θ_{bw} is the beam width in degrees, and ϕ is the angle from the transducer axis. The beam pattern of a transducer can be calculated using either the specified beam width in each plane or the dimensions of the active surface and the operating frequency of the transducer. The calculated beam pattern for a rectangular transducer with along- and across-track beam widths of 4° and 10°, respectively, is shown in **Figure D-14**.

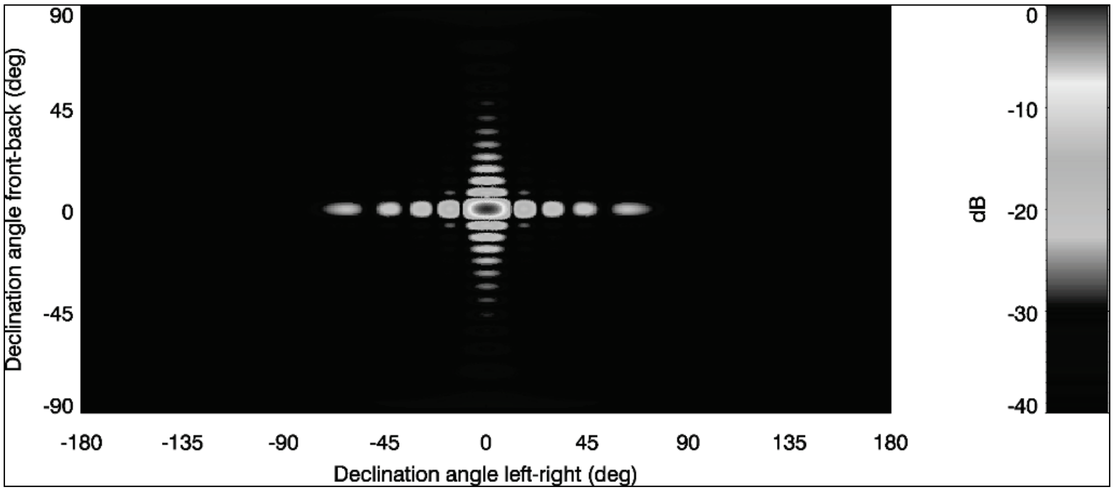

Figure D-14. Calculated Beam Pattern for a Rectangular Transducer With a 4°×10° Beam Width. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

3.2.4. Beam Pattern of a Multibeam System

High-frequency systems often have two or more transducers, as is the case for side-scan sonars and swath bathymetry sonars. Typical side-scan sonar uses two transducers, with the central axes directed perpendicular to the track of the ship and at some depression angle to the horizontal plane. By contrast, multibeam bathymetry survey systems can have upwards of 100 transducers. Such systems generally utilize rectangular transducers and have a narrow beam width in the horizontal plane (0.2°–3°) and a wider beam width in the vertical plane.

For multibeam systems, the beam patterns of individual transducers are calculated separately then combined into the overall pattern of the system based on the engagement type of the beams, which can be simultaneous or successive. If the beams are engaged successively, the SL of the system along a specific direction is assumed to be equal to the maximum SL realized from each of the individual transducers, whereas if the beams are engaged simultaneously, the beam pattern of the system is simply the sum of all beam patterns. **Figure D-15** presents the predicted beam pattern for two rectangular transducers engaged simultaneously. In this example, the individual transducers have along- and across-track beam widths of 1.5° and 50°, respectively.

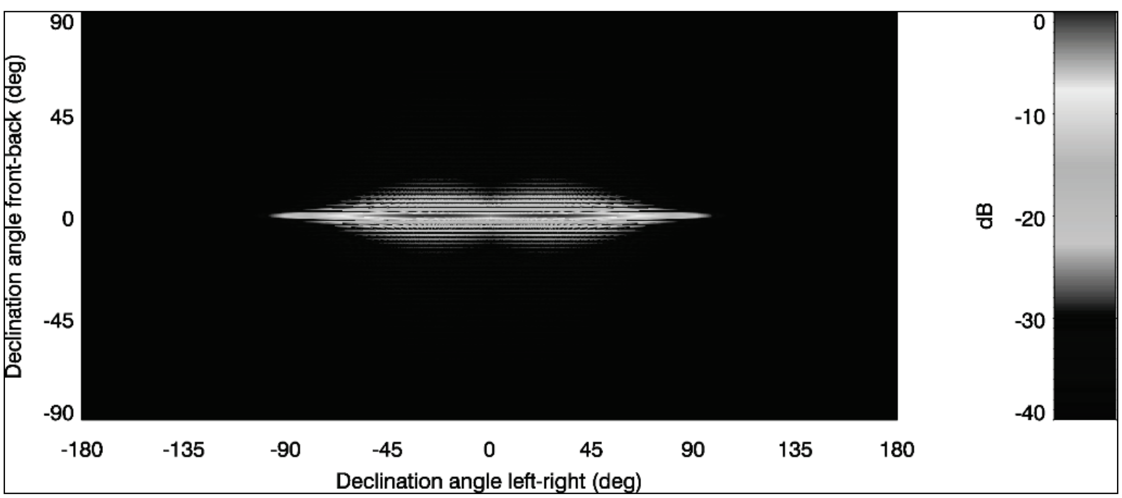

Figure D-15. Calculated Beam Pattern for Two Rectangular Transducers Engaged Simultaneously, with Individual Beam Widths of 1.5°×50°, and a Declination Angle of 25°. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

3.2.5. Boomer

3.2.5.1. Boomer Source Description

Boomers consist of a circular piston moved by electromagnetic force; the emitter plate of a surface towed boomer system is shown in **Figure D-16**. The high voltage energy that excites the boomer plate is stored in a capacitor bank; operating voltages range from 1-6 kilovolts (kV), and the energy discharged for a single shot can vary from 50 joules (J) to 2 kilojoules (kJ). The typical pulse width is in order of tenths of a millisecond (**Figure D-17**). The narrow pulse allows the boomer to achieve high rms SPL (210–220 dB re 1 µPa at 1 m) with relatively low total energy input. The peak pressure level for a boomer with the input energy less than 400 J do not exceed 220 dB re 1 µPa at 1 m (Simpkin, 2005).

Figure D-16. A Surface Towed Boomer Source. Source: Simpkin (2005).

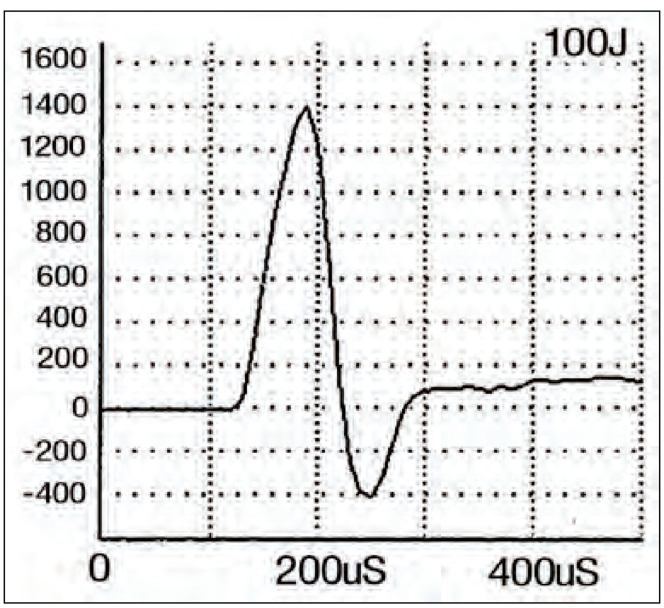

Figure D-17. Source Pulse of the AA201 Boomer at 100 J Energy Output. Source: Applied Acoustic Engineering Ltd. (2011).

The amount of energy discharged is controlled by increasing either the voltage or the size of the capacitor. Increasing the voltage, for a given capacitance, shortens the pulse duration and thus shifts the spectral band of generated acoustic energy toward higher frequencies. Increasing the capacitance for a given voltage increases the pulse length and thus generates lower frequencies. In both cases the peak amplitude and broadband SL increase. By controlling the parameters of the applied electrical impulse, frequencies as high as 20 kHz can be generated. The power spectrum of the acoustic wave generated by a boomer source peaks at 1.5–5 kHz (Simpkin, 2005). Boomer systems can penetrate as deep as 200 m in soft sediments, with a resolution as small as 75 centimeters (cm) (Simpkin, 2005). Boomer sources show some directionality, which increases with the acoustic frequency; at frequencies below 1 kHz they can usually be considered omnidirectional.

3.2.5.2. Acoustic Characteristics

The emitting element of the boomer source is a boomer plate with the diameter of about 30–40 cm mounted on a catamaran-like sled as shown in **Figure D-18** (Applied Acoustic Engineering Ltd., 2011). Because the boomer source is a circular piston surrounded by a rigid baffle, it cannot be considered a point-like source (Verbeek and McGee, 1995). The boomer is a strongly directive source for frequencies at which the boomer dimension is not small compared to the wavelength; by this criterion the boomer becomes directional at frequencies above 1 kHz. In order to produce estimates of the sound field for a generic boomer source, the specifications of the Applied Acoustics AA201 boomer were taken to represent a standard system.

Figure D-18. An Example of a Representative Boomer Plate System. Source: Applied Acoustic Engineering Ltd. (2011).

The manufacturer's product fact-sheet specifies an rms SPL of 212 dB re 1 μPa at 1 m at 200 J (maximum input energy) with a pulse duration less than 0.18 ms and a typical ping rate of 2–3 Hz (**Table D-6**). The peak source level was estimated based on the rms SPL source level using the relation between the peak and rms levels for a sine wave. The source level expressed in SEL units (dB re 1 $\mu Pa^2 \cdot s$) was estimated based on the rms SPL and the pulse length using Equation (4). Please refer to **Attachment A** for recent findings resulting from a sound source verification study on an AP3000 boomer system.

Table D-6

Representative Boomer Specifications. The Source Levels Are Provided for 200 J Power Input

Operational Frequency Range	Broad Band: 200 Hz – 16 kHz
Beam Widths (degrees)	omnidirectional – 8°
Maximum Energy Input (per shot)	300 J
Maximum Power Input	600 W
Pulse Length (at 200 J)	180 µs
rms SPL (dB re 1 µPa at 1 m)	212
Peak Level (dB re 1 µPa at 1 m)	215
SEL (dB re 1 µPa^2·s at 1 m)	174.6

The power spectrum of the boomer signal and the beam width at different frequencies was estimated based on Simpkin's (2005) study of the Huntec '70 Deep Tow Boomer, a typical boomer plate of comparable dimensions. The estimated values are presented in **Table D-7**.

Table D-7

Estimated Source Levels (rms SPL) and Beam Width from the Representative Boomer Distributed into Twenty 1/3-Octave Bands. Broad Band Source Level Is 212 dB 1 µPa at 1 m

Third-Octave Band Center Frequency (Hz)	rms SPL (dB re 1 µPa at 1 m)	SEL (dB re 1 µPa^2·s at 1 m)	Beam Width
200	196.0	158.6	omnidirectional
250	196.4	159.0	omnidirectional
315	197.1	159.7	omnidirectional
400	197.7	160.3	omnidirectional
500	198.5	161.1	omnidirectional
630	199.4	162.0	omnidirectional
800	200.0	162.6	omnidirectional
1,000	200.8	163.4	omnidirectional
1,250	201.5	164.1	105°
1,600	201.6	164.2	78°
2,000	201.9	164.5	60°
2,500	201.4	164.0	47°
3,150	200.8	163.4	37°
4,000	200.1	162.7	29°
5,000	198.9	161.5	23°
6,400	197.8	160.4	18°
8,000	196.1	158.7	14°
10,000	192.8	155.4	11°
12,800	186.8	149.4	9°
16,000	176.8	139.4	8°

The beam pattern calculations were then based on the standard formula for the beam pattern of a circular array (Equation [2]), with a decay rate in the back half space of 0.30 dB per degree from the horizontal plane, in order to reduce the back SL to -30 dB or less. **Figures 19** and **20** show the flat image and vertical slice for the calculated beam pattern at (a) 1.25 and (b) 16.0 kHz.

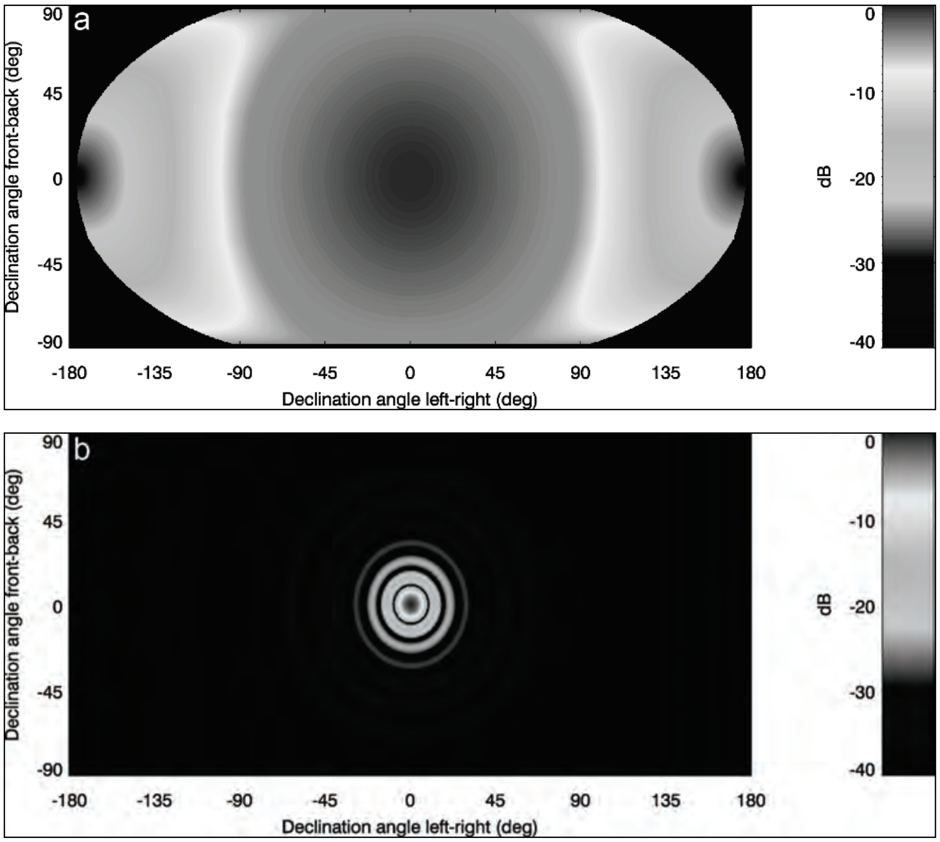

Figure D-19. Calculated Beam Pattern for the Representative Boomer at (a) 1.25 and (b) 16.0 kHz. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

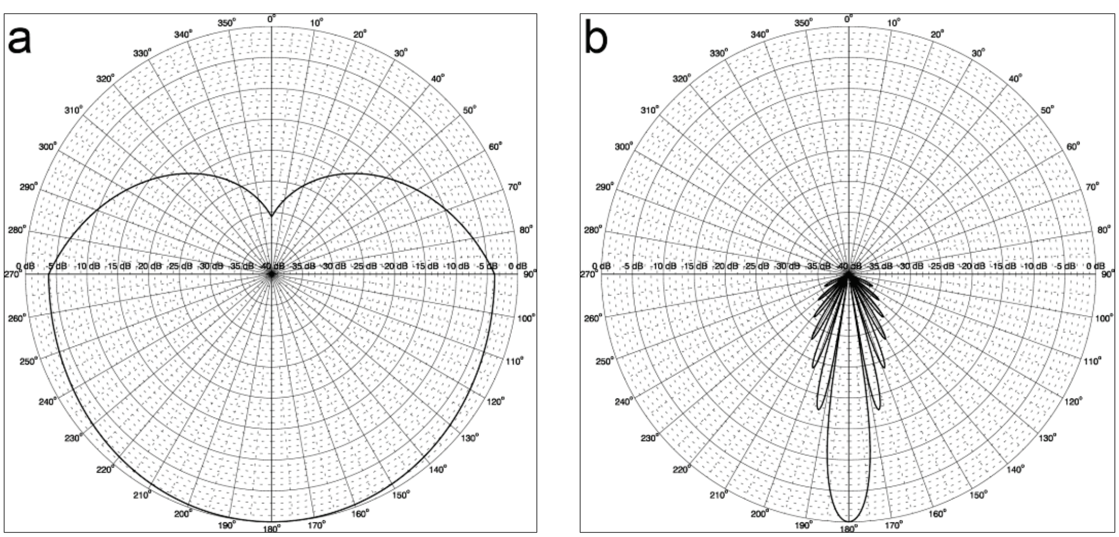

Figure D-20. Calculated Beam Pattern Vertical Slice for the Representative Boomer at (a) 1.25 and (b) 16.0 kHz; Across-Track Direction.

The boomer source can be treated as an omnidirectional source for the frequencies of 1,000 Hz and lower. For frequencies higher than 1,000 Hz the directionality of the boomer was taken into account. The acoustic field projected by the boomer source was modeled using two propagation models: for frequencies of 1,000 Hz and below were modeled using MONM-RAM, while frequencies above 1,000 Hz were modeled using MONM-BELLHOP.

3.2.6. Side-Scan Sonar

The representative side-scan sonar is assumed to be a dual-frequency side-scan sonar with two simultaneously-engaged transducers, each producing a full spectrum chirp signal (**Figure D-21**). The sonar can be operated in dual-frequency bands with central frequencies of 100/400 kHz. In order to produce estimates of the sound field for a generic side-scan sonar source, the specifications of the EdgeTech 4200-MP side-scan sonar were taken to represent a standard system. (EdgeTech, 2011).

Figure D-21. An Example of a Representative Side-Scan Sonar System. Source: EdgeTech (2011).

The sonar is installed inside a streamlined towfish that can be towed behind a vessel at different depths. The central axes of the two transducers are oriented perpendicular to the towing line in the horizontal plane, i.e., at 90° and 270° relative to the ship's course. In the vertical plane, the central axes are tilted downward at 20° to the horizontal plane. The vertical beam width (across-track) is 50° for both frequencies. The horizontal beam width (along-track) varies between 0.4° and 1.26°, depending on the frequency and the operating mode. The relevant modeling parameters for the representative side-scan sonar system are presented in **Table D-8**.

Table D-8

Representative Side-Scan Sonar Parameters for the High-Speed and High-Definition (HD) Operating Modes

	100 kHz		400 kHz	
	High-Speed	HD	High-Speed	HD
Output pulse energy (J)	4		2	
Pulse duration (ms)	≤20		≤10	
rms SPL (dB re 1 µPa at1 m)	212	217	215	218
Transducers	2			
Transducer along-track beam width	1.26°	0.64°	0.40°	0.30°
Transducer across-track beam width	50°			
Transducer declination	20°			
Transducer azimuth	90°, 270°			

Each transducer's beam directivity was calculated based on the standard formula for the beam pattern of a rectangular transducer. These 3D beam patterns were then summed to produce the final sonar beam pattern. **Figure D-22** presents the calculated beam power function for the representative side-scan sonar system at 100 kHz, operating in (a) high-speed mode and (b) high-definition mode. **Figure D-23** shows vertical slices of the beam pattern at 100 kHz in the along- and across-track directions, for the sonar operating in high-speed mode.

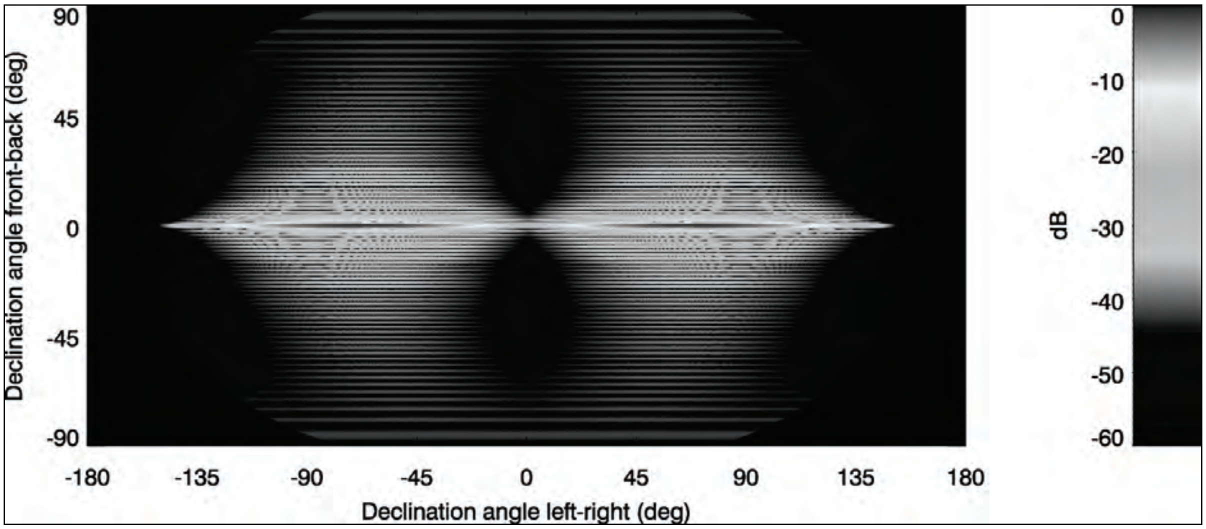

Figure D-22. Calculated Beam Pattern for the Representative Side-Scan Sonar at 100 kHz, Operating in High-Speed Mode. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

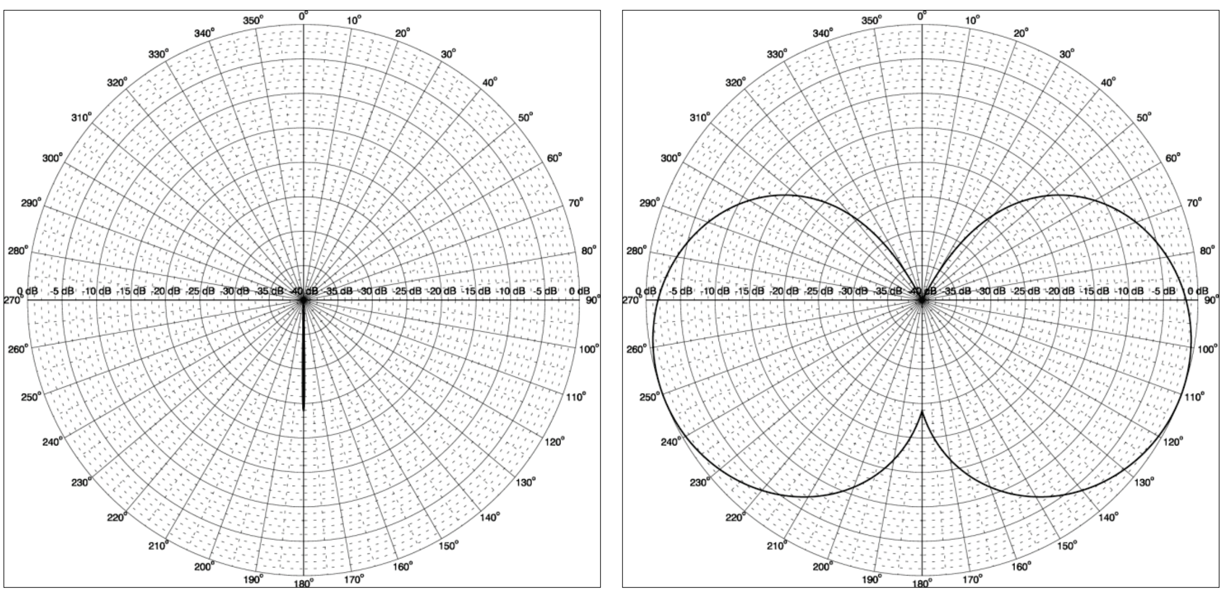

Figure D-23. Calculated Beam Pattern Vertical Slice for the Representative Side-Scan Sonar at 100 kHz Operating in High-Speed Mode; (left) Along- and (right) Across-Track Directions.

Modeling Approach

The side-scan sonar was modeled in the high-speed operation mode with 100/400 kHz frequencies. The SL for the purpose of modeling was chosen to be 223 dB re 1 µPa at 1 m in each of the two frequency bands, for a total broadband rms SPL of 226 dB re 1 µPa at 1 m. The tow depth of the source was chosen to be 5 m for modeling purposes. For the chosen rms SPL source level, the source levels in terms of the peak pressure level was calculated to be 229 dB re 1 µPa at 1 m. The SEL in each of the two bands was estimated at 206 dB re 1 $\mu Pa^2 \cdot s$ at 1 m considering the pulse length of 20 ms.

With a very narrow beam width, the variability of the emitted energy in different directions in the horizontal plane is very high. A circular fan of modeling radials with variable angular step (see **Table D-9**) was created to a maximum range of 1.5 km from the source. The density of the radials was greater in proximity of the broadside, where beam variability is maximum, and lesser toward the endfire. The total number of rays modeled was 660.

Table D-9

Variable Angular Steps of the Modeling Radials in Different Sectors. Only the Steps for the First Quadrant (0°-90°) Are Shown; Those for the Other Quadrants Were Symmetrical

Sector	Angular Step
0° – 45°	1°
45° – 80°	0.5°
80° – 90°	0.2°

The towing direction for each modeling site was selected individually based on the bathymetry, making the assumption that survey lines would run along the isobaths. The sound field was modeled using the MONM-BELLHOP acoustic propagation code. Since the SL was provided in rms SPL units, the output from the modeling was directly in terms of the rms SPL metric.

3.2.7. Chirp Subbottom Profiler

For the purpose of modeling a generic subbottom profiler source, the Knudsen Chirp 3260 model was chosen as representative example. This device is capable of working in three frequency bands simultaneously, providing subbottom images with acoustic signals at 3.5 kHz, 12 kHz, and 200 kHz. It uses two transducers, one operating at 3.5 kHz and the other at dual frequencies of 12 kHz and 200 kHz. The sonar head is mounted at the bottom of the ship's hull, with the central axes of both transducers oriented directly downward.

The SL of the 3.5 kHz transducer is 222 dB re 1 µPa at 1 m at 3 kilowatt (kW) output power level (LGL, 2010). The maximum output power levels for the 12 kHz and 200 kHz bands are 3 kW and 0.5 kW respectively. As no direct information about SLs was available for the 12 kHz and 200 kHz bands, these were estimated based on the output power levels for these bands relative to the output power level and corresponding SL for the 3.5 kHz band. The specifications of the subbottom profiler used for the modeling are presented in **Table D-10**.

The beam patterns were estimated using a mathematical model based on beam forming theory. Since the transducers are hull mounted, it was assumed that the most of the acoustic energy is emitted in the downward half-space and that the upward component is negligible.

Figures D-24 through **D-26** present the calculated beam power function for the representative chirp subbottom profiler at 3.5, 12, and 200 kHz, respectively. Vertical slices of the beam patterns for the same three frequencies are shown in **Figures D-27** through **D-29**.

Table D-10

Representative Chirp Subbottom Profiler Specifications

	3.5 kHz	12 kHz	200 kHz
Beam	Circular 30°	Rectangular 26° by 38°	Circular 8°
Output power	3 kW	3 kW	0.5 kW
rms SPL (dB re 1 µPa at 1 m)	222	222	215.2
Peak level (dB re 1 µPa at 1 m)	225	225	218.2
SEL (dB re 1 $\mu Pa^2 \cdot s$ at 1 m)	210.1	210.1	191.2
Total peak level (dB re 1 µPa at 1 m)	228.2		
Ping duration (max)	64 ms		4 ms

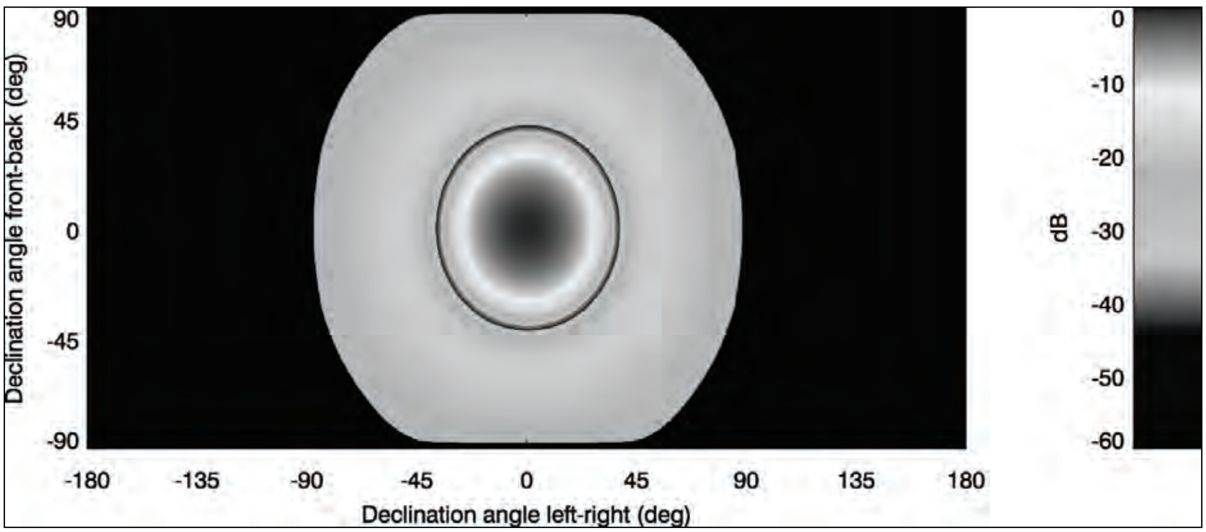

Figure D-24. Calculated Beam Pattern for a Representative Chirp Subbottom Profiler at 3.5 kHz. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

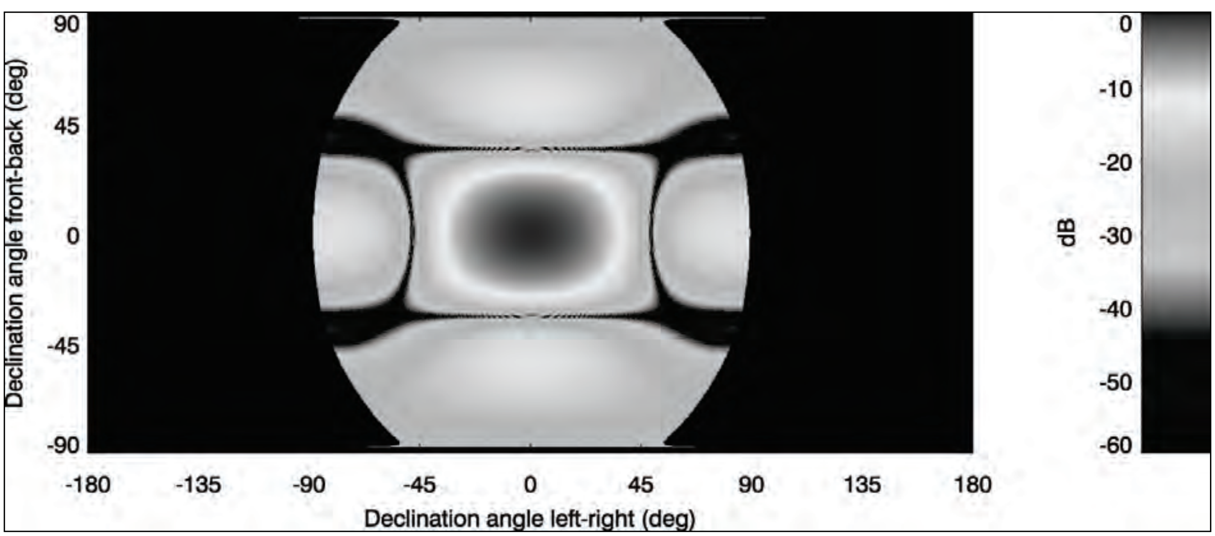

Figure D-25. Calculated Beam Pattern for a Representative Chirp Subbottom Profiler at 12 kHz. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

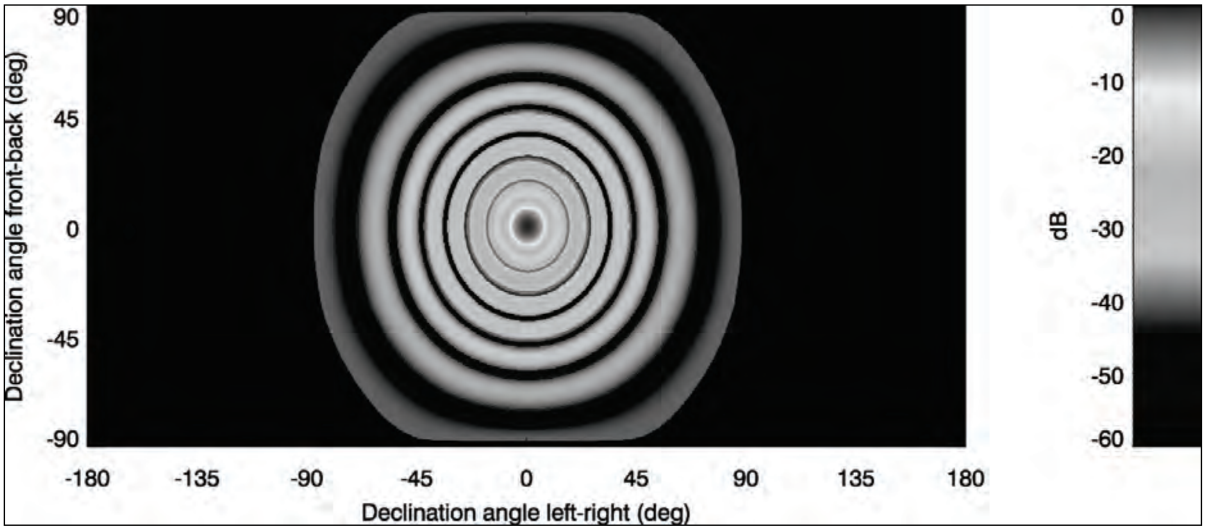

Figure D-26. Calculated Beam Pattern for a Representative Chirp Subbottom Profiler at 200 kHz. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

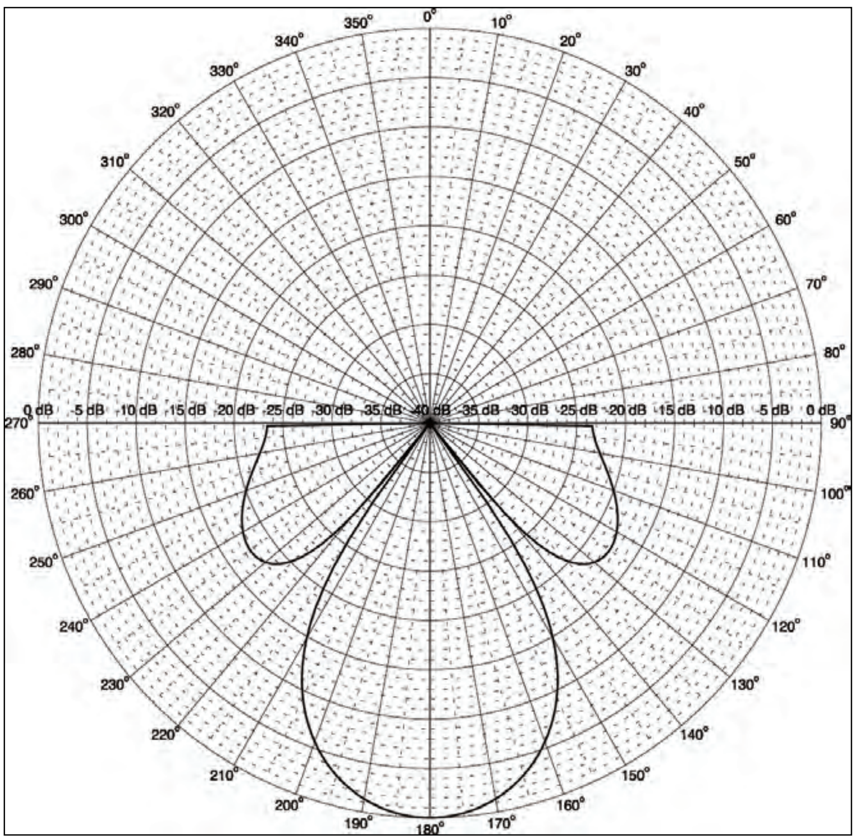

Figure D-27. Calculated Beam Pattern Vertical Slice for a Representative Chirp Subbottom Profiler Operating at 3.5 kHz.

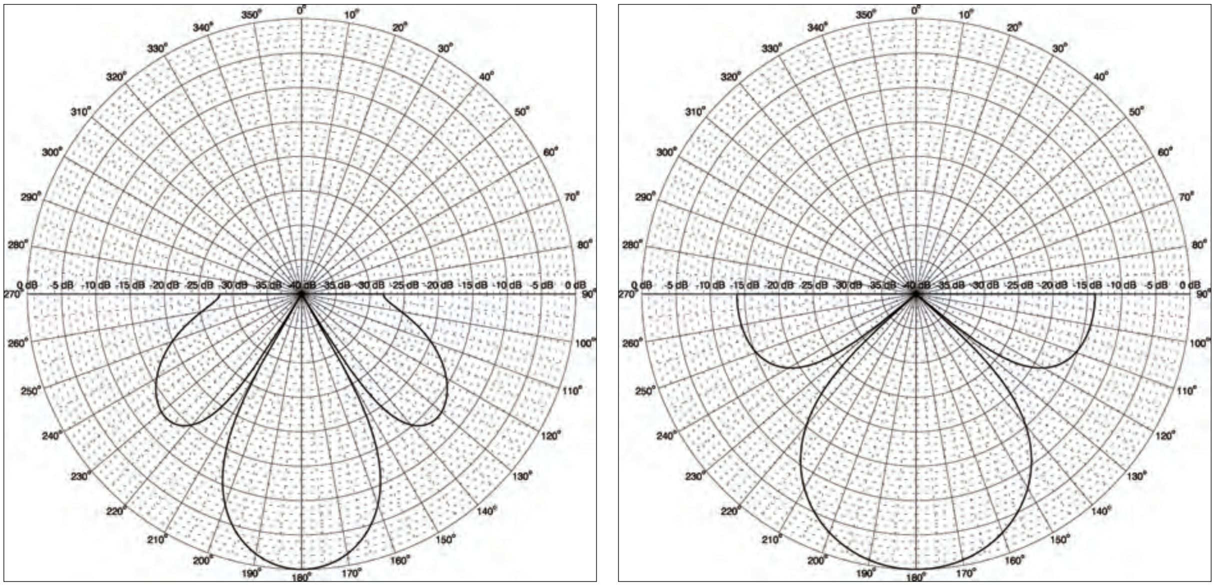

Figure D-28. Calculated Beam Pattern Vertical Slice for a Representative Chirp Subbottom Profiler Operating at 12 kHz (left) Along- and (right) Across-Track Directions.

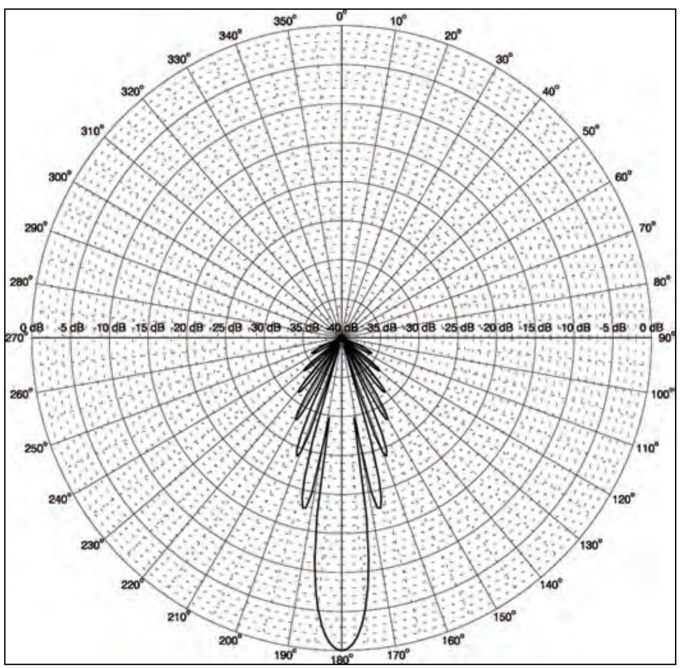

Figure D-29. Calculated Beam Pattern Vertical Slice for a Representative Chirp Subbottom Profiler Operating at 200 kHz.

Modeling Approach

The chirp subbottom profiler was modeled operating at all three frequencies simultaneously. The depth of the source was chosen to be 5 m. A total of 72 radial profiles with equal angular steps of 5° and extending to a maximum range of 20 km from the source were modeled using the MONM-BELLHOP acoustic propagation model. The same assumption about source heading was made for the side-scan sonar. The SLs were provided in rms SPL units; hence the output from the modeling was directly in terms of the rms SPL metric.

3.2.8. Multibeam Depth Sounder

For the purpose of modeling a representative multibeam depth sounder, the RESON SeaBat 7101 model was selected as an example. This depth sounder uses the main working frequency of 240 kHz (RESON, 2009). The system utilizes a single beam transducer and multibeam receiver. The transducer head is mounted at the bottom of the ship's hull. The projector beam width is 1.5° in the along-track direction and 170° in the across-track direction. The specifications of the depth sounder used for the modeling are presented in **Table D-11**.

Table D-11

Representative Multibeam Depth Sounder Specifications

Main Operational Frequency	240 kHz
Beam width along-track	1.5°
Beam width across-track	170°
rms SPL (dB re 1 µPa at 1 m)	210
Peak level (dB re 1 µPa at 1 m)	213
Pulse length	21–225 µs
SEL (dB re 1 $\mu Pa^2 \cdot s$ at 1 m) at 225 µs pulse length	173.5

The beam patterns were again estimated using a mathematical model based on beam forming theory. Since the transducers are hull mounted, it was assumed that most of the acoustic energy is emitted in the downward half-space and that the upward component is negligible.

Figure D-30 presents the calculated beam power function for the representative multibeam depth sounder at 240 kHz. Vertical slices of the beam pattern in along- and across-track directions are shown in **Figure D-31**.

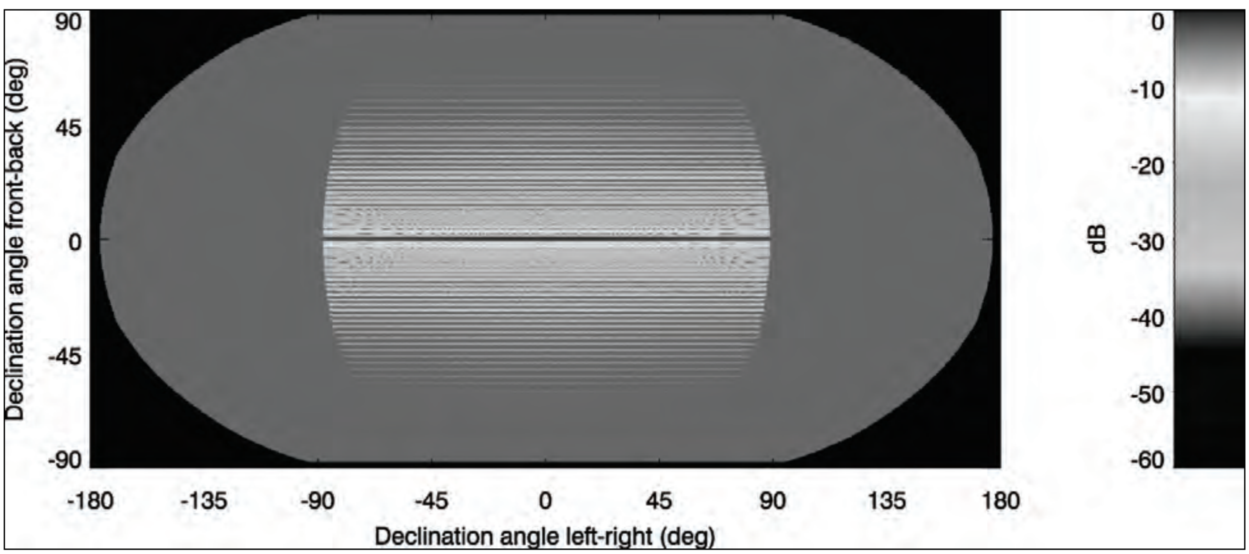

Figure D-30. Calculated Beam Pattern for the Representative Multibeam Depth Sounder at 240 kHz. Beam Power Function Shown Relative to the On-Axis Level, Using the Robinson Projection.

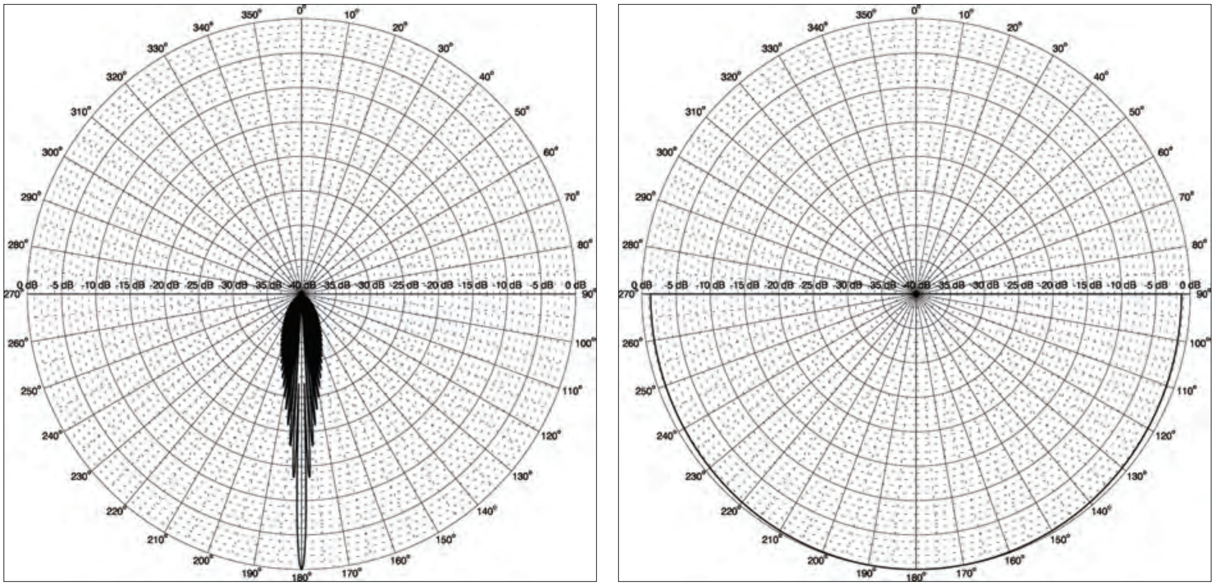

Figure D-31. Calculated Beam Pattern Vertical Slice for the Representative Multibeam Depth Sounder at 240 kHz; (left) Along- and (right) Across-Track Directions.

Modeling Approach

The multibeam depth sounder was modeled at the single frequency of 240 kHz. The depth of the source was chosen to be 5 m. With a very narrow beam width, the variability of the emitted energy in different horizontal directions is very high. A circular fan of modeling radials with variable angular step (see **Table D-12**) was created to a maximum range of 20 km from the source. The density of the radials was greater in proximity of the broadside, where beam variability is maximum, and lesser toward the endfire. The total number of rays modeled was 660. The source heading was again chosen for each modeling site considering the bathymetry at that location, with the assumption that the survey lines would run along the isobaths. The SL was provided in rms SPL units, hence the output from the modeling was directly in terms of the rms SPL metric. The depth sounder was modeled only at the sites designated for renewable energy development (water depth ~100 m). The source level for the sonar was chosen to be 210 dB re 1 µPa.

Table D-12

Variable Angular Steps of the Modeling Radials in Different Sectors. Only the Steps for the First Quadrant (0°-90°) Are Shown; Those for the Other Quadrants Were Symmetrical

Sector	Angular Step
0° – 45°	1°
45° – 80°	0.5°
80° – 90°	0.2°

3.2.9. Sparker

Sparkers are seismic sources that produce an electric arc between electrodes with a high voltage energy pulse. The arc momentarily vaporizes water in a localized volume and the vapor expands, generating a pressure wave. An example sparker system is shown in **Figure D-32**. Sparkers have an operating voltage of several kilovolts (kV) and the energy input can vary from several hundred joules (J) to tens of kilojoules (kJ). The source level depends on the input energy and is between 215 and 225 dB re 1 µPa @ 1 m. The length of the pulse varies in the range of 0.3–5 ms and the generated frequencies are generally between 300 and 5,000 Hz (**Table D-13**) (Applied Acoustic Engineering Ltd., 2010a). The pulse length and the frequency band depend on the input power. A sample spectrum for a sparker with input energy of 6 kJ is shown on **Figure D-33**. The sparkers are usually used with the same energy source as boomers (Applied Acoustics Engineering Ltd., 2010b). The receiver for sparker systems usually is a hydrophone or hydrophone array.

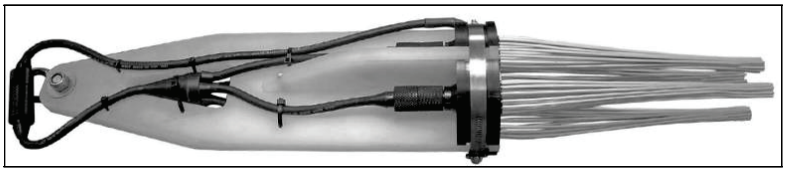

Figure D-32. The Sparker SQUID 500 (Applied Acoustic Engineering Ltd., 2010c).

Table D-13

SQUID 500 Sparker Specifications. (Applied Acoustic Engineering Ltd., 2010a,c)

Operational Frequency Range	Broad Band: 300 Hz – 5 kHz
Beam Widths (degrees)	omnidirectional
Maximum Energy Input (per shot)	1200 J
Pulse Length	0.3 – 5 ms
rms SPL (dB re 1 µPa at 1 m) at 800 J input energy	212
SEL (dB re 1 µPa^2·s at 1 m) at 1.5 ms pulse	184

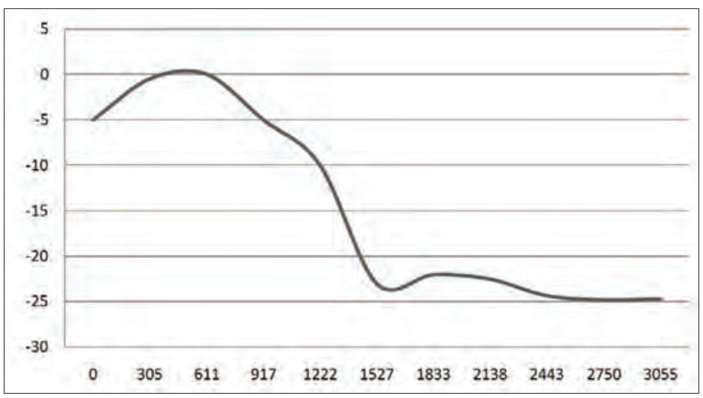

Figure D-33. Example of the pulse frequency spectrum from a Delta Sparker at 6 kJ (Applied Acoustic Engineering Ltd., 2010a).

The sparker generates an omnidirectional signal that can penetrate several hundred meters into the sediment with a resolution of several meters. Unlike airguns, sparkers produce no secondary pulses. Drawbacks of sparker sources include lack of directionality and low repeatability of the pulse. As with airgun sources, sparkers may be used in an array.

The characteristics of the acoustic wave emitted by sparker source are comparable to the one for boomer source (see **Section 3.2.5**). The pulse length (for low energy operation) and source level are similar to the boomer specifications. The spectrum of the boomer source tends to extend further into higher frequency range (up to 10 kHz), however, at higher frequencies the boomer has strong directionality towards the bottom and insignificant contribution to the overall broadband level.

Considering the similarity of the parameters of the acoustic wave emitted by the sparker and boomer sources it can be said that for a rough estimation of the sound field produced by the sparker the modeling results for the boomer can be used. The sparker source was not modeled in this study since they obtain similar shallow penetration data.

4. MODELING METHODOLOGY

Distinct modeling approaches were used for the low-frequency sources (airgun arrays) and mid- and high-frequency sources (electromechanical sources).

The modeling of the underwater acoustic field resulting from the operation of a seismic array in a particular area involved the use of two complementary software codes. The AASM, described in **Section 3.1.4**, was used to predict the directional SL of a seismic airgun array. The MONM, an acoustic propagation model, was then used to estimate the acoustic field at any range from the source. Sound propagation modeling uses acoustic parameters appropriate for the specific geographic region of interest, including the water column sound speed profile, the bathymetry, and the bottom geoacoustic properties, to produce site-specific estimates of the radiated noise field as a function of range and depth. MONM-RAM, described in **Section 4.1.1**, was used to predict the directional TL footprint from various source locations corresponding to trial sites for experimental measurements. The RL at any 3D location away from the source is calculated by combining the SL and TL, both of which are direction dependent, using the fundamental relation $RL = SL - TL$. Acoustic TL and RL are a function of depth, range, bearing, and environmental properties of the propagation medium.

The RLs estimated by MONM, like the SLs from which they are computed, are expressed in terms of the so SEL metric over the duration of a single source pulse. Sound exposure level is expressed in units of dB re 1 $\mu Pa^2 \cdot s$. For the purposes of this study, the SEL results were converted to the rms SPL metric using a range dependent conversion coefficient (see **Section 4.1.3**).

To model the sound field from the electromechanical sources a mathematical model (see **Sections 2.2.1–3.24**) was used to estimate the source beam pattern taking into account source specification data. The MONM-BELLHOP propagation code was then used to estimate the acoustic field around the source. Source beam pattern data as well as bathymetry, sediment geoacoustic properties, and water sound velocity profile information were provided as inputs for the propagation code.

Once the unweighted acoustic fields were calculated, the M-weighting filters were applied to the fields to yield M-weighted acoustic fields. The application of the M-weighting filters were performed as outlined in **Section 2.3.1** using Equation (6).

4.1. Sound Propagation Model: MONM

JASCO's MONM was used for the sound field modeling of all the sources in this study, using two variants of the computational engine for handling different frequency ranges. The MONM computes acoustic fields in 3D by modeling TL along evenly spaced 2D radial traverses covering a 360° swath from the source, an approach commonly referred to as *N*×2D. The model fully accounts for depth and/or range dependence of several environmental parameters including bathymetry and sound speed profiles in the water column and the subbottom. The acoustic environment is sampled at a fixed range step along radial traverses. The acoustic propagation code estimates sound pressure levels at various horizontal distances from the source as well as at different depths. Depending on the input source sound level metric provided, MONM can compute received sound fields in SEL or rms SPL metrics.

4.1.1. Low-Frequency – MONM-RAM

For the acoustic sources in the low-frequency band (below 2 kHz) the MONM-RAM variant of the computational code was used. In this study the sources that operate in the low-frequency bands are the airgun array sources and the boomer. For the former, the directional SLs computed with AASM were input to MONM-RAM to determine the predicted RLs.

The MONM-RAM treats sound propagation in range-varying acoustic environments through a wide-angled parabolic equation (PE) solution to the acoustic wave equation. The PE code used by MONM-RAM is based on a version of the Naval Research Laboratory's RAM, which has been modified to account for an elastic seabed. The PE method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al., 1996). The MONM-RAM also accounts for the additional reflection loss at the seabed that is due to partial conversion of incident compressional waves to shear waves at the seabed and subbottom interfaces. It includes wave attenuations in all layers.

The MONM-RAM treats frequency dependence by computing acoustic TL at the center frequencies of third-octave bands, between 10 Hz and 2 kHz in this study. Third-octave band RLs are computed by subtracting band TL values from the corresponding directional SLs. Broadband RLs are then computed by summing the received band levels. The MONM sound level predictions have been validated against experimental data in a formal study (Hannay and Racca, 2005) and in several instances where operational field measurements were obtained that allowed direct comparison to model estimates.

4.1.2. Mid- and High-Frequency – MONM-BELLHOP

For the acoustic sources in the mid- and high-frequency band (above 2 kHz), the MONM-BELLHOP variant of the computational code was used. In this study the sources that operate in the mid- and high-frequency bands are the boomer, side-scan sonar, chirp subbottom profiler, and multibeam depth sounder.

The MONM-BELLHOP models sound propagation in range-varying acoustic environments using the BELLHOP acoustic ray trace model (Porter and Liu, 1994), which is based on the Gaussian beam tracing technique. In addition to other types of attenuation, MONM-BELLHOP accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water (Fisher and Simmons, 1977). This type of attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeable effect on the modeling results at longer distances from the source.

The geoacoustic layering model for the MONM-BELLHOP propagation code consists of only one interface, namely the sea bottom. This is an acceptable limitation because the influence of the subbottom layers on the propagation of acoustic waves with frequencies above 2 kHz is negligible.

The acoustic model takes into account the variability of the sound levels emitted in different directions from the source, referred to as source directivity. Source directivity is specified to the model as a function of both azimuthal and depression angle where azimuth is the horizontal direction relative to north and depression is the vertical angle relative to the horizontal plane.

4.1.3. Estimating 90 Percent RMS SPL from SEL for Airgun Array Sources

Existing U.S. safety radius regulations for impulsive sound sources are based on the rms SPL metric. An objective definition of pulse duration is needed when measuring the rms level for a pulse. Following suggestions by Malme et al. (1986), Greene (1997), and McCauley et al. (1998), pulse duration is conventionally taken to be the interval during which 90 percent of the pulse energy is received. Although the 90 percent rms SPL can be easily measured *in situ*, this metric is difficult to model in general because the adaptive integration period, implicit in the definition of the 90 percent rms level, is highly sensitive to the specific multipath arrival pattern from an acoustic source and can vary abruptly with distance from the source or with depth of the receiver. To accurately predict the 90 percent rms level, it is necessary to model full-waveform acoustic propagation, which in highly range dependent environments is computationally overwhelming for long range, large water depth (more than 1,000 m), and multiple profile models.

Accurate estimates of airgun array safety ranges must take into account the acoustic energy that is returned to the water column by bottom and surface reflections. This is especially important in the case of shallow water conditions, which are found at many sites in the current study. If multipath reflections were taken into account, the resultant temporal spreading of the received seismic pulse would change the received pulse duration, rms estimates, and safety radii. The MONM algorithm does not attempt to predict the rms pressure directly; rather it models the propagation of acoustic energy in third-octave bands in a realistic, range-dependent acoustic environment. When these third-octave band levels are summed, the result is a broadband SEL, equivalent to the sound pressure level that would occur if the energy for a single airgun array pulse were spread evenly over a nominal time window of 1 s.

From these predicted SEL values, the approximate rms equivalents can be obtained taking into account the interrelationships of SEL, rms SPL, and pulse duration as known from theory and from field studies where these parameters have all been measured for the same received airgun pulses. The rms SPL based on the 90 percent energy pulse duration is related to SEL via a simple function that depends only on the rms integration period *T*:

$$\mathrm{SPL}_{\mathrm{RMS90}} = \mathrm{SEL} - 10\log(T) - 0.458 \tag{11}$$

Here, the last term accounts for the fact that only 90 percent of the acoustic pulse energy is delivered over the standard integration period. In the absence of *in situ* measurements, the integration period is difficult to predict with any reasonable degree of accuracy.

Two approaches can be used in this case. The first is to use a heuristic value of *T*, based on field measurements in similar environments, to estimate an rms SPL level from the modeled SEL. Safety radii estimated in this way are approximate since the true time spreading of the pulse has not actually been modeled. In various studies where the $SPL_{RMS\ 90}$, SEL, and duration have been determined for individual airgun pulses, the average offset between SPL and SEL has been found to be 5–15 dB, with considerable variation dependent on water depth and geo-acoustic environment (Greene, 1997; McCauley et al., 2000; Blackwell et al., 2007; MacGillivray et al., 2007). On average, the measured SPL–SEL offsets tend to be larger at close distances, where the pulse duration is short (<<1 s), and to diminish at longer distances, where pulse duration tends to increase because of propagation effects.

An alternative approach is to use a full-waveform acoustic propagation model to generate range-dependent estimates of SPL and SEL for a small set of representative transects, and then apply the SPL-SEL offsets obtained in this manner to the full MONM results. This approach combines the accurate pulse length information available from the full-waveform model with the greater computational efficiency of the MONM algorithm. For the conversion of the acoustic field in SEL metrics to rms SPL metrics, appropriate SPL–SEL range dependent functions are selected from the set of available representative transects on the basis of similarity of water depth and bottom type.

For this study a combination of the two approaches was chosen. The results of the full waveform estimation were combined with the data obtained during field measurements of similar sources in similar environments (e.g., Austin et al., 2003; Funk et al., 2008). Full-waveform results were derived for idealized flat bottom models with water depths of 40, 150, and 1,000 m. The bottom type was sand for the 40 and 150 m models and clay for the 1,000 m model. The estimated range dependent SPL–SEL offset functions used in this study are shown in **Figure D-34**.

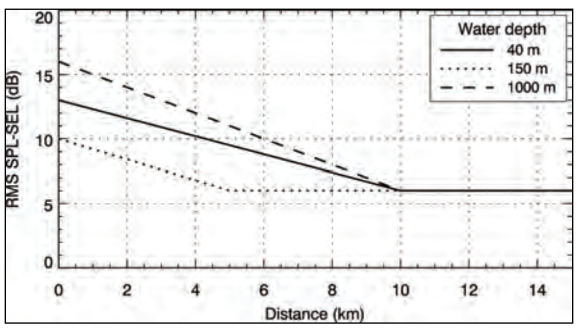

Figure D-34. SPL–SEL Conversion Functions for Different Water Depths.

In applying the above conversions to the model results in this study, the sites with water depths from 30-60 m were assigned the SPL–SEL function for 40 m depth, the sites with water depth from 61-300 m the function for 150 m, and the sites deeper than 300 m the function for 1,000 m water depth.

4.2. MODELING PROCEDURE

4.2.1. Area of Interest and Proposed Activities

The AOI includes U.S. Atlantic waters from the mouth of Delaware Bay to just south of Cape Canaveral, Florida, and from the shoreline (excluding estuaries) to 648 km (350 nmi) from shore (**Figure D-35**). The total area of the AOI is 854,779 km^2 (330,032 mi^2). The water depths inside the AOI vary from a few meters to more than 5,000 m, covering various types of oceanic bottom: continental shelf, continental slope and rise, and abyssal plain.

Three major program areas of G&G activities are included in this study:

- oil and gas exploration;
- renewable energy development; and
- marine minerals.

Different activities would be performed in specific water depths. The types of acoustic sources are also defined by the type of planned activity (**Table D-14**).

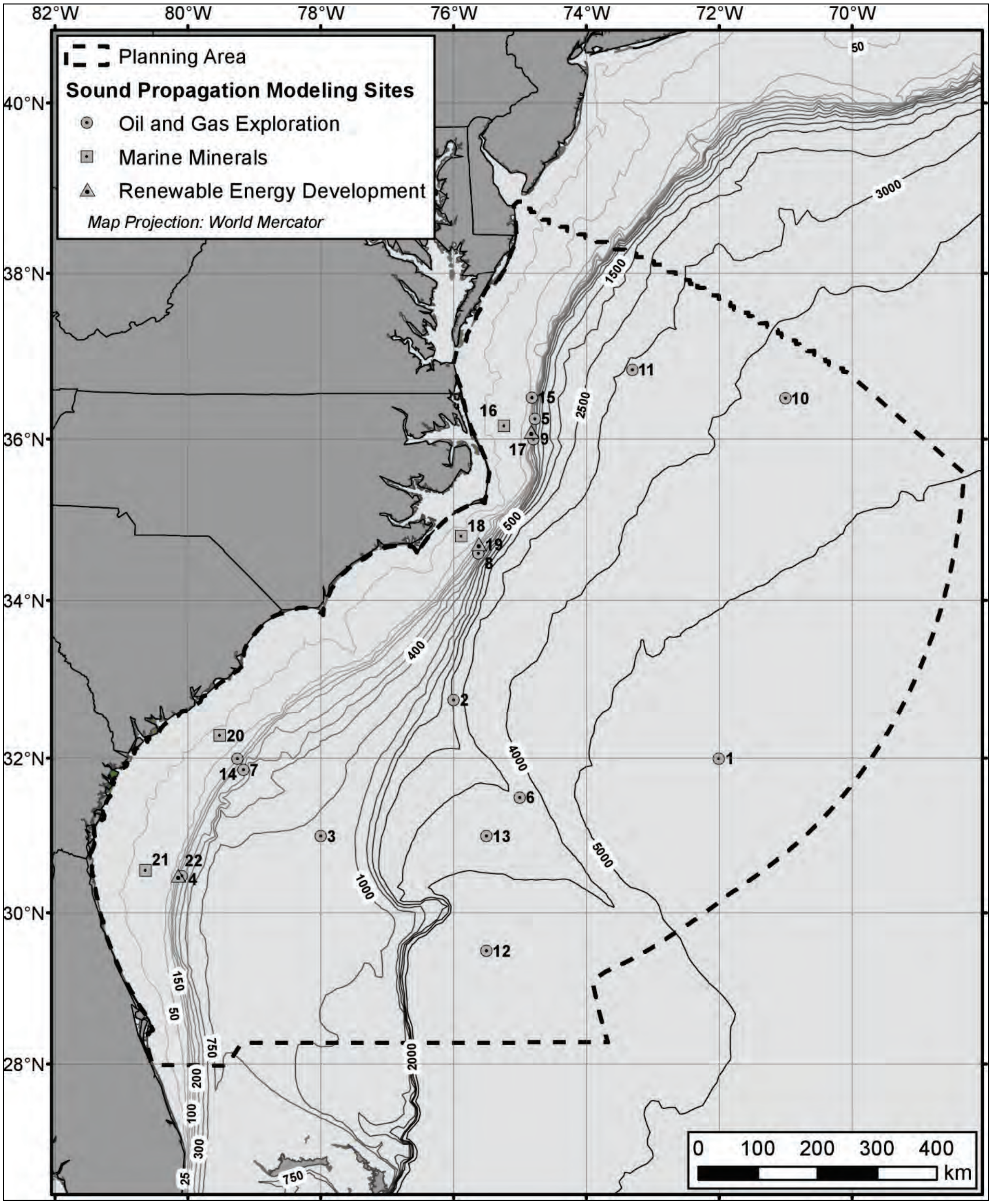

Figure D-35. Area of Interest with the Locations of the Modeling Sites.

Table D-14

List of Proposed G&G Activities and Sources

Activity Type	Acoustic Source	Representative Modeling	
		Water Depth (m)	Acoustic Source
Oil and Gas Exploration and Development (50–6,000 m)			
2D seismic survey	Airgun array 3,000–9,000 in^3	50 – 6,000	Large airgun array 5,400 in^3
3D seismic survey	Dual airgun array 3,000–9,000 in^3	50 – 6,000	Large airgun array 5,400 in^3
Vertical seismic profiling	Airgun array 1,000–6,000 in^3	50 – 6,000	Large airgun array 5,400 in^3
High-resolution geophysical survey	Single gun or airgun array 45–200 in^3	50 – 6,000	Small airgun array 90 in^3
Renewable Energy (0–100 m)			
Bathymetry data collection	Multibeam depth sounder	100	Multibeam depth sounder[a]
Bottom obstruction detection	Side-scan sonar	100	Side-scan sonar
Shallow sediment mapping (0–100 mbsf)	Shallow penetration subbottom profiler	100	Chirper
Medium depth sediment mapping (0–200 mbsf)	Medium penetration subbottom profiler	100	Boomer[b]
Marine Minerals (0–50 m)			
Bathymetry data collection	Multibeam depth sounder	30	Multibeam depth sounder
Bottom obstruction detection	Side-scan sonar	30	Side-scan sonar
Shallow sediment mapping (0–100 mbsf)	Shallow penetration subbottom profiler	30	Chirper
Medium depth sediment mapping (0–200 mbsf)	Medium penetration subbottom profiler	30	Boomer[b]

Abbreviations: mbsf = meters below seafloor.

[a] single beam echosounder could be used in place of a multibeam depth sounder, but were not modeled due to their low source level and narrow beam relative to multibeams.

[b] sparkers could also be used, but were not modeled due to the acoustic similarities to boomers.

Oil and gas explorations surveys could occur at water depths ranging from 50 m to more than 4,000 m, covering all three bottom types – shelf, slope, and abyssal plain. The acoustic sources that would be utilized for these surveys include seismic airgun arrays of different types. The volume of air gun arrays may vary from less than 100 in^3 (high-resolution geohazard seismic surveys) to more than 5,000 in^3 (2D and 3D seismic surveys).

Renewable energy development and marine mineral surveys would be limited to shallow waters with maximum water depth of about 100 m. The acoustic sources involved would include mid- to high-frequency electromechanical sources (boomers, chirp subbottom profilers, side-scan sonars, multibeam depth sounders, etc.).

The information about the selected modeling sites is provided in **Table D-15**, and the map with the locations of these sites is shown in **Figure D-35**.

Table D-15

Modeling Site Information

Site Number	Geographic Coordinates		UTM Coordinates			Bottom Type	Water Depth at the Source (m)	Towing Azimuth
	North	West	Northing	Easting	Zone			
1	32.00	-72.00	3544000	783000	18	Clay	5,390	N/A
2	32.75	-76.00	3624000	406000	18	Clay	2,560	N/A
3	31.00	-78.00	3433000	214000	18	Sand	880	N/A
4	30.48	-80.09	3373000	588000	17	Sand	249	N/A
5	36.25	-74.77	4012000	520000	18	Sand	288	N/A
6	31.50	-75.00	3485000	500000	18	Clay	3,200	N/A
7	31.85	-79.16	3526000	674000	17	Sand	251	N/A
8	34.59	-75.63	3828000	443000	18	Sand	249	N/A
9	36.00	-74.79	3984000	519000	18	Sand	275	N/A
10	36.50	-71.00	4041000	321000	19	Clay	4,300	N/A
11	36.84	-73.31	4079000	651000	18	Clay	3,010	N/A
12	29.50	-75.50	3263000	452000	18	Clay	4,890	N/A
13	31.00	-75.50	3430000	452000	18	Clay	3,580	N/A
14	32.00	-79.25	3542000	665000	17	Sand	100	N/A
15	36.51	-74.82	4040000	516000	18	Sand	51	N/A
16	36.16	-75.24	4001808	478773	18	Sand	30	N/A
17	36.09	-74.84	3993702	514548	18	Sand	100	10°
18	34.80	-75.89	3851633	418959	18	Sand	30	40°
19	34.70	-75.63	3840310	442218	18	Sand	100	40°
20	32.30	-79.52	3574265	639795	17	Sand	30	35°
21	30.55	-80.64	3380052	534518	17	Sand	30	20°
22	30.49	-80.16	3372884	580545	17	Sand	100	20°

N/A = not applicable. Towing azimuth not needed for calculations because the seafloor is flat.

4.2.2. Model Profiles

Both acoustic propagation models, MONM-RAM and MONM-BELLHOP, compute acoustic fields along one 2D radial traverse at a time. One can obtain a 3D distribution of the acoustic field around a source by combining a set of radial traverses covering a 360° swath from the source. The angular step between the radials can be either constant or variable, depending on the type of source and its horizontal directivity function. This approach commonly is referred to as N×2D.

Assuming that the bottom geoacoustic properties and the water column are uniform in all directions from a given modeling site, the parameters that change from profile to profile are the bathymetry and the SL for a directional source. For an omnidirectional source, the only parameter that would change between profiles is the bathymetry.

For the purpose of this study an adaptive approach was taken for defining the distribution of modeling profiles. For the boomer and airgun array sources, the profiles were evenly spaced around the source; the number of profiles, however, depended on the water depth observed inside the modeling area, varied from 120 (3° step) to 24 (15° step). Also for the very deep sites (water depth more than 3,000 m), only one profile was modeled and then cloned 24 times along the fan of radials. This approach was considered readily justifiable since the bathymetry, which is the only parameter that would change from profile to profile, is virtually flat at deep sites and at such depths has very little influence on the sound propagation. The angular step and the total number of profiles modeled at different sites for the boomer and airgun arrays sources are provided in **Table D-16**.

Table D-16

Modeling Profile Information for Airgun Array Sources at Different Sites

Site Number	Water Depth at the Source (m)	Number of Profiles	Angular Step	Maximum Receiver Depth (m)
1	5,390	1	–	2,000
2	2,560	24	15°	2,000
3	880	120	3°	1,000
4	249	120	3°	500
5	288	72	5°	2,000
6	3,200	1	–	2,000
7	251	120	3°	600
8	249	72	5°	2,000
9	275	72	5°	2,000
10	4,300	1	–	2,000
11	3,010	1	–	2,000
12	4,890	1	–	2,000
13	3,580	1	–	2,000
14	100	120	3°	650
15	51	72	5°	2,000
16	30	72	5°	40
17	100	72	5°	200
18	30	72	5°	50
19	100	72	5°	1,000
20	30	72	5°	50
21	30	72	5°	40
22	100	72	5°	500

The angular step size for the high-frequency sources was chosen based on the minimum beam width and the directivity pattern. The minimum angular step size was chosen to be no more than half the size of the beam width. The modeling profiles information for the engineering source, except the boomer is provided in **Table D-17**. The same profile pattern was used for all sites where these sources were modeled, namely locations 16-22. The water depth at the source and the maximum receiver depth are the same as shown in **Table D-16**.

Table D-17

Modeling Profile Information for Electromechanical Sources Except the Boomer

Source	Smallest Beam Width	Number of Profiles	Angular Step Size
Side-scan sonar	0.4°	660	Variable: 0.2°–1°
Chirp subbottom profiler	8°	72	Constant: 5°
Multibeam depth sounder	1°	309	Variable: 0.5°–2°

4.2.3. Model Receiver Depths

Model receiver depths are the depths below the water surface at which virtual receivers are placed in the acoustic propagation model and the TL is sampled. From the chosen source positions, the model can generate a grid of predicted acoustic levels over any desired area, as well as at any depth in the water column. The virtual receivers can, in principle, be placed at a vertical step size as fine as the acoustic field modeling grid, which varies from 2 m for low frequencies to 6 cm for high frequencies. Such a fine grid of receivers, however, would be very inefficient and provide too large a quantity of data. The depth spacing between the receiver planes was therefore chosen on the basis of the vertical variability of the acoustic field, which in turn depends on the variability of the sound speed profile – higher at the top of the water column, lower at greater depths. The maximum depth for the virtual receivers (2,000 m) was chosen based on the normal dive depth limits for the marine mammals in the AOI.

The set of virtual receivers depths for the sites designated for oil and gas exploration (water depth from 50-5,390 m) was: 2, 5, 10, 15, 20, 25, 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, 1,000, 1,100, 1200, 1,400, 1,600, 1,800, and 2,000 m.

For the sites where electromechanical sources were modeled (water depths at the source 30 and 100 m) several depths were added at the top of the water column. The set of virtual receiver depths for the sites designated for marine minerals and renewable energy development (sites 16-22) was as follows: 2, 5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5, 25, 27.5, 30, 35, 40, 45, 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, and 1,000 m.

4.2.4. Model Radial Step Size

The quality of the modeling results is highly dependent on the radial step size, as with too large a step the modeling approximation can become unstable and produce inaccurate results. For the purpose of this study the radial modeling step size was set at a very finely resolved 5 m. Further reduction of the step size provides virtually no quality benefit for the results while increasing the computational requirements. Before transferring the modeled acoustic field data for use with the Acoustic Integration Model (AIM) individual-based exposure model, however, the radial results were downsampled with a variable step size in order to increase the efficiency of the data processing. The set of distances from the source in meters at which the received acoustic field was reported for use in AIM was generated according to the following equation:

$$r = i^2, \qquad \text{where } i = 1,2,3,\ldots,141 \tag{12}$$

4.3. BATHYMETRY AND ACOUSTIC PARAMETERS

4.3.1. Bathymetry

The bathymetry data for this project was provided by CSA Ocean Sciences Inc. The bathymetry grid spans from 28° N to 40° N and from 66.5° W to 82.5° W, fully covering the AOI. The resolution of the grid is about 1.5 arc seconds or approximately 50 m.

For the purpose of modeling, smaller portions of the large grid were extracted for each modeling site. The overall bathymetry information was considered from the start in choosing the locations for the modeling sites, both in terms of selecting locations with desired water depths and of avoiding areas with highly site-specific bathymetry features such as localized sea bottom rises or depressions.

4.3.2. Geoacoustic Properties

In view of the generalized nature of this study, a more generic approach to the definition of geoacoustic properties was exercised than would normally be used for site specific modeling. The AOI spans numerous geological provinces with highly variable stratification profiles. It would not have been opportune to consider site specific geoacoustic profiles, since the acoustic modeling results thus obtained would introduce excessive bias when used as estimation for other locations. Generic geoacoustic profiles were created instead, which only take into account the type of sediment found at the sea bottom with the appropriate porosity value and typical porosity trend with depth below the seafloor (which is sediment type specific). Any layered model of the sediment column was avoided, i.e. there were no interfaces in the geoacoustic profiles at which a rapid change of properties is observed because of sediment type transition. Instead, only a gradual change of properties with depth was introduced.

The acoustic properties of sediment layers that are required by MONM are density (ρ), compressional speed (V_p), compressional attenuation coefficient in decibels per wavelength (α_p), shear wave speed (V_s), and shear wave attenuation coefficient (α_s), also in decibels per wavelength. These geoacoustic parameters were estimated using a sediment grain-shearing model (Buckingham, 2005), which computes the acoustic properties of the sediments from porosity and grain-size measurements. The input parameters required by the geoacoustic model were the bottom type (grain size) and sediment porosity, inferred from the geological description of the modeling region.

Numerous surficial sediment-type data exist for the Atlantic region off-shore U.S. coast, for example the U.S. Geological Survey (USGS) Continental Margin Program (Hathaway, 1977) and the National Geophysical Data Center (NGDC) Seafloor Sediment Descriptions (Bershad and Weiss, 1975). Poppe et al. (1989) provided a map of distribution of the surficial sediments for the region. According to the map, the surficial sediments over 85 percent of the area of interest are represented either by sand or clay. The remaining 15 percent of the area is characterized by transitional sediment types.

The distribution of the specific type of sediment is primarily determined by the bathymetry. Sediments that can be described as sand are found at water depths from 0-1,000 m. In deeper environment the prevailing sediment type is clay, which is found at water depths 900 m and greater.

Clay

The geoacoustic profile for clay sediments was constructed based on the data obtained by the Ocean Drilling Program (ODP) at site 905, leg 150 (Shipboard Scientific Party, 1994). The well was located at a water depth of 2,700 m. The reported porosity for the surficial sediments was 60 percent and did not change with depth, maintaining the same value of 60 percent down to 600 m below the seafloor. The geoacoustic model for clay sediments is presented in **Table D-18**.

Table D-18

Geoacoustic Model for the Clay Sediments

Depth (m)	ρ (g/cm^3)	V_p (m/s)	α_p (dB/λ)	V_s (m/s)	α_s (dB/λ)
0–10	1.70	1,563–1,613	0.19–0.40	61	0.01
10–50	1.70	1,613–1,683	0.40–0.67		
50–150	1.70	1,683–1,763	0.67–0.93		
150–300	1.70	1,763–1,833	0.93–1.14		
300–600	1.70	1,833–1,925	1.14–1.37		
>600	1.70	1,925	1.37		

Sand

The geoacoustic profile for sand sediments was constructed based on the data obtained by the ODP at site 1071, leg 174 (Shipboard Scientific Party, 1998). The well was located at a water depth of 100 m. The reported porosity for the surficial sediments was 50 percent and decreased gradually decreasing with depth below the seafloor; at 150 m below the seafloor the porosity reached 40 percent and did not change for greater depths. The geoacoustic model for sand sediments is presented in **Table D-19**.

Table D-19

Geoacoustic Model for the Sand Sediments

Depth (m)	ρ (g/cm^3)	V_p (m/s)	α_p (dB/λ)	V_s (m/s)	α_s (dB/λ)
0–10	1.87	1,648–1,785	0.45–0.92	158	0.07
10–50	1.87	1,785–1,987	0.92–1.45		
50–150	1.87–2.04	1,987–,2276	1.45–1.79		
150–300	2.04	2,276–2,482	1.79–2.08		
300–600	2.04	2,482	2.08		

4.3.3. Sound Speed Profiles

The vertical sound speed profiles used in this modeling study were provided by Marine Acoustics, Inc. (MAI). The selected profiles were to reflect the variation of the sea water properties at different locations throughout the AOI as well as seasonal variation at the same location. They represent various types of sound propagation through the water layer such as ducted propagation, presence of convergence zone, and bottom bounce propagation.

As indicated by MAI, the data for the computation of the sound velocity in the water column were mined from the U.S. Naval Oceanographic Office’s Generalized Digital Environmental Model (GDEM) database (Teague et al., 1990). The GDEM database provides average monthly profiles of temperature and salinity for the world’s oceans on a latitude-longitude grid with 0.25-degree resolution. Profiles in GDEM are provided at 78 fixed-depth points up to a maximum depth of 6,800 m. The profiles in GDEM are based on historical observations of global temperature and salinity from the U.S. Navy’s Master Oceanographic Observational Data Set (MOODS). The GDEM provides historical average profiles that extend to the maximum depth in a given 15-arc-minute square. The parameters for the sound speed profiles used in this study are shown in **Table D-20**. The sound speed profiles for the winter, spring, summer, and fall seasons are shown in **Figures D-36** through **D-39**, respectively.

Table D-20

The List of Sound Speed Profiles Used in This Study

Profile Number	Season	Propagation Characteristic	Representative Location
1	Winter	Convergence zone (deep water) Bottom bounce (mid-range water depth)	32°45’N 72°00’W
2	Winter	Shallow water	30°30’N 74°45’W
3	Winter	Shallow water	36°15’N 80°15’W
4	Spring	Convergence zone (deep water) Bottom bounce (mid-range water depth)	31°30’N 75°00’W
5	Spring	Bottom bounce (shallow water)	32°00’N 79°15’W
6	Spring	Moderately ducted (shallow water)	35°00’N 76°15’W
7	Summer	Convergence zone (deep water) Bottom bounce (mid-range water depth)	31°30’N 75°00’W
8	Summer	Shallow water	36°00’N 74°45’W
9	Fall	Convergence zone (deep water)	36°30’N 71°30’W
10	Fall	Convergence zone (deep water) Bottom bounce (mid-range water depth)	31°00’N 78°00’W
11	Fall	Shallow water	32°00’N 79°15’W
12	Fall	Shallow water	36°30’N 74°45’W

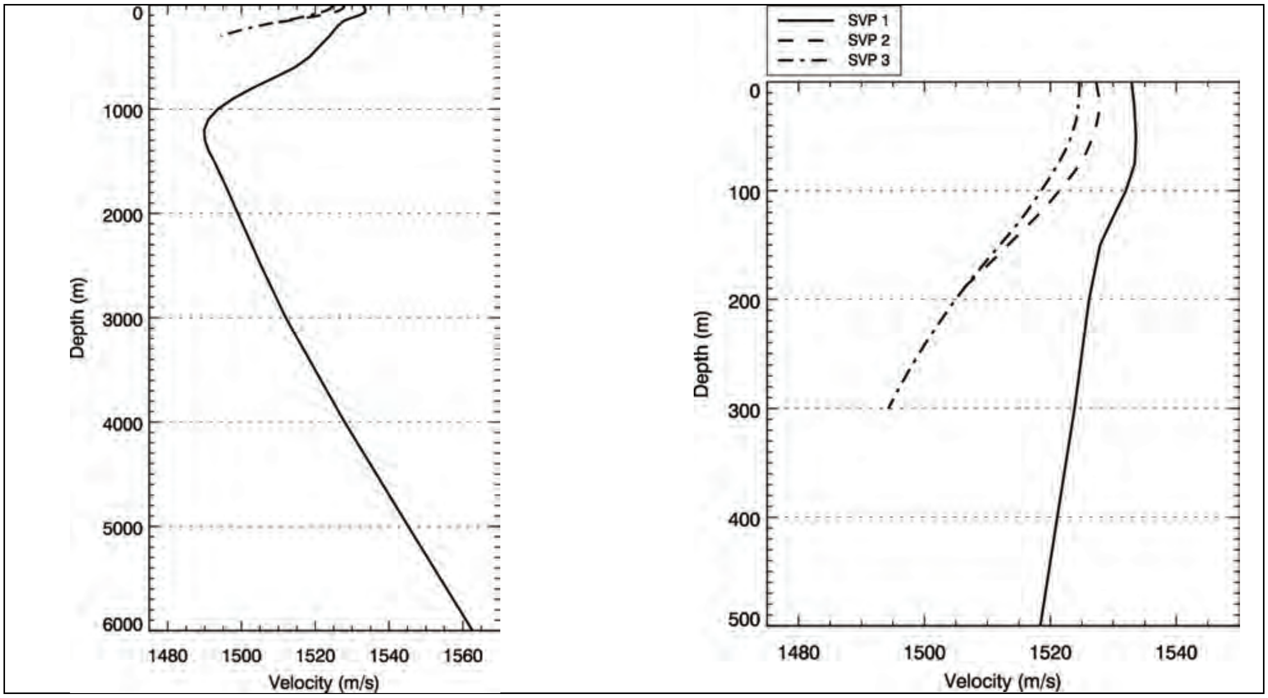

Figure D-36. Sound Velocity Profiles for Winter Season Used in This Modeling Study: Fully Extended to the Maximum Depth (left) and Zoomed-in Upper Portion (right).

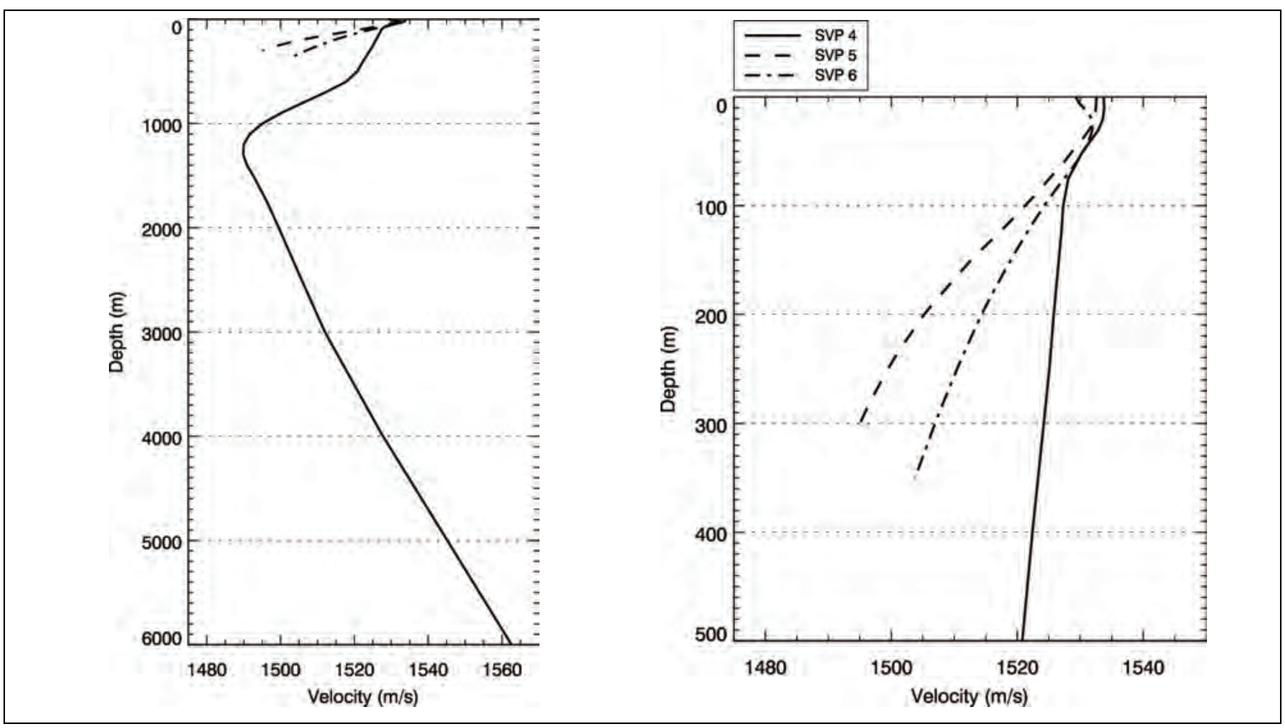

Figure D-37. Sound Velocity Profiles for Spring Season Used in This Modeling Study: Fully Extended to the Maximum Depth (left) and Zoomed-in Upper Portion (right).

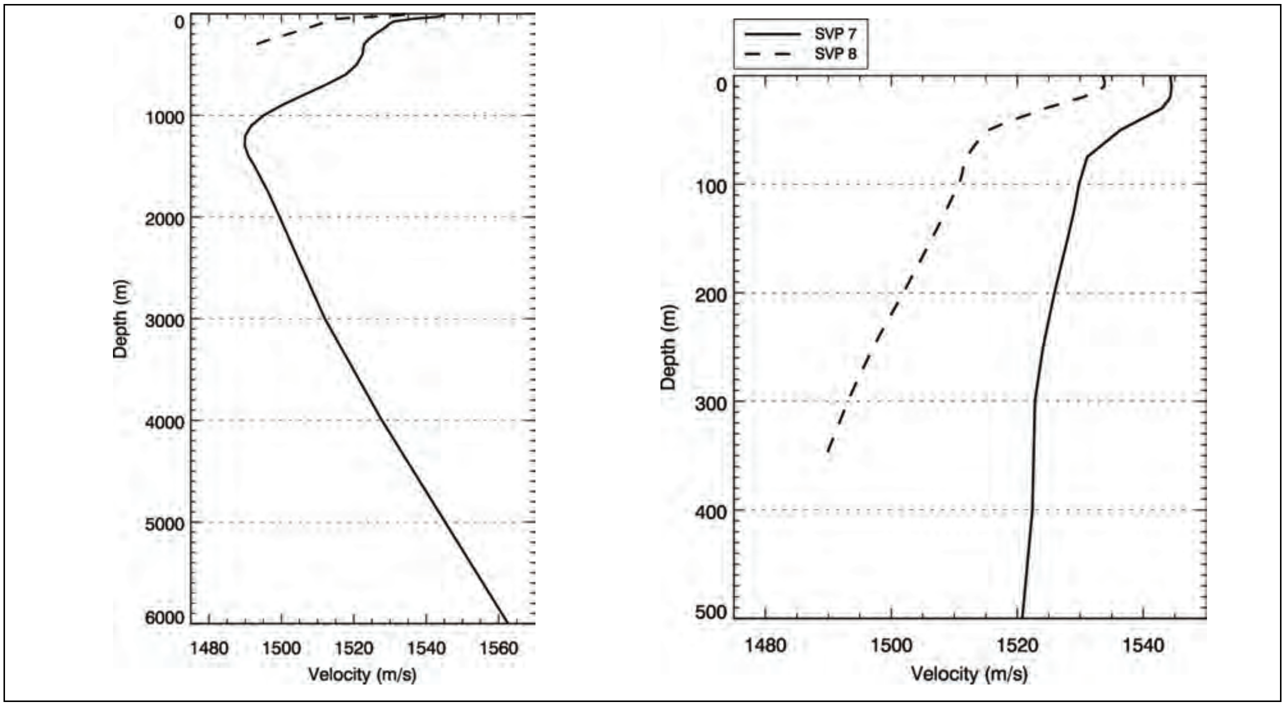

Figure D-38. Sound Velocity Profiles for Summer Seasons Used in This Modeling Study: Fully Extended to the Maximum Depth (left) and Zoomed-in Upper Portion (right).

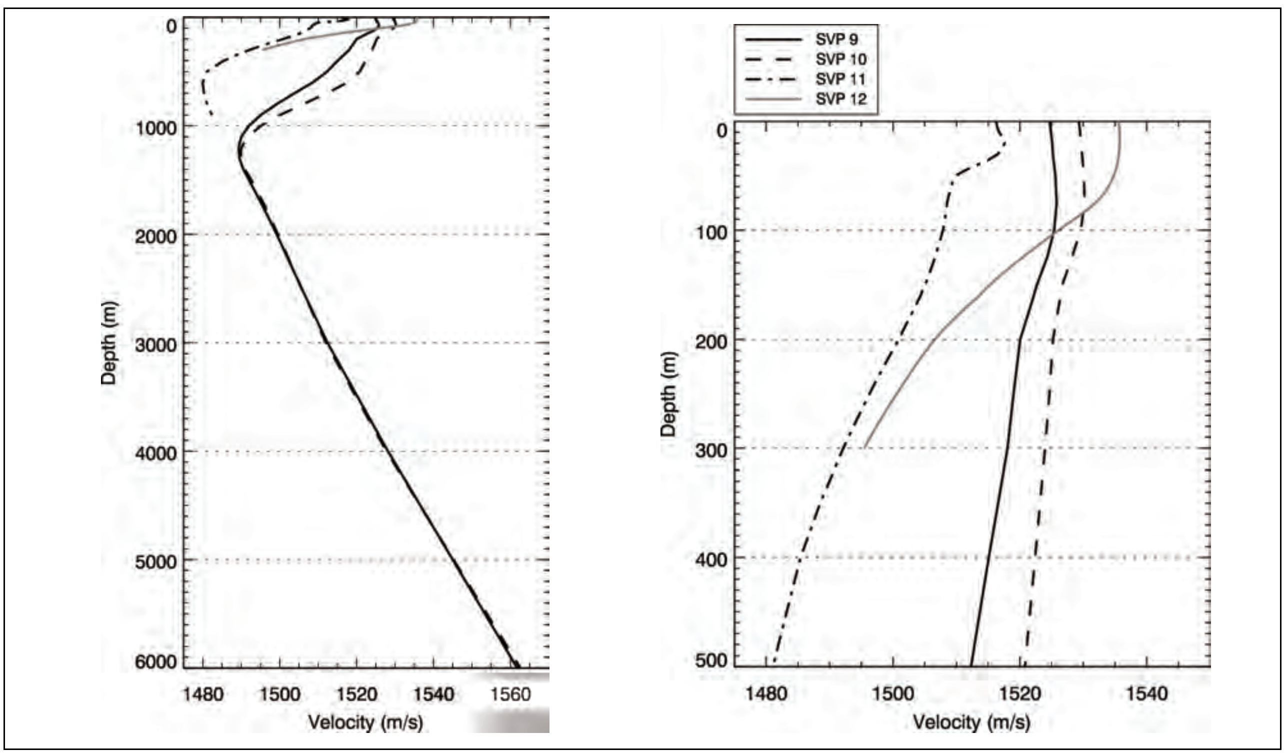

Figure D-39. Sound Velocity Profiles for Fall Season Used in This Modeling Study: Fully Extended to the Maximum Depth (left) and Zoomed-in Upper Portion (right).

4.4. Modeling Scenarios

A total of 22 modeling sites was identified in various parts of the AOI (see **Table D-15** and **Figure D-35**). For each site, modeling was done using 1-4 different sound velocity profiles (see **Table D-20** and **Figures D-36** through **D-39**), for a total of 35 modeling scenarios. The geoacoustic model also varied from site to site. Scenarios from 1-21 were designated for modeling oil and gas exploration activities using airgun array sources. Scenarios 22-35 were modeled for marine minerals and renewable energy development using the boomer, side-scan sonar, chirp subbottom profiler, and multibeam depth sounder.

The complete list of scenarios modeled in this study together with indication of the sources that were modeled for each scenario is provided in **Table D-21**. There were a total of 105 combinations of scenarios and sources. For each combination, an acoustic field was modeled and threshold distances to the specified rms SPL value were calculated. Each acoustic field was also downsampled as previously described and provided as an input for exposure modeling with the AIM software.

4.5. Classification of Acoustic Environments

Each acoustic modeling scenario is characterized by a unique combination of parameters. The main variables in the environment configuration are the bathymetry and the sound velocity profile in the water column. The geoacoustic properties of the sea bottom are directly correlated with the water depth of the modeling site. The major factor that affects sound propagation in different areas throughout the AOI is the water depth. Four regions can be classified based on the bathymetry:

- shallow continental shelf (<60 m);
- continental shelf (60–150 m);
- continental slope (150–1,000 m); and
- deep ocean (>1,000 m).

Each region exhibits a specific acoustic propagation regime, which will be discussed in following sections and exemplified graphically using frequency versus distance plots. These are useful tools for analysis of the acoustic propagation environment, as they help to understand how the physical conditions, mostly water depth, affect propagation of the acoustic waves at different frequencies.

4.5.1. Shallow Continental Shelf

Shallow continental shelf is defined as the areas with depth less than 60 m. Modeling sites that fall into this region are 15, 16, 18, 20, and 21. The bottom type for this area is sand and the bottom sloping is minimal, usually less than 0.1°. Inside each modeling area (20 km radius) the variability in depth is less than 5 m; such a small variation in bathymetry has virtually no effect on the sound propagation in different directions from the source except for some local features of the sea bottom.

An example of frequency versus distance plot for Scenario 22 (Site 16) is provided in **Figure D-40**. The shallow environment does not favor the propagation of low frequencies as the mode propagation condition cannot be established for the acoustic waves at these frequencies. The TL for frequencies lower than 20 Hz is significantly greater than for higher frequencies. Acoustic waves with frequencies between 20 and 80 Hz also experience higher attenuation due to shallow environment.

The vertical sound speed profile in the water column has very little influence on the propagation of the sound in shallow waters, as the variation in sound velocity is not significant in the top 30 m of the profile. The geometric spreading of the acoustic wave energy transitions from spherical-spreading into a cylindrical-spreading regime very close to the source. A highly reflective bottom interface ensures that most of the acoustic energy is returned into the water column after interaction with the seafloor, and bottom reflections contribute significantly to the total acoustic field.

Table D-21

List of Modeling Scenarios

Scenario Number	Site Number	Water Depth (m)	Season	Sound Profile	Bottom Type	Modeled Sources			
						5,400 in^3 Airgun Array	90 in^3 Airgun Array	Boomer[a], SSS, SBP	MBE
1	1	5,390	Winter	SVP 01	Clay	X	X		
2	2	2,560	Winter	SVP 01	Clay	X	X		
3	3	880	Winter	SVP 01	Sand	X	X		
4	4	249	Winter	SVP 02	Sand	X	X		
5	5	288	Winter	SVP 03	Sand	X	X		
6	1	5,390	Spring	SVP 04	Clay	X	X		
7	6	3,200	Spring	SVP 04	Clay	X	X		
8	3	8,80	Spring	SVP 04	Sand	X	X		
9	7	251	Spring	SVP 05	Sand	X	X		
10	8	249	Spring	SVP 06	Sand	X	X		
11	1	5,390	Summer	SVP 07	Clay	X	X		
12	6	3,200	Summer	SVP 07	Clay	X	X		
13	3	880	Summer	SVP 07	Sand	X	X		
14	9	275	Summer	SVP 08	Sand	X	X		
15	10	4,300	Fall	SVP 09	Clay	X	X		
16	11	3,010	Fall	SVP 09	Clay	X	X		
17	12	4,890	Fall	SVP 10	Clay	X	X		
18	13	3,580	Fall	SVP 10	Clay	X	X		
19	3	880	Fall	SVP 10	Sand	X	X		
20	14	100	Fall	SVP 11	Sand	X	X		
21	15	51	Fall	SVP 12	Sand	X	X		
22	16	30	Spring	SVP 03	Sand			X	
23	17	100	Spring	SVP 03	Sand			X	X
24	16	30	Summer	SVP 08	Sand			X	
25	17	100	Summer	SVP 08	Sand			X	X
26	16	30	Fall	SVP 12	Sand			X	
27	17	100	Fall	SVP 12	Sand			X	X
28	18	30	Spring	SVP 06	Sand			X	
29	19	100	Spring	SVP 06	Sand			X	X
30	20	30	Spring	SVP 05	Sand			X	
31	14	100	Spring	SVP 05	Sand			X	X
32	20	30	Fall	SVP 11	Sand			X	
33	14	100	Fall	SVP 11	Sand			X	X
34	21	30	Winter	SVP 02	Sand			X	
35	22	100	Winter	SVP 02	Sand			X	X

Abbreviations: MBE = multibeam depth sounder; SBE = chirp subbottom profiler; SSS = side-scan sonar.

[a] Sparkers could be used in certain instances in place of boomers, but the boomer modeling is representative of both.

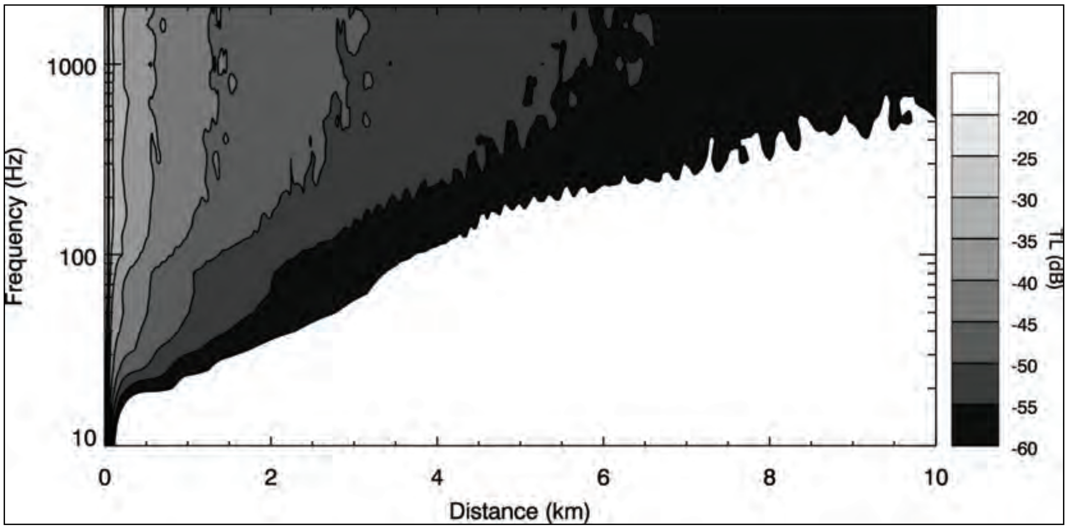

Figure D-40. Frequency Versus Distance Plot Based on Modeled Data for Scenario 22 (SVP 03). Water Depth at the Source is 30 m.

4.5.2. Continental Shelf

For the purpose of this work, continental shelf is defined as the areas with water depth less than 150 m with the exclusion of areas defined as shallow continental shelf in **Section 4.5.1**. Modeling site numbers that fall into this region are 14, 17, 19, and 22. The bottom type for this area is sand and the bottom sloping is more pronounced than in the shallow continental area, with a slope varying from 0.5°-1° and a bathymetry condition that can be no longer be considered flat. With a water depth at the source of 100 m, the depth inside the modeling area (20 km radius) can vary from 40 m to as deep as 1,500 m.

An example of frequency versus distance plot for Scenario 23 (Site 17) is provided in **Figure D-41**. With greater water depth than in the shallow continental shelf environment, all modeled frequencies can effectively propagate through the water layer waveguide; very low frequencies (10–15 Hz), however, still experience elevated TL compared to the higher frequencies.

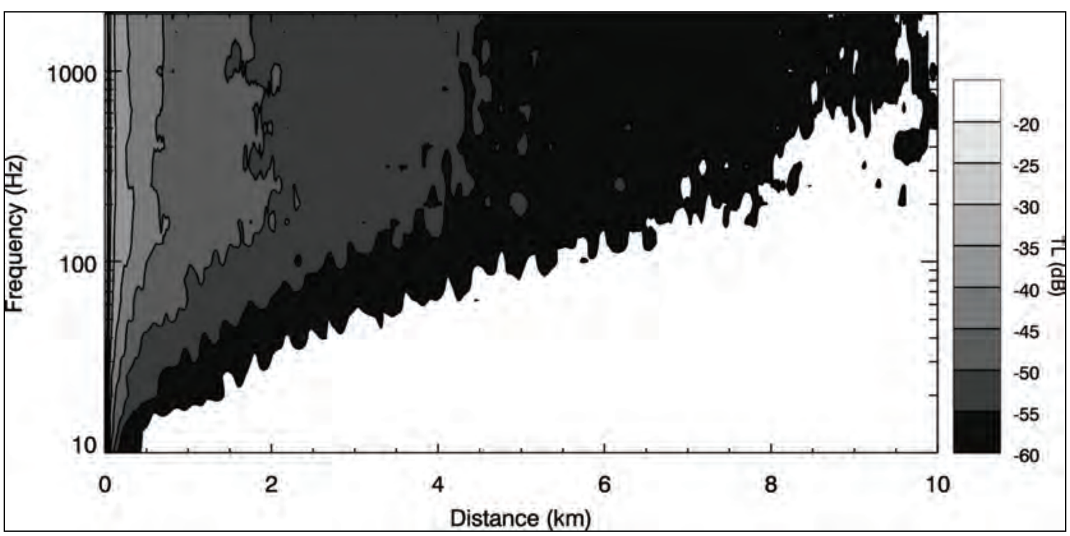

Figure D-41. Frequency Versus Distance Plot Based on Modeled Data for Scenario 23 (SVP 03). Water Depth at the Source is 100 m.

The vertical sound speed profile in the water column influences the propagation of the sound in the area. Most of the sound speed profiles used in the modeling scenarios feature negative velocity gradient at a depth of 30 m below the sea surface. Negative velocity gradient refracts the acoustic wave downwards and directs it into the seafloor, increasing the effect of bottom loss. The TL for high frequencies (100–2,000 Hz) is greater compared to the shallow continental shelf regions.

The geometric spreading of the acoustic wave energy still transitions into cylindrical spreading regime very close to the source. A highly reflective bottom interface ensures that most of the acoustic energy is returned into the water column after interaction with the seafloor, and bottom reflections contribute significantly to the total acoustic field.

4.5.3. Continental Slope

For the purpose of this work, continental slope is defined as the areas with water depth between 150 and 1,000 m. Modeling site numbers that fall into this category are 3, 4, 5, 7, 8, and 9. The bottom type for this area is sand and the bottom inclination is significant, reaching values as high as 13°. With a water depth at the source between 250 and 900 m, the depth inside the modeling area (20 km radius) can vary from 40 m to as deep as 2,500 m.

Two examples of frequency versus distance plot for Scenario 14 (Site 9) and for Scenario 3 (Site 3) are provided in **Figures D-42** and **D-43**, respectively. With greater water depth than in continental shelf environment, all modeled frequencies can effectively propagate through the water layer waveguide. Low frequencies (10–100 Hz), however, can still experience elevated TL for a shallow location of the source.The sound speed profile in the water column influences the propagation of the sound in the area. Most of the sound speed profiles used in the modeling scenarios feature negative velocity gradient from 30 m to about 1,200 m below the sea surface. Negative velocity gradient refracts the acoustic wave downward and directs it into the seafloor, increasing the effect of the bottom loss. The TL for high frequencies (100–2,000 Hz) is greater compared to the shallow continental shelf regions.

The geometric spreading of the acoustic wave energy transitions into a cylindrical-spreading regime at about 250 m or farther from the source. A highly reflective bottom interface ensures that most of the acoustic energy is returned into the water column after interaction with the seafloor, and bottom reflections contribute significantly to the total acoustic field near the source; their contribution, however, diminishes for greater water depths at the source.

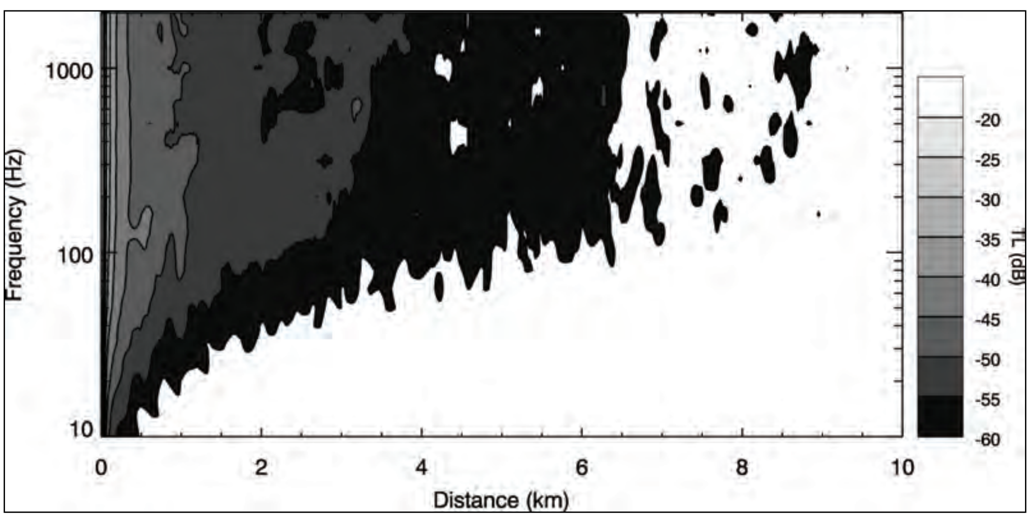

Figure D-42. Frequency Versus Distance Plot Based on Modeled Data for Scenario 14 (SVP 08). Water Depth at the Source is 250 m.

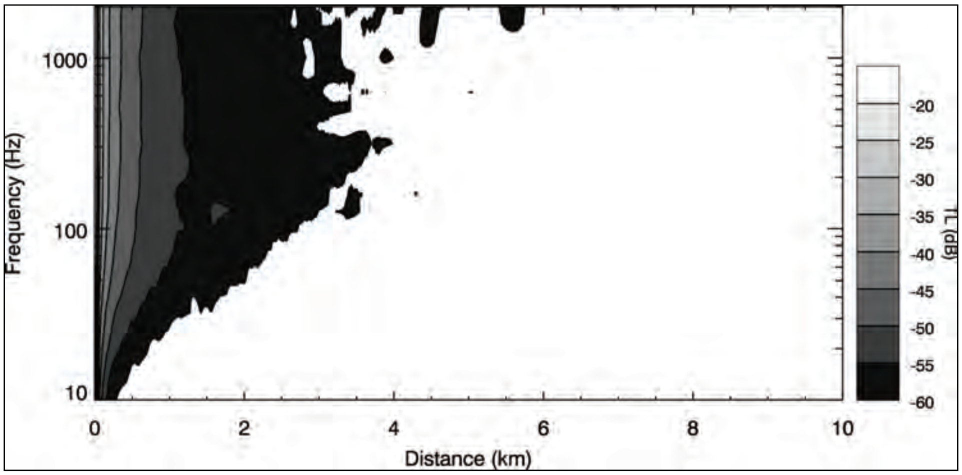

Figure D-43. Frequency Versus Distance Plot Based on Modeled Data for Scenario 3 (SVP 01). Water Depth at the Source is 880 m.

4.5.4. Deep Ocean

For the purpose of this work, deep ocean is defined as the areas with water depth greater than 1,000 m. Modeling site numbers that fall into this category are 1, 2, 6, and 10–13. The bottom type for this area is clay; bottom sloping can be significant near the continental slope regions and almost absent at depths greater than 2,000 m. The relative variation of the water depth inside a modeling area (radius 20 km) is small.

An example of frequency versus distance plot for Scenario 1 (Site 1) is provided in **Figure D-44**. With larger water depths all modeled frequencies can effectively propagate through the water layer waveguide. However, low frequencies (10–100 Hz) can still experience elevated TL for a shallow location of the source.

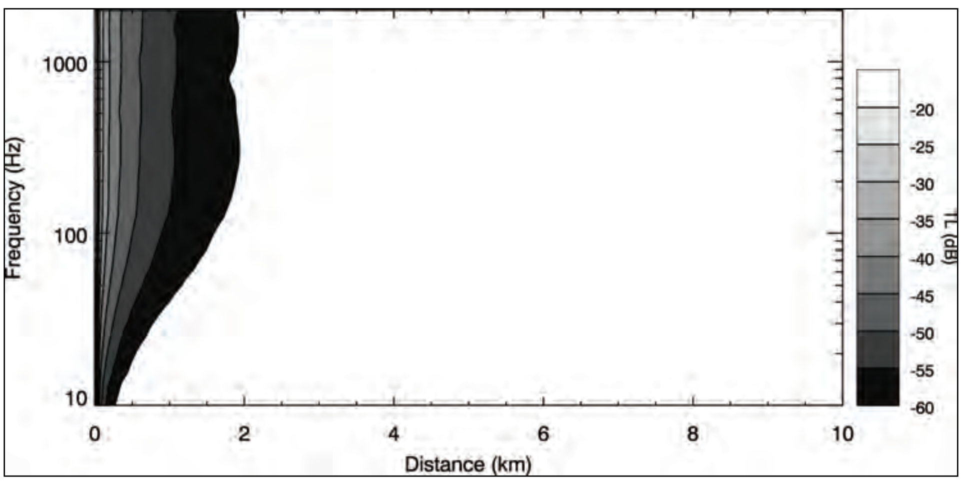

Figure D-44. Frequency Versus Distance Plot Based on Modeled Data for Scenario 1 (SVP 01). Water Depth at the Source is 5,390 m.

The vertical sound speed profile in the water column has significant effect on the propagation of the sound in the area. All sound speed profiles used in the modeling scenarios feature a deep sound channel at about 1,200–1,300 m below the surface. Positive velocity gradient refracts the acoustic wave upwards and directs it away from the bottom, decreasing the effect of the bottom loss. Also, shadow zones can be established in the water volume because of refraction. At the sites with water depths greater than 4,000 m a ray convergence effect can be observed; such a phenomenon can, over small volumes, lower the TL to as little as 60 dB at distances of 130 km.

Spherical spreading of the acoustic wave energy can persists as far as 5,000 m from the emitter (a range equal to the water depth at the source). Since the reflection coefficient of the clay bottom is low, most of the waterborne acoustic energy reaching the sediment layer experiences substantial loss. There is no significant contribution from bottom reflections to the total acoustic field near the source because of the large difference in travel distance between the direct and reflected wave.

5. MODEL RESULTS

The sound propagation code was run in the full N×2D scheme as described in **Section 4.1.1** for each of the 35 model scenarios and corresponding acoustic sources for a total of 105 combinations of sources and scenarios. The model estimates of received SEL for the airgun array sources were converted to rms SPL as outlined in **Section 4.1.3**.

To produce single maps of received sound level distribution and to calculate threshold distances to specified levels, the maximum level over all modeled receiver depths was calculated at each horizontal point of the modeling regions. The radial grid of modeled profiles was then resampled to produce a regular Cartesian grid with a cell size of 5 m. All contours and threshold ranges were calculated from these flat Cartesian projections of the estimated acoustic fields. The sound level maps, grouped by scenarios, are provided in **Attachment B**, **Figures Attachment B-1** through **B-35**.

For each sound level threshold, two different statistical estimates of the safety radii are provided in the tables in **Attachment C**: the maximum range and the 95 percent range. Given a regularly gridded spatial distribution of modeled RLs, the 95 percent range is defined as the radius of a circle that encompasses 95 percent of the grid points whose value is equal to or greater than the threshold value. This definition is meaningful in terms of potential impact to an animal because, regardless of the geometrical shape of the noise footprint for a given threshold level, it always provides a range beyond which no more than 5 percent of a uniformly distributed population would be exposed to sound at or above that level. The maximum range, which is simply the distance to the farthest occurrence of the threshold level, is the more conservative but may misrepresent the effective exposure zone. Indeed, there are cases where the volume ensonified to a specific level may not be continuous and small pockets of higher RLs may be found far outside the main ensonified volume (for example, because of convergence). If only the maximum range is presented, a false impression of the extent of the acoustic field can be given.

Tables D-22 and **D-23** summarize the results of the acoustic modeling in terms of threshold radii to the 160 dB and 180 dB rms SPL for the airgun arrays and electromechanical sources respectively. The complete sets of predicted threshold radii for each source to levels from 210 dB down to 150 dB rms SPL in 10 dB steps are presented in **Attachment C**, **Tables Attachment C-1** through **Attachment C-6**.

From the tabulated results it can be seen that the largest threshold radii for the airgun array sources are typically associated with sites in intermediate water depths (250 and 900 m); this is especially applicable to the 160 dB level. As noted above, low frequencies propagate relatively poorly in shallow water (i.e., water depths on the same order as or less than the wavelength). At intermediate water depths, this stripping of low-frequency sound no longer occurs, and longer-range propagation can be enhanced by the channeling of sound caused by reflection from the surface and seafloor (depending on the nature of the sound speed profile and sediment type).

The modeling results for the radii for the specific threshold levels presented in **Table D-23** do not account for the difference between the length of the pulse emitted by the acoustic instrument and the minimum integration time of the mammalian hearing apparatus. Instead, a receiver with unlimited minimum integration time was considered in the calculations. The calculation of rms SPL depends on the integration time (see Equation [1]). The application of the appropriate minimum integration time assumed for the marine mammals can significantly decrease the received rms SPL levels and, consequently, the threshold radii. The adjustment of the received rms SPL for the different integration time can be calculated with Equation [7]. **Table D-24** provides the adjustment values for the representative electromechanical sources with their respective pulse durations and the assumed minimum integration time of 100 ms.

Table D-22

Summary of the Predicted Threshold Radii (in Meters) for the 180 and 160 dB SPL (rms) for Airgun Array Sources

Source	Airgun Array 5,400 in^3				Airgun Array 90 in^3			
dB SPL	180		160		180		160	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
1	835	810	5,379	4,969	148	144	1,295	1,256
2	876	827	5,720	5,184	148	143	1,363	1,291
3	1,557	1,093	9,329	8,104	148	145	2,210	2,038
4	822	748	12,737	8,725	76	75	1,452	1,342
5	816	742	13,337	8,896	76	74	1,568	1,286
6	837	811	5,379	4,989	148	144	1,295	1,256
7	855	829	5,322	5,026	146	142	1,322	1,281
8	1,556	1,091	9,654	8,056	148	145	2,212	2,039
9	801	737	11,056	8,593	76	74	1,464	1,331
10	799	752	11,695	8,615	76	75	1,512	1,108
11	837	811	5,379	4,973	146	143	1,295	1,255
12	853	827	5,320	5,013	146	141	1,321	1,280
13	1,552	1,082	9,316	8,095	147	143	2,211	2,036
14	880	761	15,305	9,122	76	74	1,371	1,100
15	841	816	5,490	5,121	146	143	1,315	1,258
16	871	846	5,360	5,098	149	145	1,325	1,285
17	838	812	5,184	4,959	149	145	1,294	1,255
18	845	819	5,450	5,069	148	145	1,329	1,289
19	1,559	1,094	9,304	8,083	149	145	2,212	2,040
20	1,134	992	12,022	8,531	90	86	2,051	1,681
21	2,109	1,677	11,380	8,384	186	177	3,056	2,493

Table D-23

Summary of the Predicted Threshold Radii (in Meters) for 180 and 160 dB SPL (rms) for Electromechanical Sources

Source:	Boomer				Side-Scan Sonar				Chirp Subbottom Profiler				Multibeam Depth Sounder			
dB SPL	180		160		180		160		180		160		180		160	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
22	43	43	1,737	1,490	192	180	604	534	32	28	808	682	--	--	--	--
23	39	38	1,060	818	128	116	512	440	38	35	380	303	27	25	147	142
24	43	42	1,956	1,444	186	176	602	532	32	28	874	772	--	--	--	--
25	38	36	1,566	1,342	138	116	532	455	37	35	376	317	27	25	147	142
26	43	41	1,712	1,428	190	176	600	530	32	28	764	664	--	--	--	--
27	40	40	1,054	807	128	116	500	438	37	35	359	297	27	25	147	142
28	41	40	1,860	1,468	177	156	655	528	33	29	971	876	--	--	--	--
29	39	38	1,129	799	133	125	650	499	42	37	854	677	27	25	156	149
30	43	41	1,730	1,435	171	154	576	510	33	29	831	644	--	--	--	--
31	40	39	1,155	840	129	115	537	462	42	39	557	313	27	25	147	140
32	45	43	2,138	1,552	178	156	600	539	33	29	962	811	--	--	--	--
33	39	38	1,655	898	132	119	567	492	42	39	684	363	27	25	147	140
34	43	43	1,844	1,467	175	159	592	526	32	29	724	634	--	--	--	--
35	40	38	1,035	669	134	121	538	458	42	38	401	300	27	25	149	144

Table D-24

Adjustment of the 180-dB and 160-dB Threshold Radii Based on the Difference between the Pulse Length of the Electromechanical Sources and the Minimum Integration Time of the Mammalian Hearing Apparatus (100 ms)

Source	Pulse Length	Adjustment Value (dB)	Adjusted Radius (m)		Operating Frequency within Cetacean Hearing Range?
			180 dB (Rmax)	160 dB (Rmax)	
Boomer	180 µs	-27.3	<5	16	Yes (0.2–16 kHz)
Side-scan sonar	20 ms	-7.0	65–96	337–450	Yes (100 kHz) No (400 kHz)
Chirp subbottom profiler[1]	64 ms	-1.9	26–35	240–689	Yes (3.5 kHz, 12 kHz) No (200 kHz)
Multibeam depth sounder	225 µs	-26.5	<5	12	No (240 kHz)

[1] Recent source characterization fieldwork indicates modeled results to be conservative, that is, observed received levels were below model results (Zykov and MacDonnell, 2013).

Adjustment for the minimum integration time is only applicable to the electromechanical sources for which pulse length is shorter than the specific minimum integration time. The modeling results for the airgun array sources are not subject to adjustment as the length of the acoustic pulse from such sources is usually greater than 100 ms, i.e., longer than the minimum integration time of the mammalian hearing apparatus.

The relatively small effect range for multibeam depth sounders is consistent with a recent analysis by Lurton and DeRuiter (2011) taking into account both the short pulse duration and high directivity of the source.

Operating frequency is another consideration in defining an appropriate safety zone. While airguns and boomers produce sounds within the hearing range of cetaceans, the operating frequency of the representative multibeam system (240 kHz) is above the hearing range of all cetaceans. For side-scan sonar, the 100 kHz operating frequency is within the cetacean hearing range but the 400 kHz operating frequency is not. For the chirp subbottom profiler, the 3.5 and 12 kHz frequencies are within the cetacean hearing range but the 200 kHz is not. Also, based on sea turtle hearing as reviewed in **Appendix I**, only airguns and boomers are likely to be within their hearing range.

The safety zone radii based on Southall et al. (2007) criteria were also estimated. The safety radii for all sources based on the peak pressure criteria are presented in **Table D-25**. The safety radii based on the sound exposure level criteria are presented in **Table D-26** for the airgun array sources and in **Table D-27** for the electromechanical sources. Only the cetaceans group was considered, as the abundance of pinnipeds inside the AOI is virtually nil (U.S. Dept. of the Navy, 2007).

Table D-25

Safety Zone Radii (in Meters) Based on Southall et al. (2007) Injury Criterion for the Maximum Peak Pressure. The Values Are Applicable to All Scenarios

Source	Peak Level of Source (dB re 1 µPa at 1 m)	Safety Zone Radii (m)
		230 dB re 1 µPa (peak)
Airgun array 5,400 in^3	247.7	7.7
Airgun array 90 in^3	232.0	1.3
Boomer	215.0	0[1]
Side-scan sonar	229.0	0[1]
Subbottom profiler	228.2	0[1]
Multibeam depth sounder	213.0	0[1]

[1] Source level is less than the criterion.

Table D-26

Safety Zone Radii (in Meters) for the Airgun Array Sources Based on Southall et al. (2007) Injury Criterion for the Sound Exposure Level (198 dB re 1 μPa^2 s). The Calculations Were Performed on the Modeled Sound Field after Application of the Relevant M-Weighting Filter

Source	Airgun Array 5,400 in^3			Airgun Array 90 in^3		
Frequency	Low	Med	High	Low	Med	High
Scenario	198 dB	198 dB	198 dB	198 dB	198 dB	198 dB
1	18	<5	<5	<5	–	–
2	18	<5	<5	<5	–	–
3	18	<5	<5	<5	–	–
4	18	<5	<5	<5	–	–
5	18	<5	<5	<5	–	–
6	18	<5	<5	<5	–	–
7	18	<5	<5	<5	–	–
8	18	<5	<5	<5	–	–
9	18	<5	<5	<5	–	–
10	18	<5	<5	<5	–	–
11	18	<5	<5	<5	–	–
12	18	<5	<5	<5	–	–
13	18	<5	<5	<5	–	–
14	18	<5	<5	<5	–	–
15	18	<5	<5	<5	–	–
16	18	<5	<5	<5	–	–
17	18	<5	<5	<5	–	–
18	18	<5	<5	<5	–	–
19	18	<5	<5	<5	–	–
20	18	<5	<5	<5	–	–
21	18	<5	<5	<5	–	–

Table D-27

Safety Zone Radii (in Meters) Based on Southall et al. (2007) Injury Criterion Based on the Sound Exposure Level (198 dB re 1 μPa^2·s). The Values Are Applicable to All Scenarios. The Effective Source Level (SL_{eff}) Was Calculated Based on the Nominal Source Level and Relevant M-Weighting Filter

Cetaceans:	Low-Frequency		Mid-Frequency		High-Frequency	
Source	SL_{eff} (dB re 1 μPa^2·s)	198 dB Radius (m)	SL_{eff} (dB re 1 μPa^2·s)	198 dB Radius (m)	SL_{eff} (dB re 1 μPa^2·s)	198 dB Radius (m)
Boomer	174.4	0[1]	174.2	0[1]	174.1	0[1]
Side-scan sonar	179.3	0[1]	203.3	2	203.9	2
Subbottom profiler	212.0	5	213.1	6	213.1	6
Multibeam depth sounder	131.9	0[1]	163.3	0[1]	164.6	0[1]

[1] Effective Source Level is less than the criterion.

The peak pressure decrease with distance was assessed based on the spherical spreading loss (see **Section 2.2.1**). The furthest calculated range for injury using the Southall peak pressure criterion was just 7.7 m from the loudest source (airgun array 5,400 in^3). This range is much less than the shallowest water depth out of all scenarios. This fact implies that the approach with spherical spreading loss application to be valid. Also it indicates that the safety range calculation does not depend on the water depth and the same value is good for all scenarios.

The safety zone radii regarding sound exposure levels were calculated using the transmission loss modeling results and corresponding source level for each modeled source expressed in SEL units. Prior to the calculation of the safety zone radii, appropriate M-weighting filter was applied to the sound field to reflect different audiograms of different marine mammals groups.

The effect of M-weighting filters application is different for different sources as their frequency spectrum varies. The airgun array sources would see virtually no change in the safety zone radii for the low-frequency M-weighting filter application, as their dominant frequencies are at the lower end of the spectrum. Application of mid- and high-frequency M-weighting filters would reduce the effective source level of the airgun array sources, as the filter suppresses the low frequency content of the spectrum; hence, the reduction of the safety zone radii. The reverse situation is observed for electromechanical sources, whose spectrum is dominated by higher frequencies. The largest reduction in the effective source levels and safety zone radii would be achieved by application of the low-frequency M-weighting filter, and the mid- and high-frequency M-weighting filter would have smaller effect.

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ATTACHMENT A: COMMENTS ON THE BOOMER SOURCE LEVELS

The modeling of the boomer source conducted for this report was primarily based on the theoretical calculations and laboratory experimental findings presented by Simpkin (2005). The modeling work commenced in May 2011 and concluded by December 2011. However, in the summer of 2012, JASCO performed field measurements on a boomer source that provided additional data on the source levels of a boomer system.

RECENT FINDINGS (SUBSEQUENT TO 2011)

JASCO performed a sound source verification study on an AP3000 boomer system (Martin et al., 2012) with a double-plate configuration operating at maximum input energy of 1000 J. During the study, the acoustic data were collected as close as 8 m to the source and directly below it. The measurements were performed at a 10 m depth.

The data showed that the broad band source level for the system was 203.3 dB 1 µPa @ 1 m rms SPL over 0.2 ms window length and 172.6 dB re 1 µPa^2·s @ 1 m SEL over 55 ms window length. The field data also revealed that even at 10 m from the source, the T_{90} is significantly longer than 0.2 ms: for distances from 8 to 20 m from the source the T_{90} varied from 6 ms to 10 ms, and for distances more than 20 m the T_{90} was greater than 10 ms.

It is believed that the source level values of 212 dB re µPa at 1 m, as provided in the specifications sheet by the manufacturer of the AA201 representative system (Applied Acoustic Engineering, Ltd., 2011), significantly overestimate the actual source levels achieved in the field environment.

JASCO suggests updating the values in Table D-6 according to the recent findings. **Table Attachment A-1** presents corrected pulse specifications values for the representative boomer system (AA201 200 J power input) derived from the measured values for AP3000 (1,000 J power input) by scaling down according to the difference in the power input (-7 dB).

Table Attachment A-1

Pulse Specifications for Boomer AP3000 Double Plate System (1000 J Power Input) and Corrected Pulse Specifications for Boomer AA201 System (200 J Power Input)

Parameter	AP3000 Double-Plate	AA201 Single-Plate
Operational Frequency Range	Broad Band: 200 Hz to 16 kHz	Broad Band: 200 Hz to 16 kHz
Beam Widths (degrees)	omnidirectional –8°	omnidirectional -8°
Energy Input (per shot)	1,000 J	200 J
Maximum Power Input	3,000 W	600 W
rms SPL (dB re 1 µPa at 1 m) T = 0.2 ms	204	197 (corrected from 212)
Peak Level (dB re 1 µPa at 1 m)	210	203 (corrected from 215)
SEL (dB re 1 µPa^2·s at 1 m)	173	166 (corrected from 174.6)

IMPLICATIONS OF THE SOURCE LEVEL VALUES CHANGE FOR THE REPRESENTATIVE BOOMER SYSTEM

According to **Table Attachment A-1**, the effective source level values for the AA201 boomer system were significantly reduced. In case of the source level in the rms SPL metric, the reduction is 15 dB. The reduction can be potentially even greater if the increased pulse length of several milliseconds is taken into account.

With the source level reduced, the threshold radii presented in **Table Attachment C-3** and **Table D-23** would need to be adjusted as well. The threshold radii presented in **Table Attachment C-3** and **Table D-23** were calculated assuming the source level for the boomer system of 212 dB re 1 µPa at

1 m. **Table Attachment A-2** provides predicted ranges to the specific threshold levels assuming the source level for the boomer system of 197 dB re 1 µPa at 1 m for the boomer system.

Table Attachment A-2

Predicted Ranges (in Meters) to Specified Threshold Levels for Boomer Source.
No Adjustment for Pulse Duration Has Been Applied

rms dB	200		190		180		170		160		150	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
22	-	-	< 5	< 5	5	5	22	22	127	121	817	691
23	-	-	< 5	< 5	5	5	21	21	74	72	405	375
24	-	-	< 5	< 5	5	5	22	22	126	120	753	688
25	-	-	< 5	< 5	5	5	21	21	74	71	405	382
26	-	-	< 5	< 5	5	5	22	22	128	123	750	668
27	-	-	< 5	< 5	5	5	21	21	76	73	420	374
28	-	-	< 5	< 5	5	5	22	22	120	117	655	616
29	-	-	< 5	< 5	5	5	21	21	75	72	410	367
30	-	-	< 5	< 5	5	5	22	22	125	119	866	585
31	-	-	< 5	< 5	5	5	21	21	76	73	425	376
32	-	-	< 5	< 5	5	5	22	22	119	116	871	653
33	-	-	< 5	< 5	5	5	21	21	75	72	419	376
34	-	-	< 5	< 5	5	5	22	22	119	116	775	611
35	-	-	< 5	< 5	5	5	21	21	75	72	385	258

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ATTACHMENT B: SOUND MAPS

Sound field maps for each of the planned model sites that present the maximum SPL (rms) at each horizontal distance from the source irrespective of the depth at which the maximum occurred were prepared. These SPL (rms) values are the maximum-over-depth broadband (10-2,000 Hz) sound exposure levels (SEL) around a source. This presentation of sound field modeling results permits an overview comparison of the modeled sound field condition at each model site for the various sound sources as well as the model results for specific sound sources for sites with different bathymetry and other factors affection sound propagation. However, these are not in the form of the sound field model results that were used for take estimation. Locations of the sites are shown in **Figure D-35** of **Section 4.2.1**. The maps are grouped by scenario (see **Table D-20**), i.e. various sources at the same geographic location (site), bottom type, and same sound velocity profile. Approximate SPL (rms), in dB re 1 μPa, is shown in all cases. The modeling results do not account for the specific properties of the mammalian hearing such as hearing integration time. Actual acoustic pulse duration was used to estimate the presented sound fields.

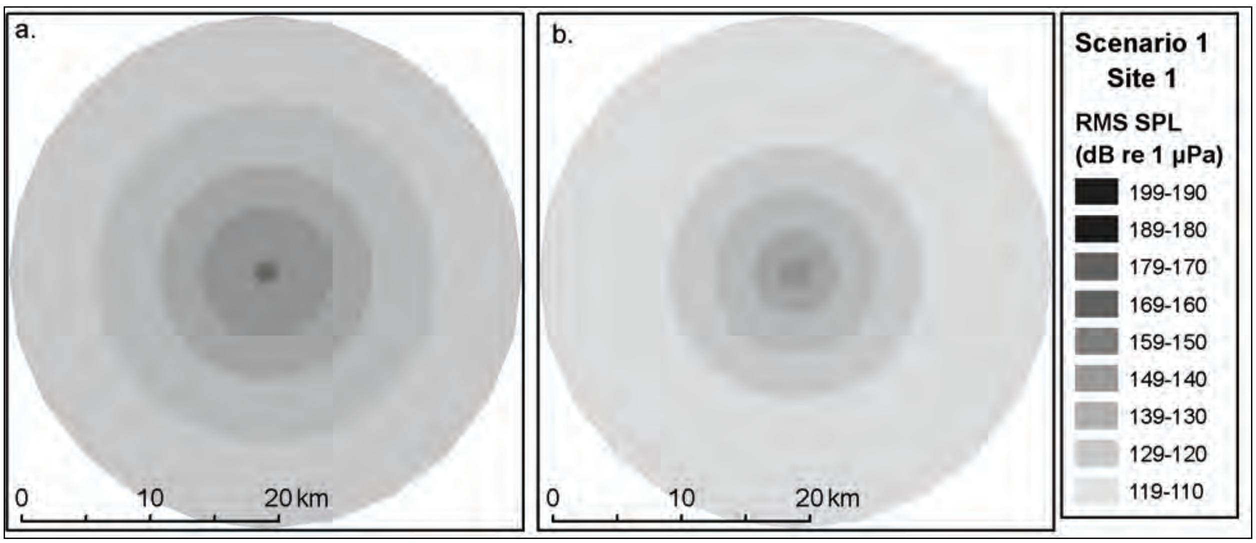

Figure Attachment B-1. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 1 (Water Depth is 5,390 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

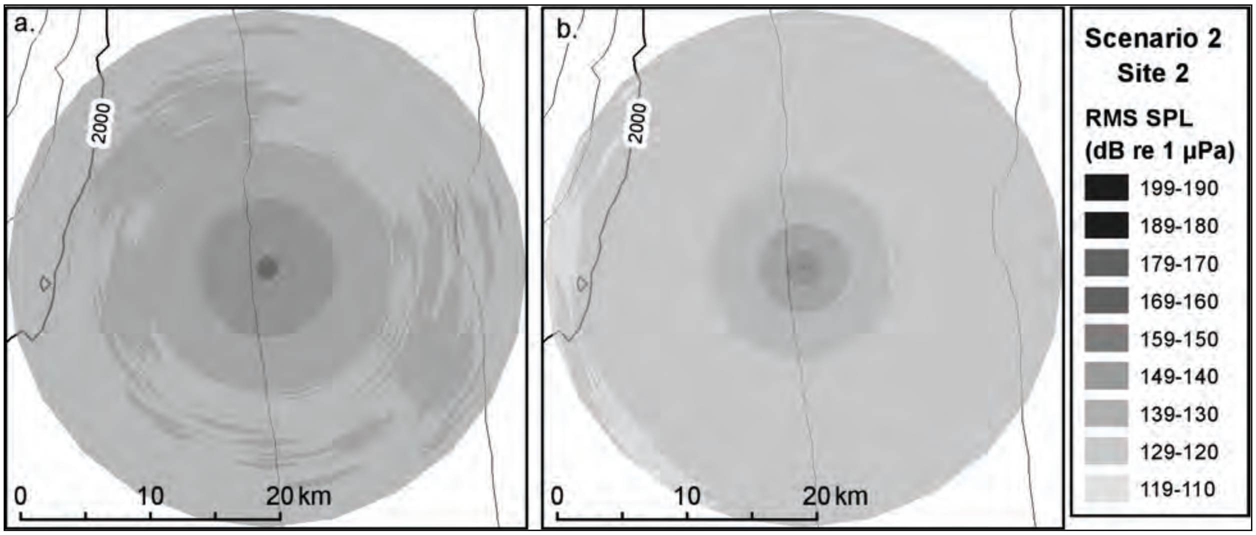

Figure Attachment B-2. Maximum-over-depth broadband (10-2,000 Hz) sound exposure levels (SEL) around the source for Modeling Scenario 2 (Water Depth is 2,560 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

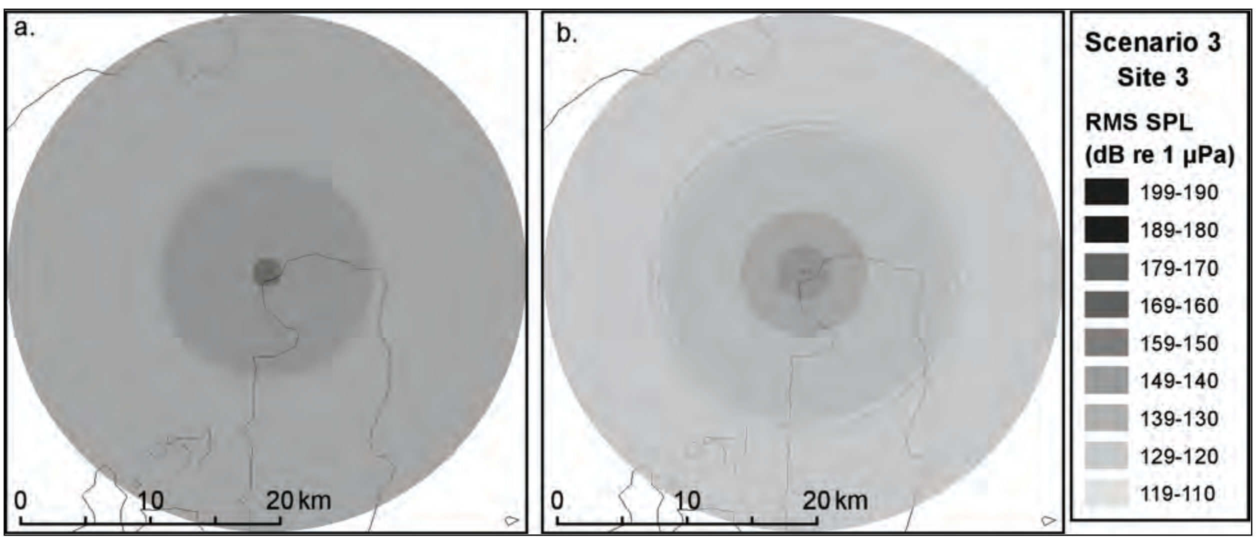

Figure Attachment B-3. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 3 (Water Depth is 880 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

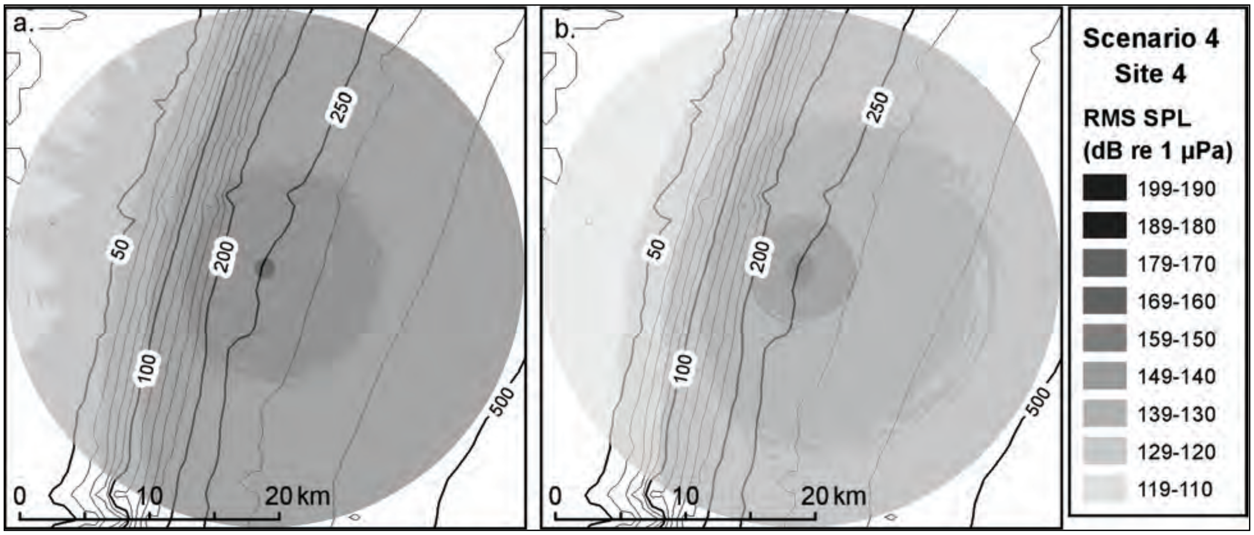

Figure Attachment B-4. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 4 (Water Depth is 249 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

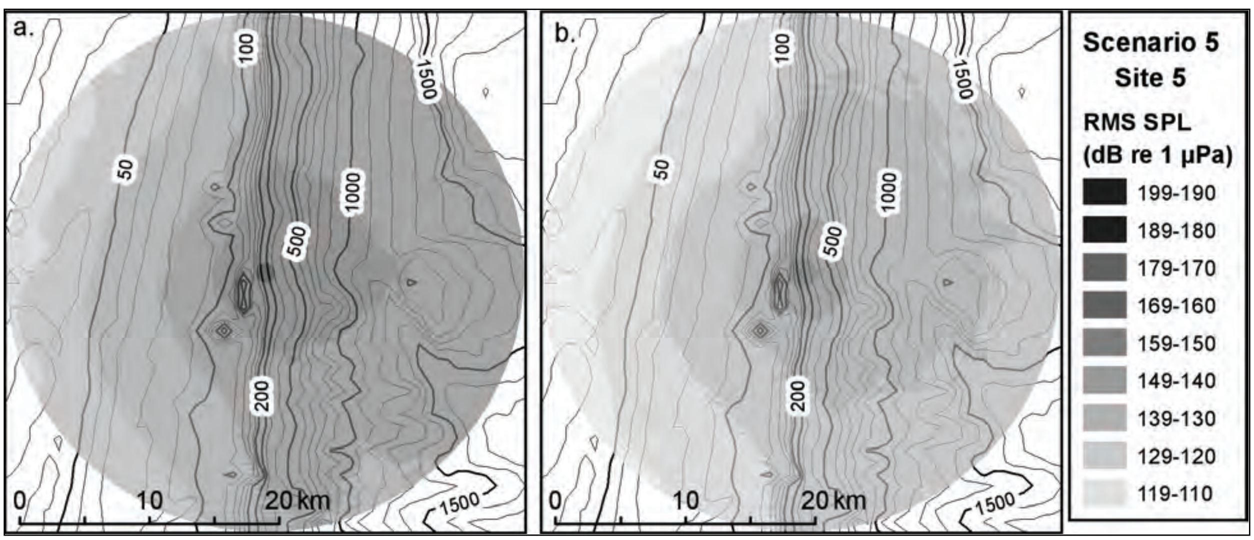

Figure Attachment B-5. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 5 (Water Depth is 288 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

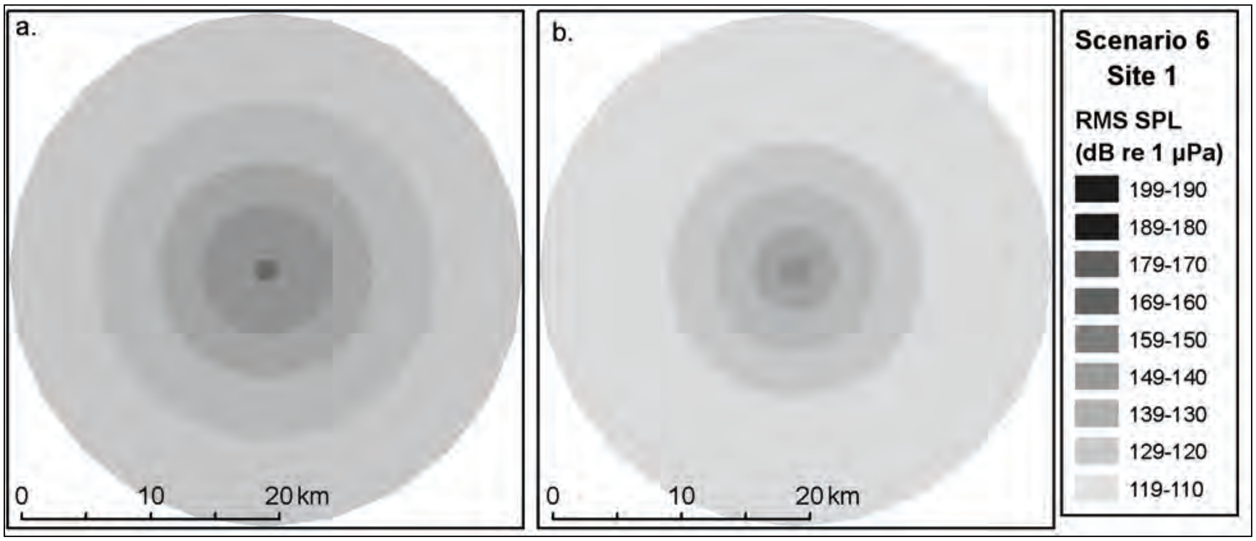

Figure Attachment B-6. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 6 (Water Depth is 5,390 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

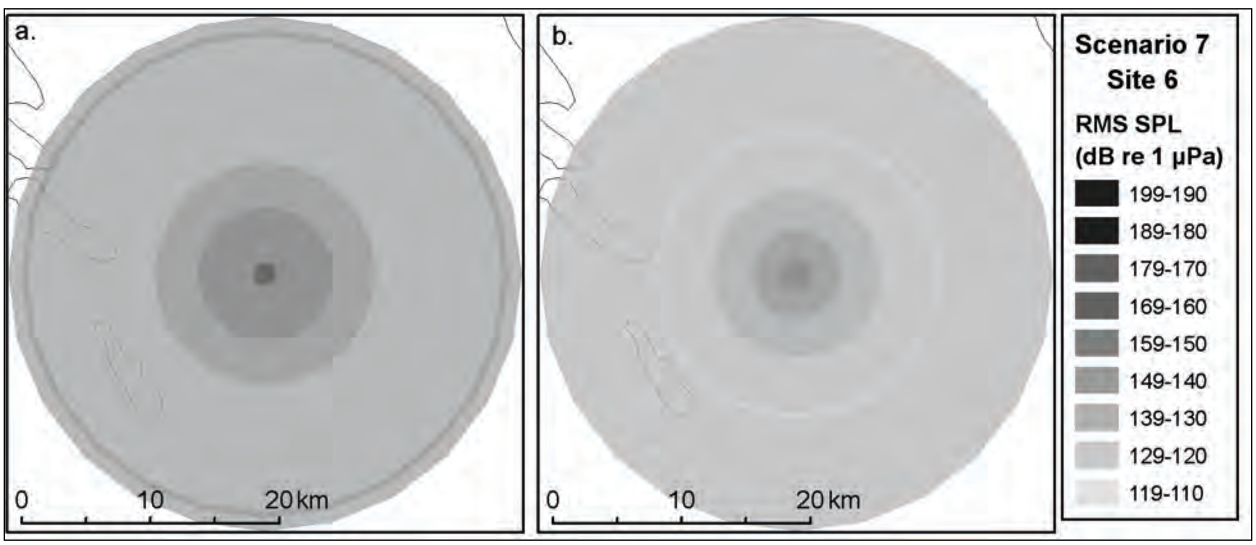

Figure Attachment B-7. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 7 (Water Depth is 3,200 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

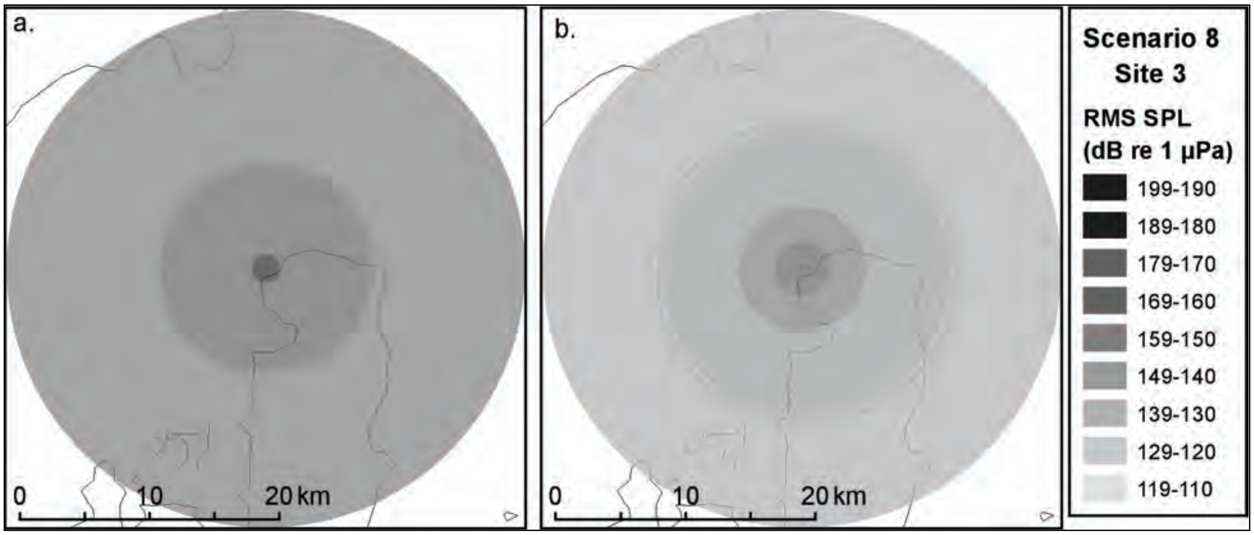

Figure Attachment B-8. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 8 (Water Depth is 880 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

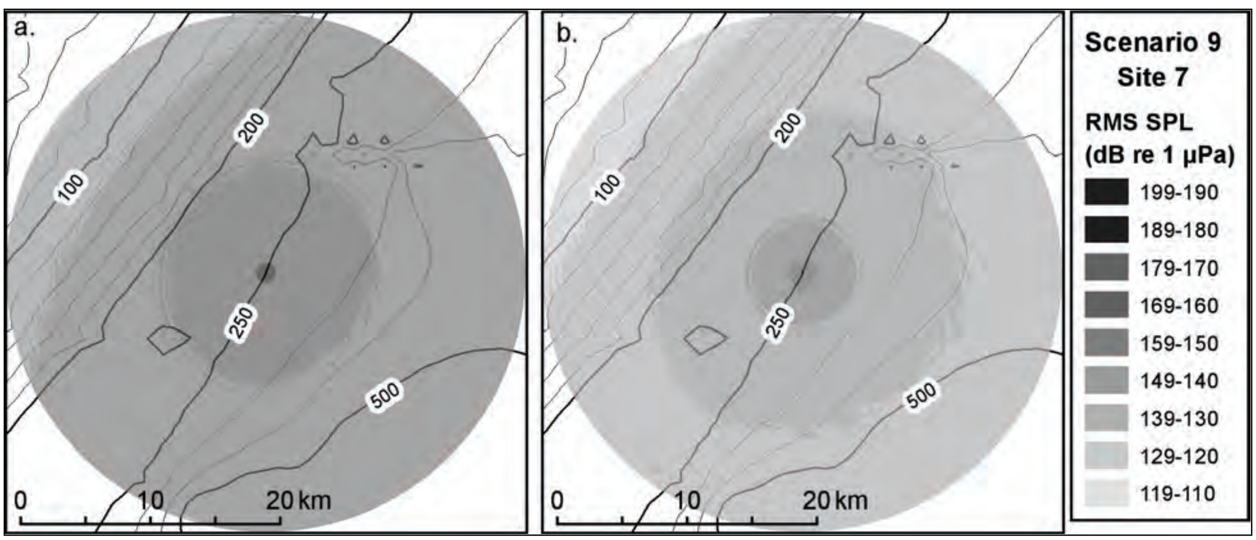

Figure Attachment B-9. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 9 (Water Depth is 251 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

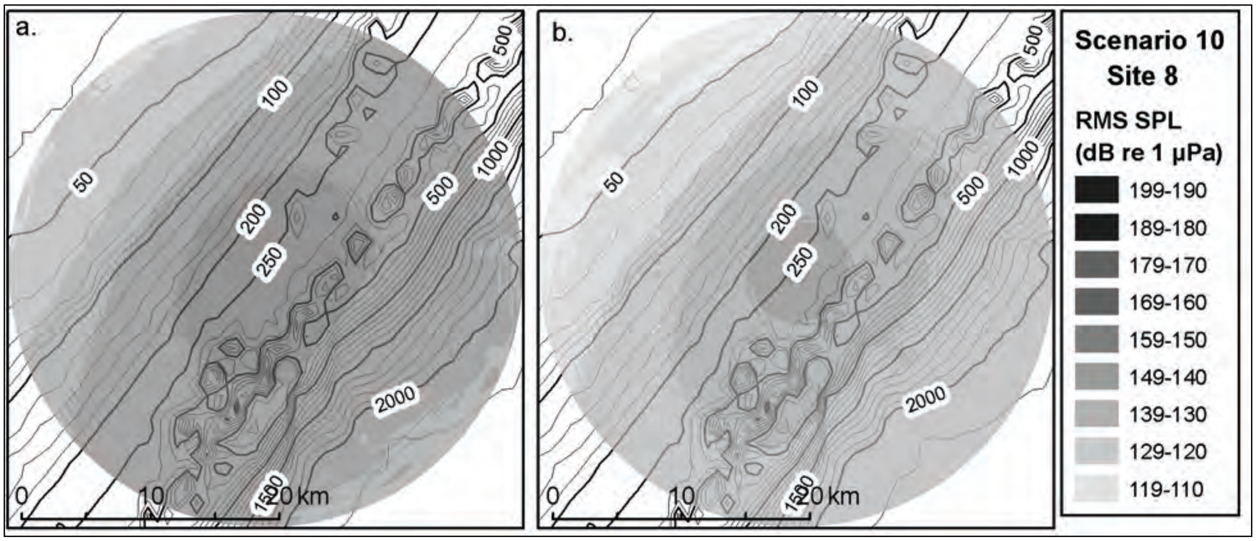

Figure Attachment B-10. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 10 (Water Depth is 249 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

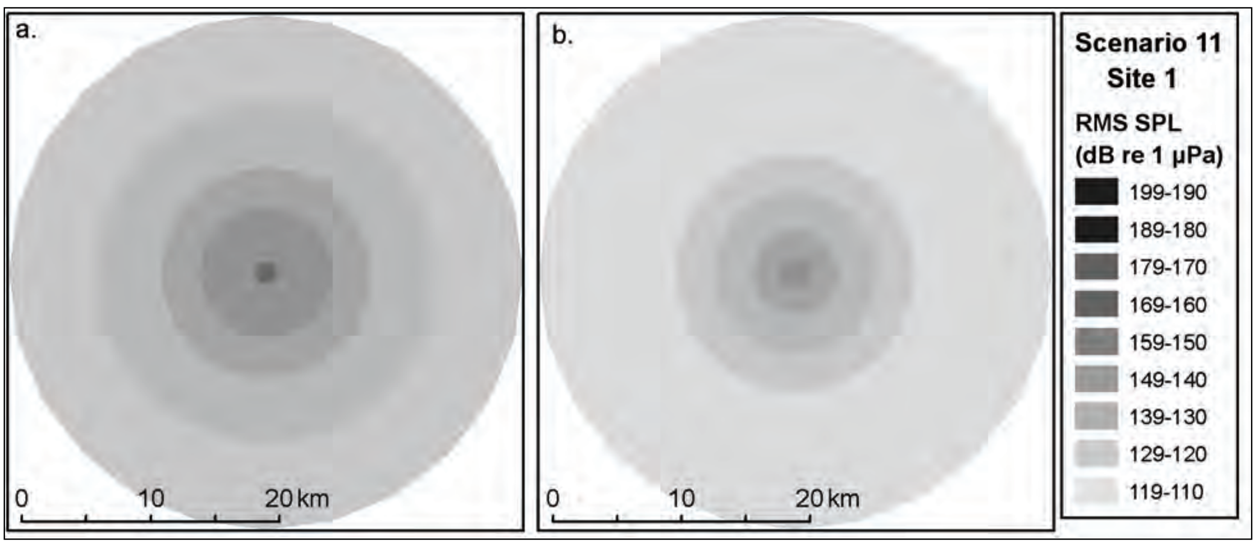

Figure Attachment B-11. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 11 (Water Depth is 5,390 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

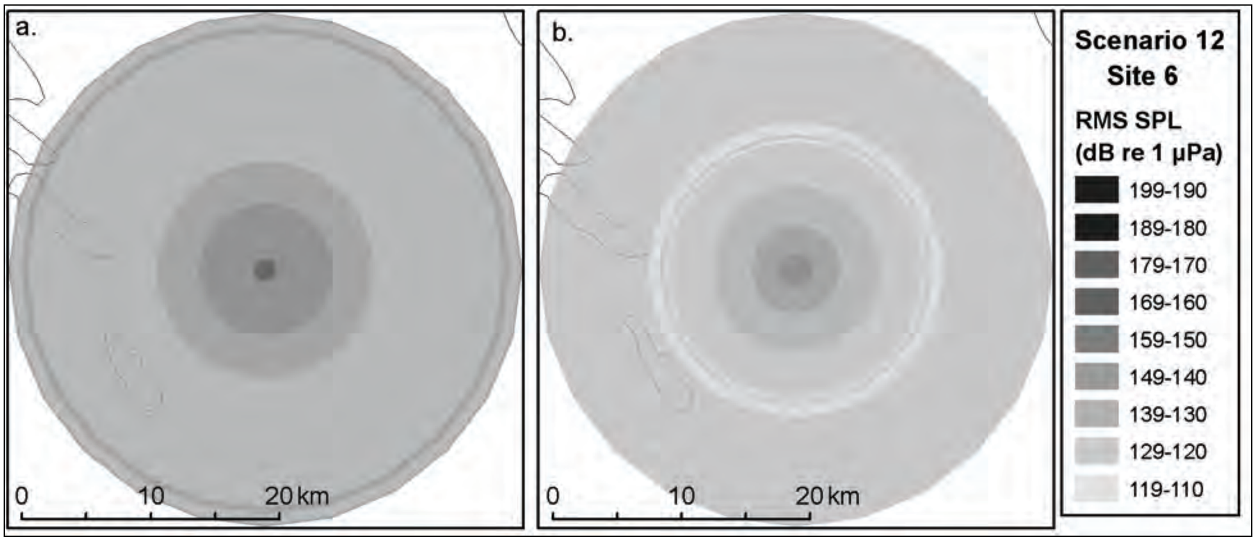

Figure Attachment B-12. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 12 (Water Depth is 3,200 m at the Source). The Sources are (a) 5,400 $in.^3$ and (b) 90 $in.^3$ Airgun Arrays.

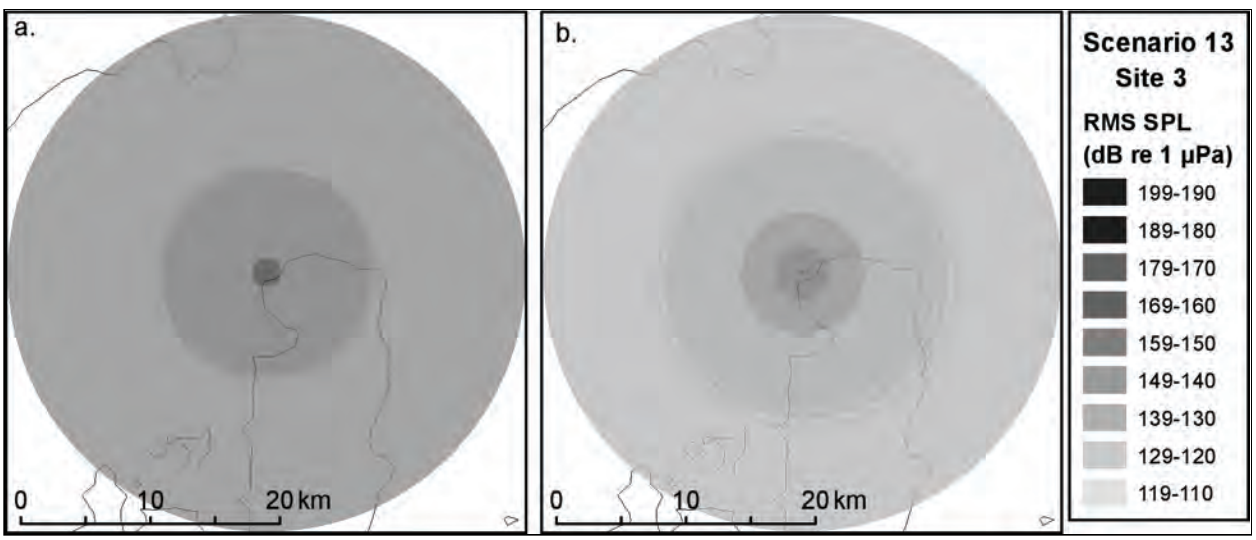

Figure Attachment B-13. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 13 (Water Depth is 880 m at the Source). The Sources are (a) 5,400 $in.^3$ and (b) 90 $in.^3$ Airgun Arrays.

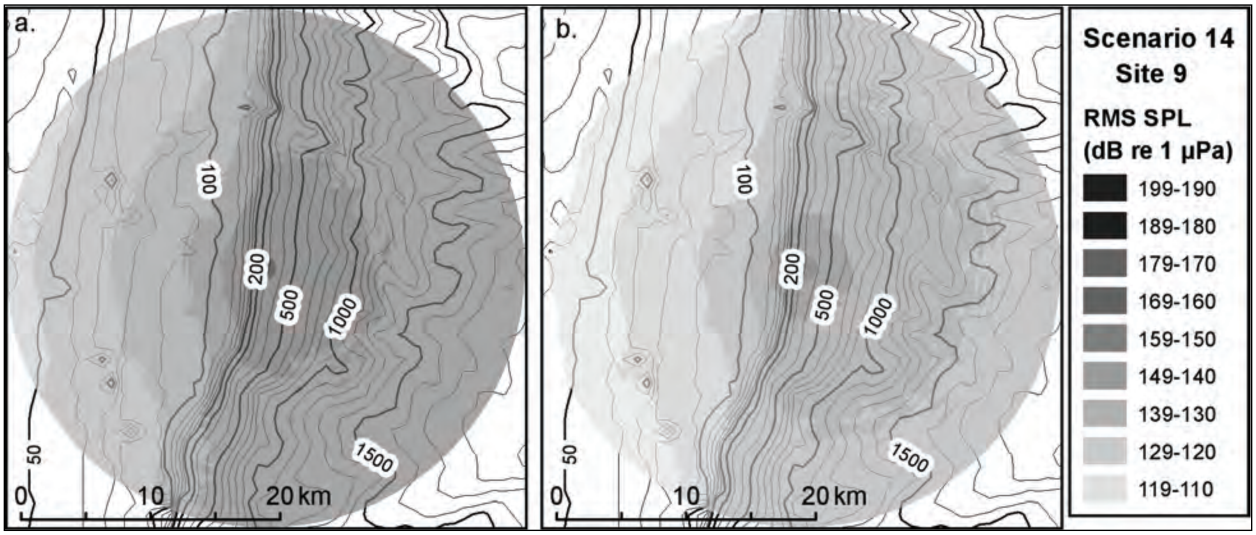

Figure Attachment B-14. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 14 (Water Depth is 275 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

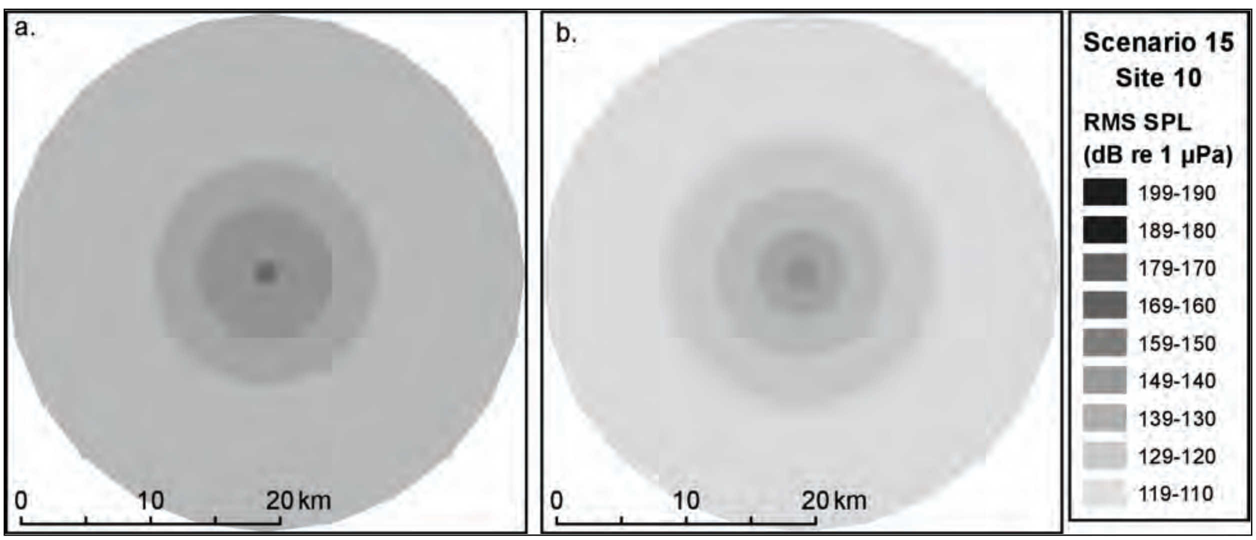

Figure Attachment B-15. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 15 (Water Depth is 4,300 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

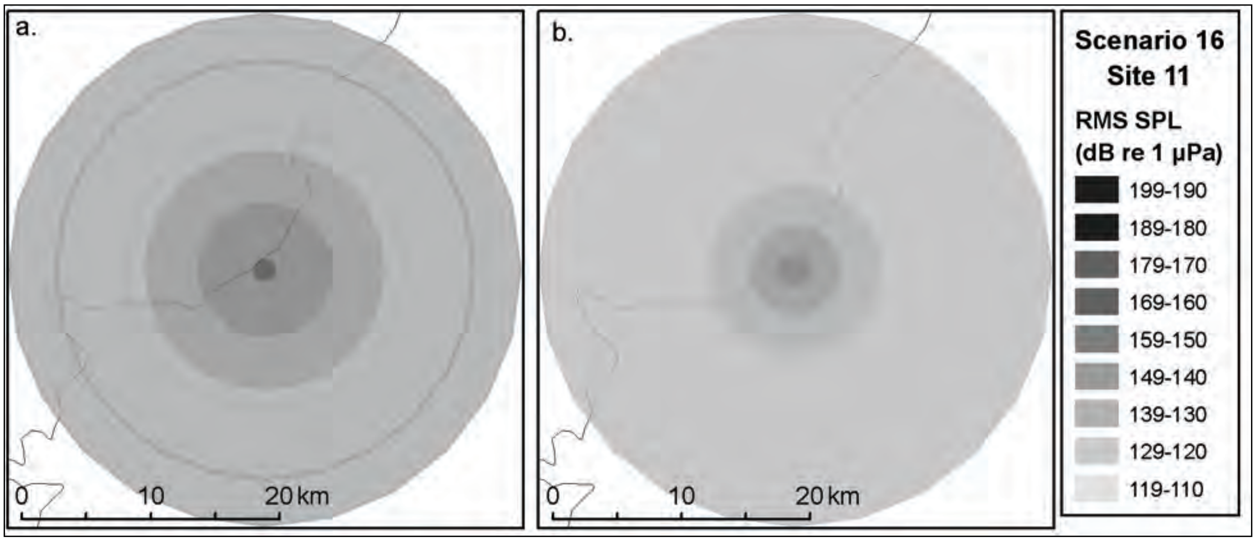

Figure Attachment B-16. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 16 (Water Depth is 3,010 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

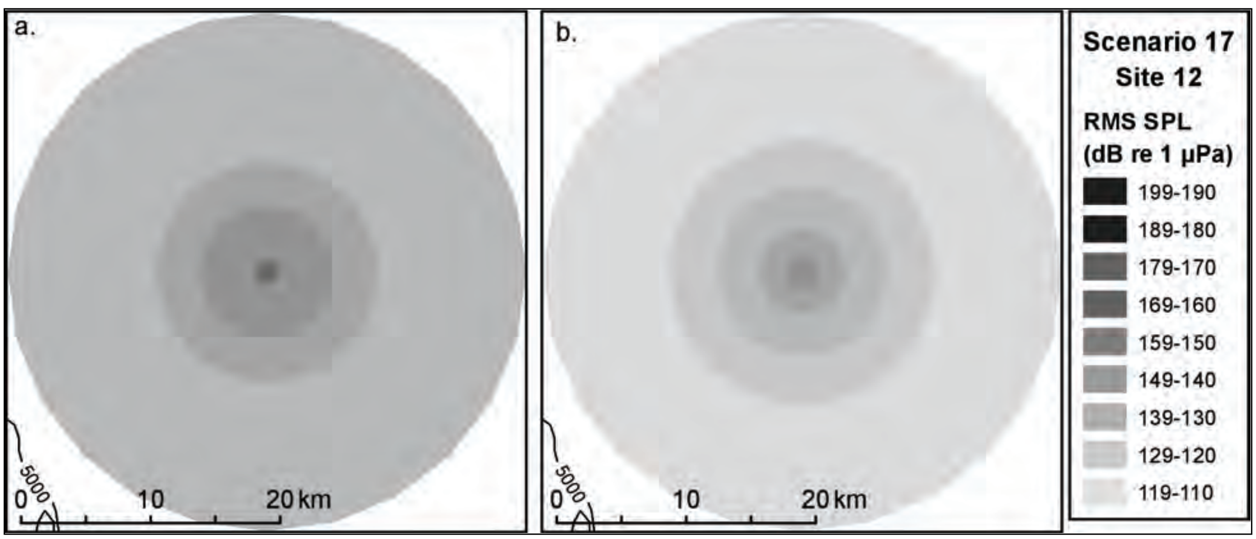

Figure Attachment B-17. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 17 (Water Depth is 4,890 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

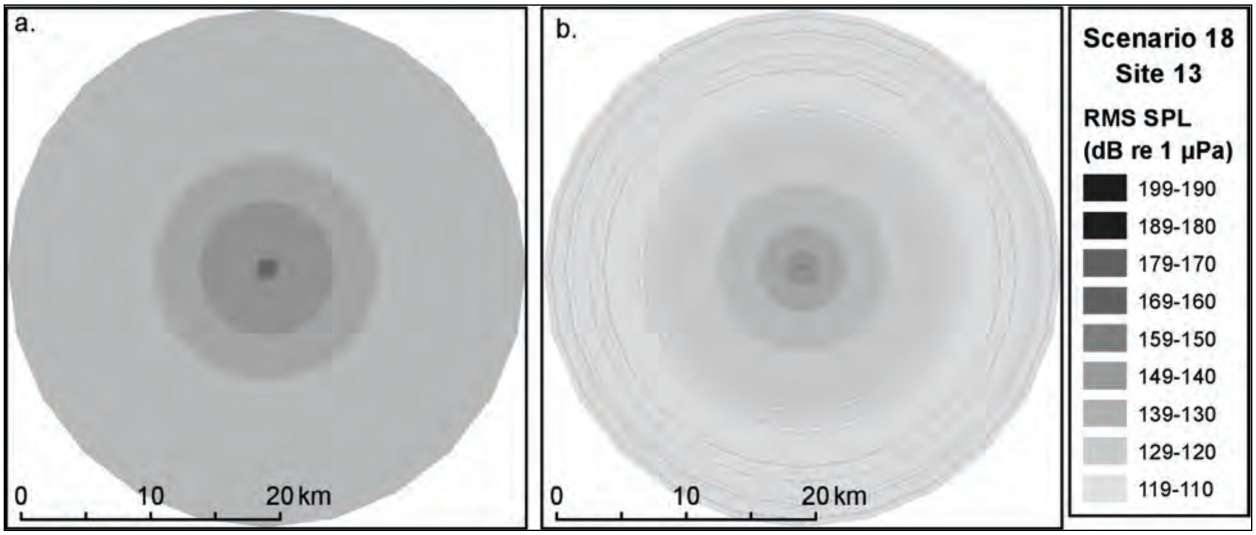

Figure Attachment B-18. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 18 (Water Depth is 3,580 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

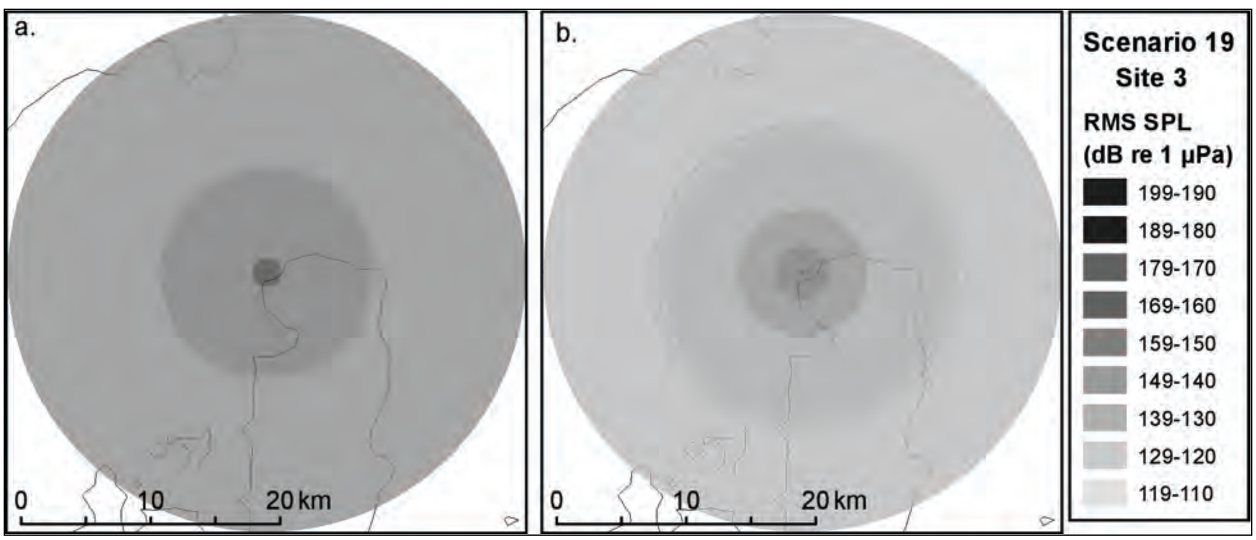

Figure Attachment B-19. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 19 (Water Depth is 880 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

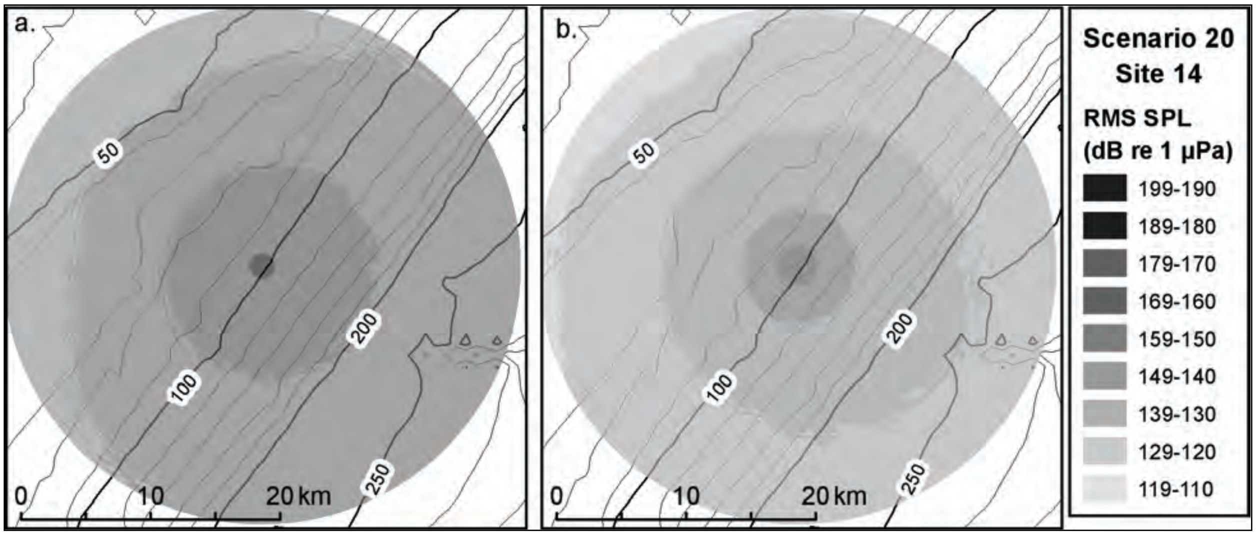

Figure Attachment B-20. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 20 (Water Depth is 100 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

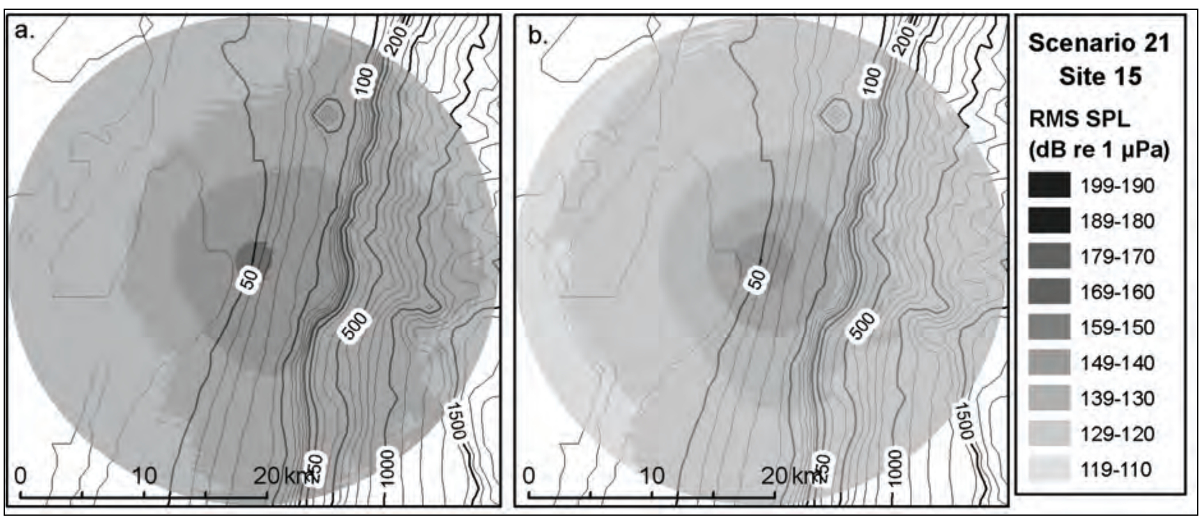

Figure Attachment B-21. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 21 (Water Depth is 51 m at the Source). The Sources are (a) 5,400 in.^{3} and (b) 90 in.^{3} Airgun Arrays.

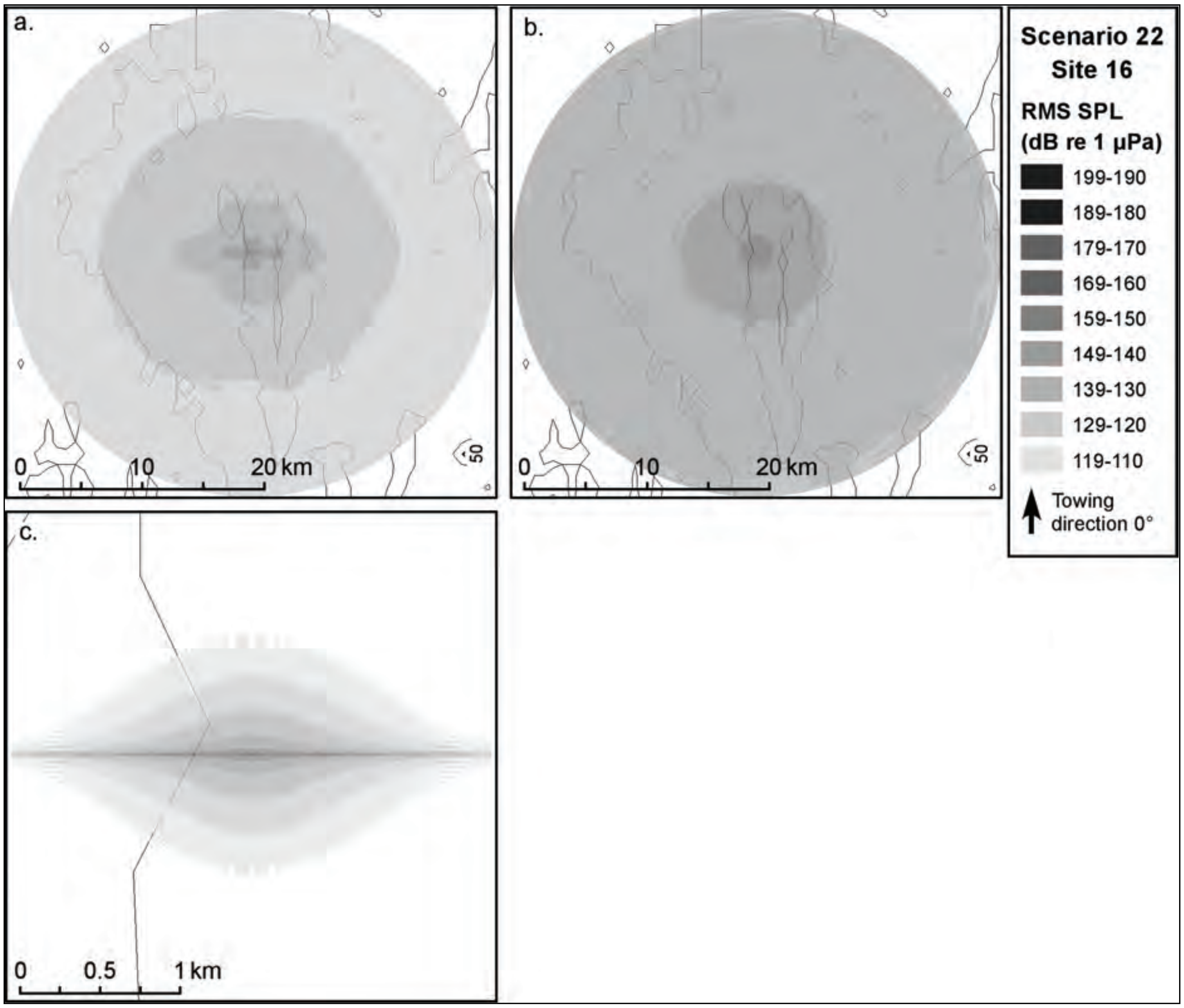

Figure Attachment B-22. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 22 (Water Depth is 30 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, and (c) Side-scan Sonar.

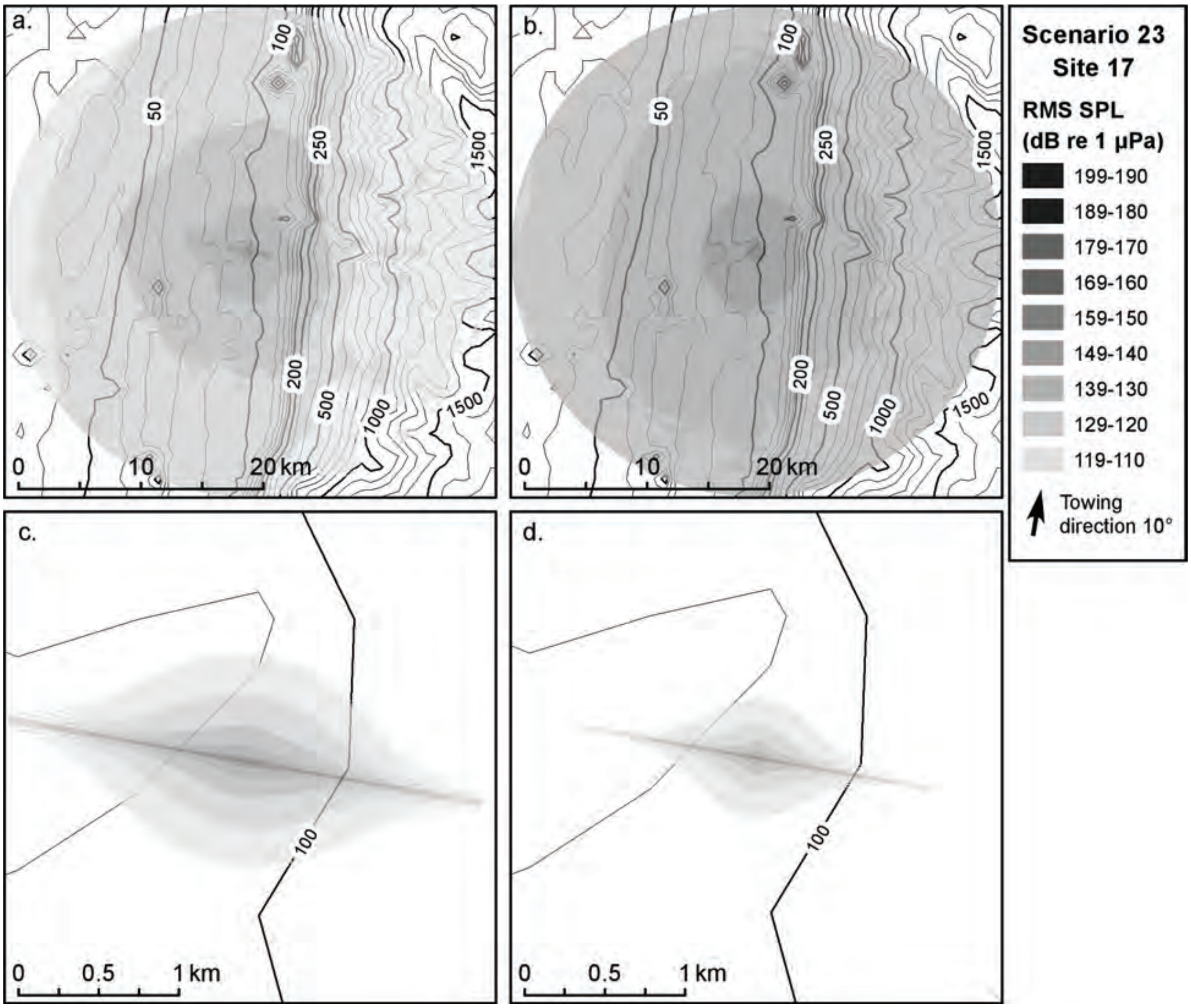

Figure Attachment B-23. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 23 (Water Depth is 100 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, (c) Side-scan Sonar, and (d) Multibeam Depth Sounder.

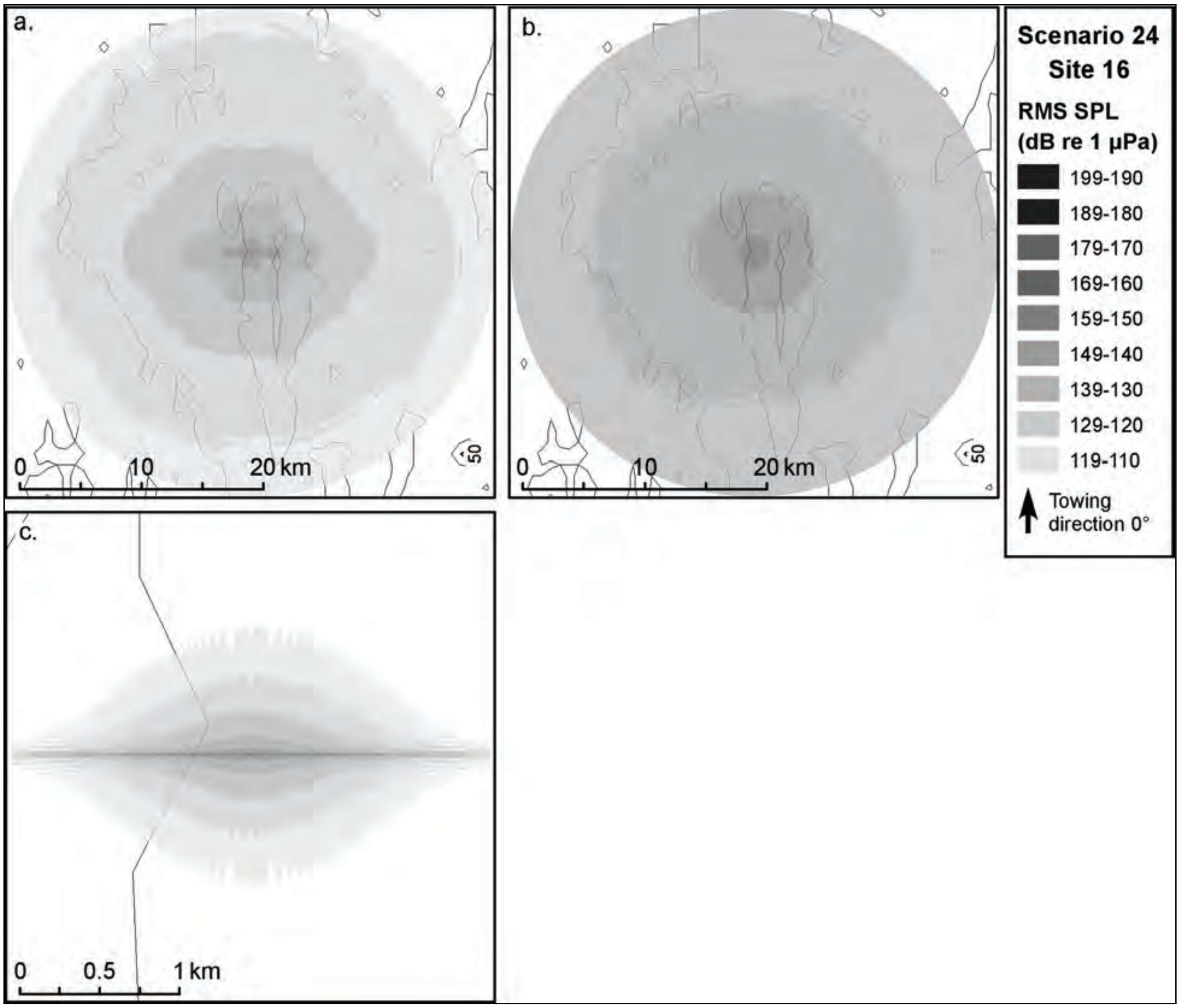

Figure Attachment B-24. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 24 (Water Depth is 30 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, and (c) Side-scan Sonar.

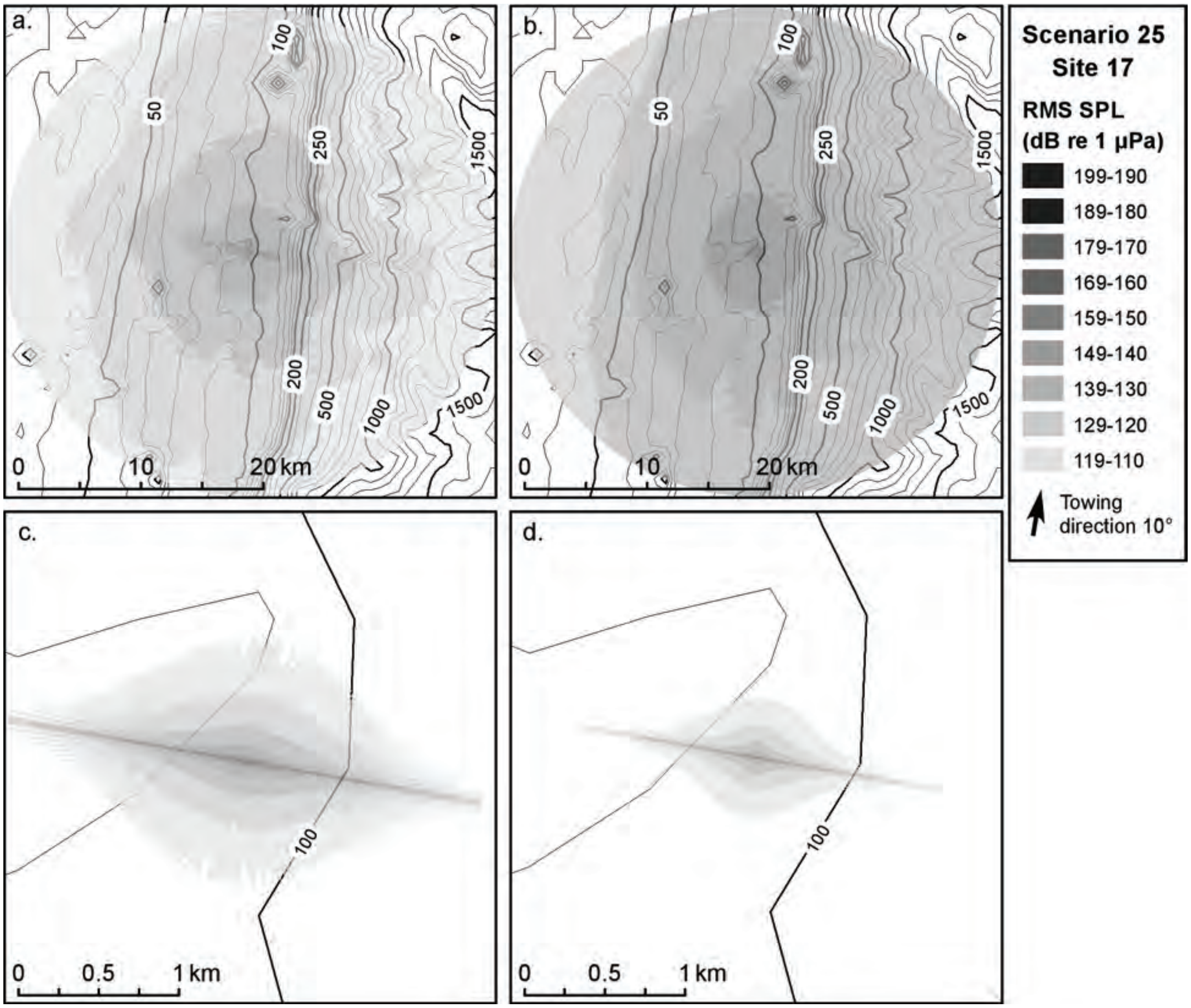

Figure Attachment B-25. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 25 (Water Depth is 100 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, (c) Side-scan Sonar, and (d) Multibeam Depth Sounder.

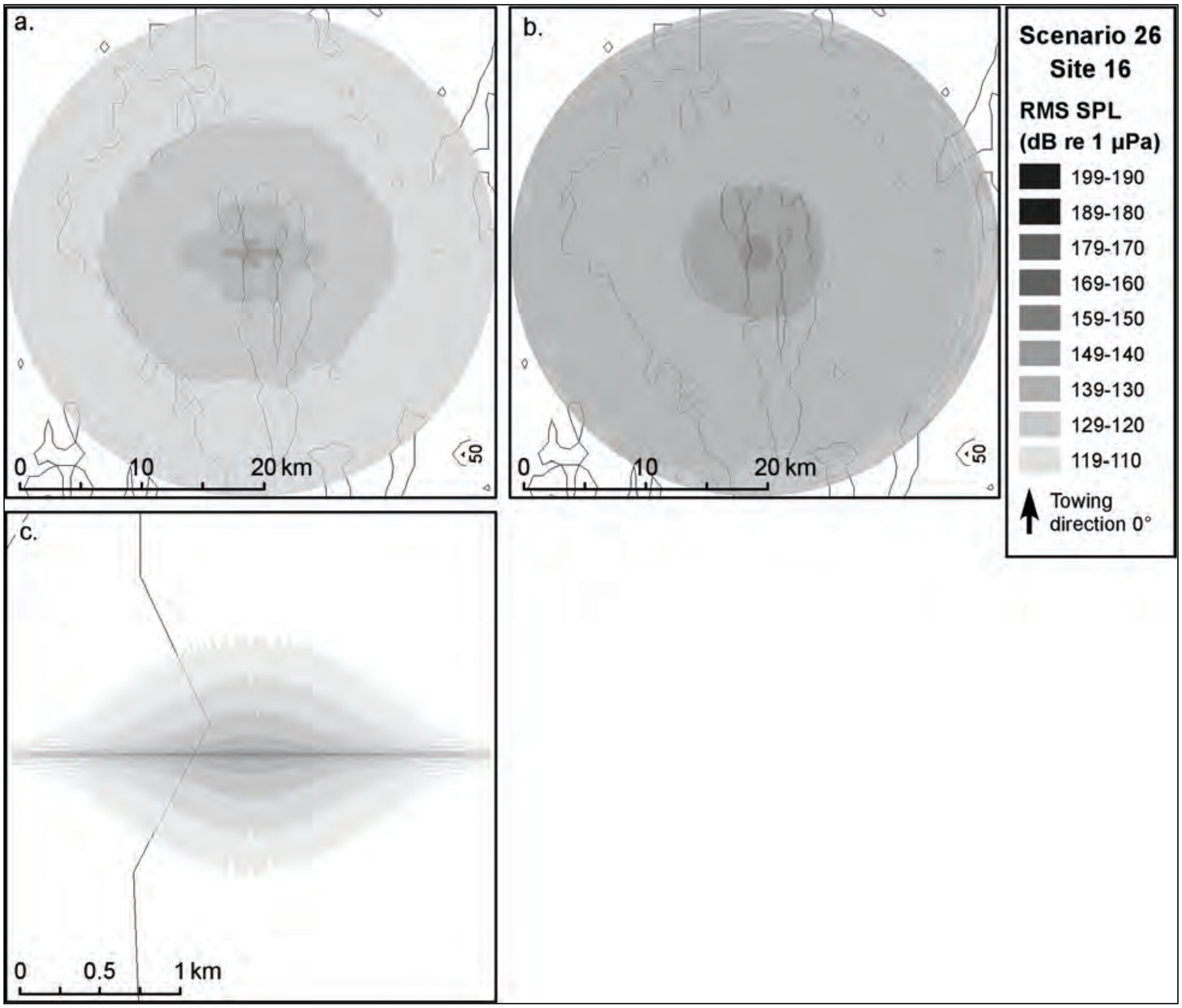

Figure Attachment B-26. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 26 (Water Depth is 30 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, and (c) Side-scan Sonar.

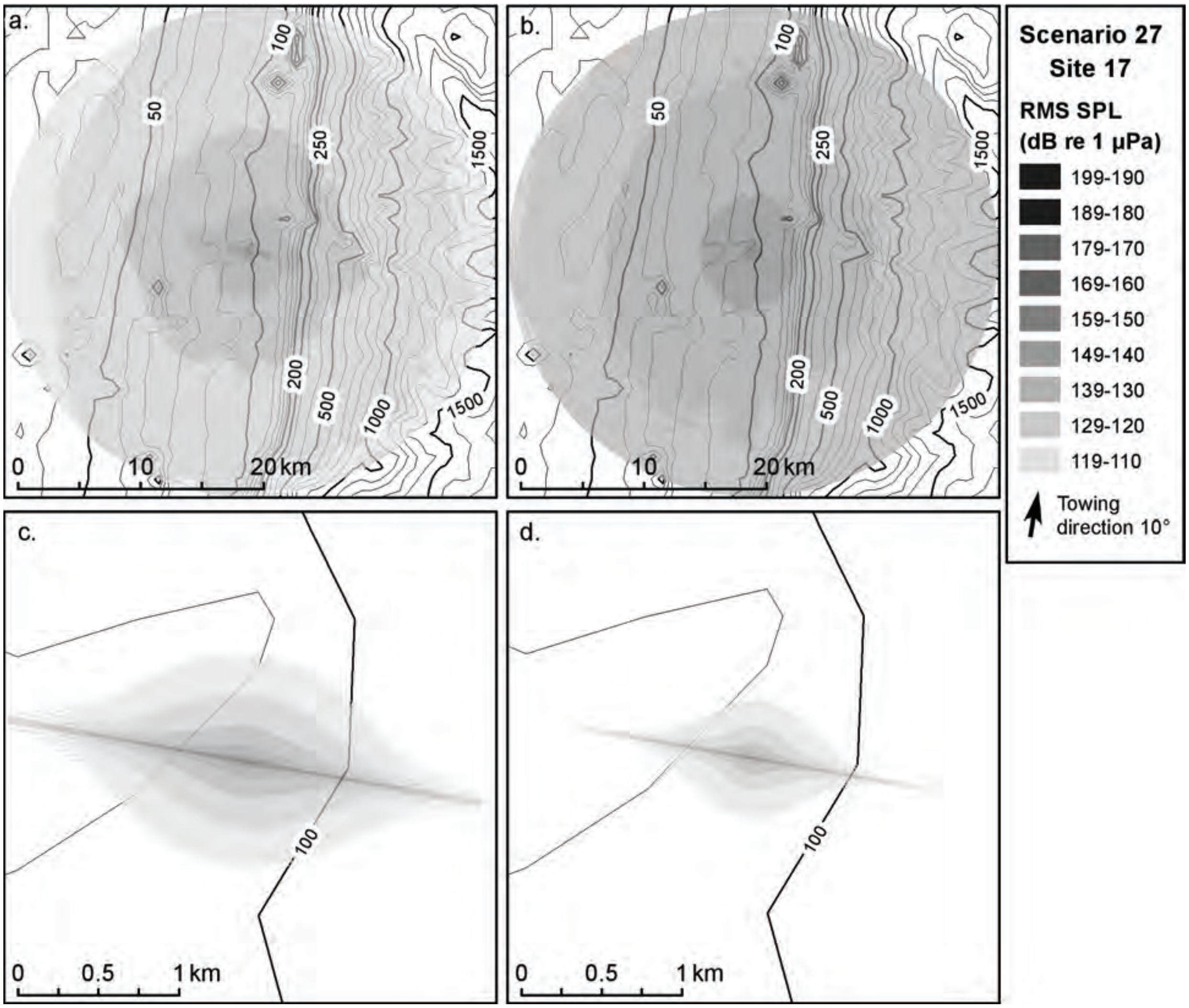

Figure Attachment B-27. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 27 (Water Depth is 100 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, (c) Side-scan Sonar, and (d) Multibeam Depth Sounder.

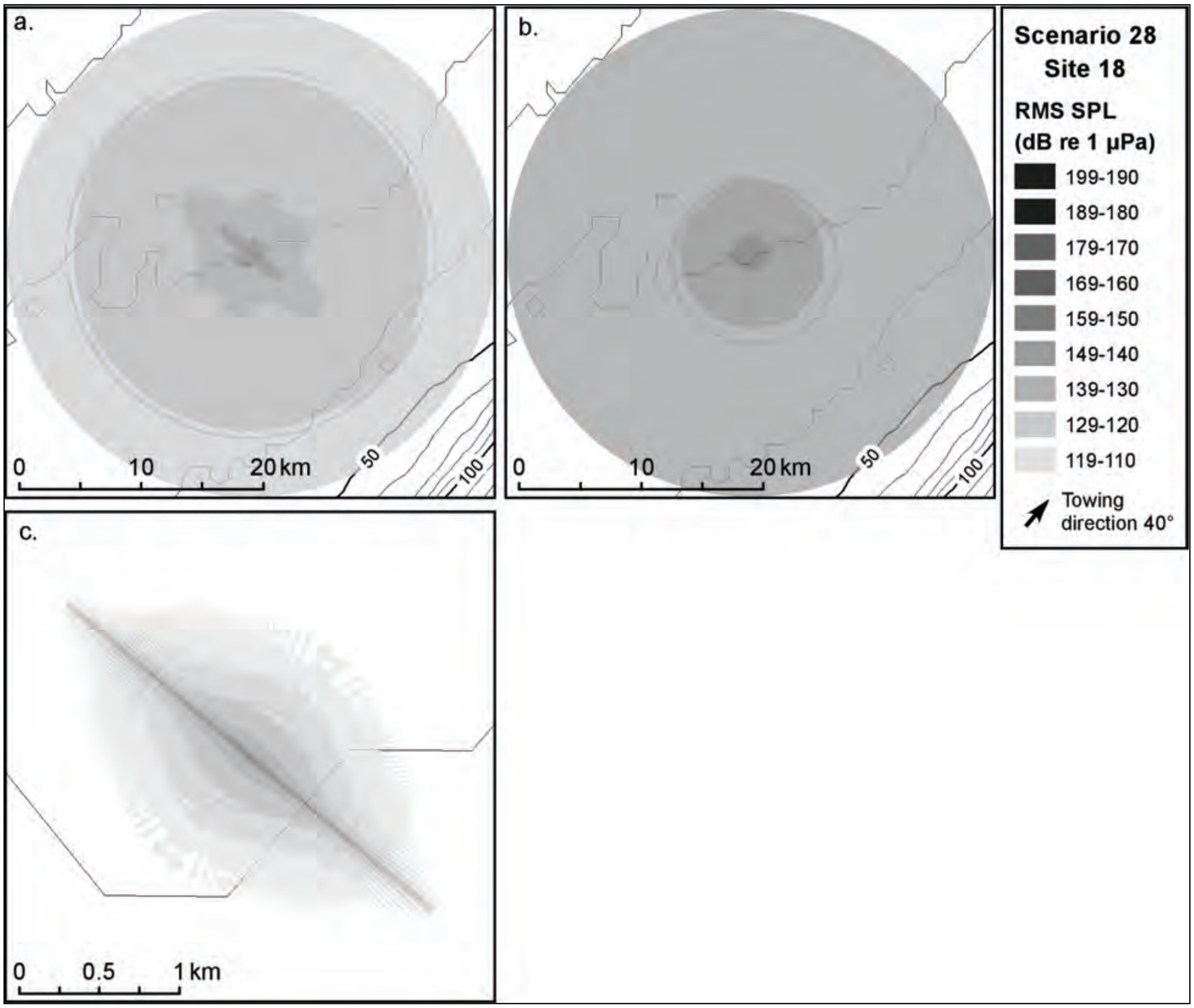

Figure Attachment B-28. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 28 (Water Depth is 30 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, and (c) Side-scan Sonar.

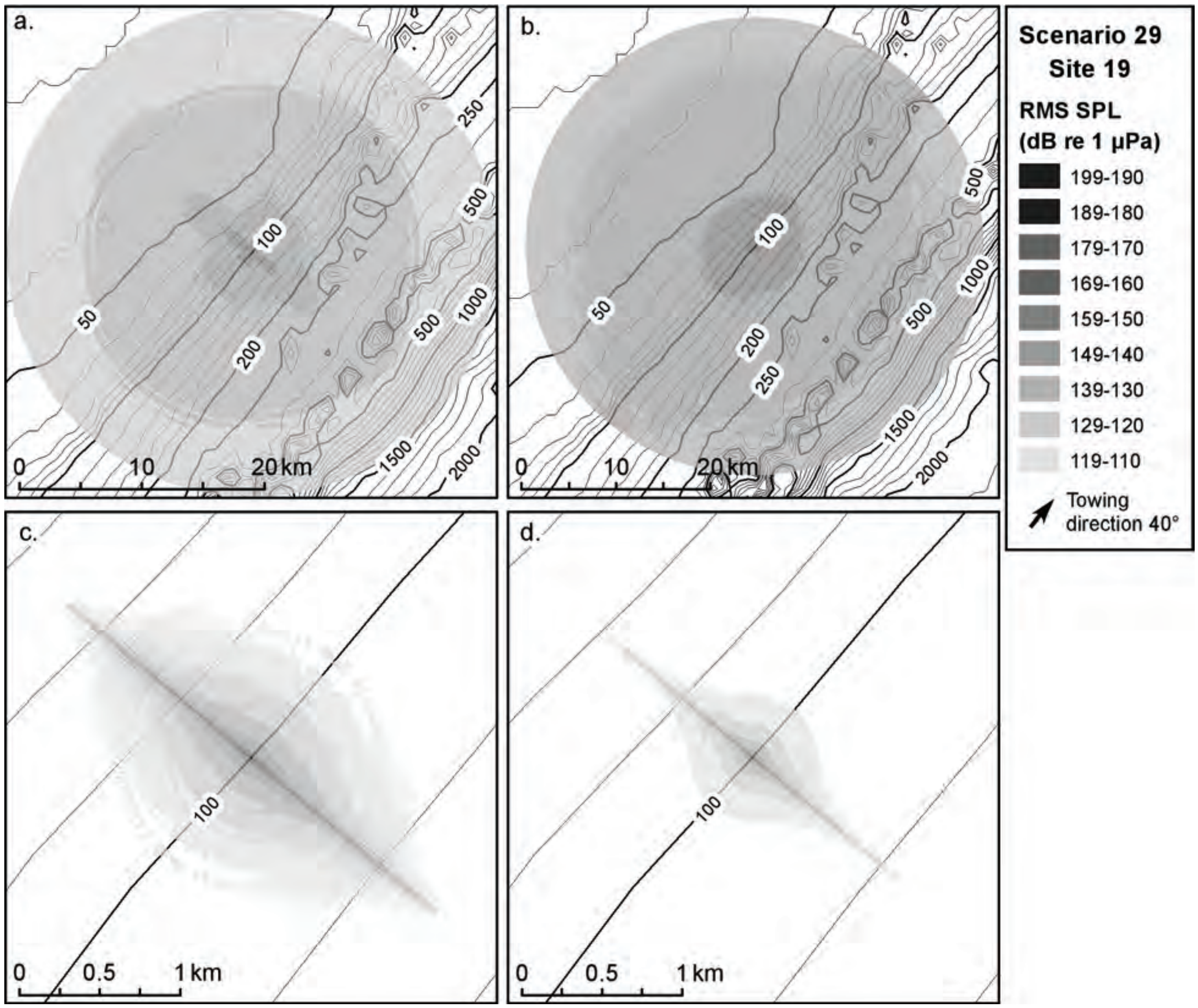

Figure Attachment B-29. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 29 (Water Depth is 100 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, (c) Side-scan Sonar, and (d) Multibeam Depth Sounder.

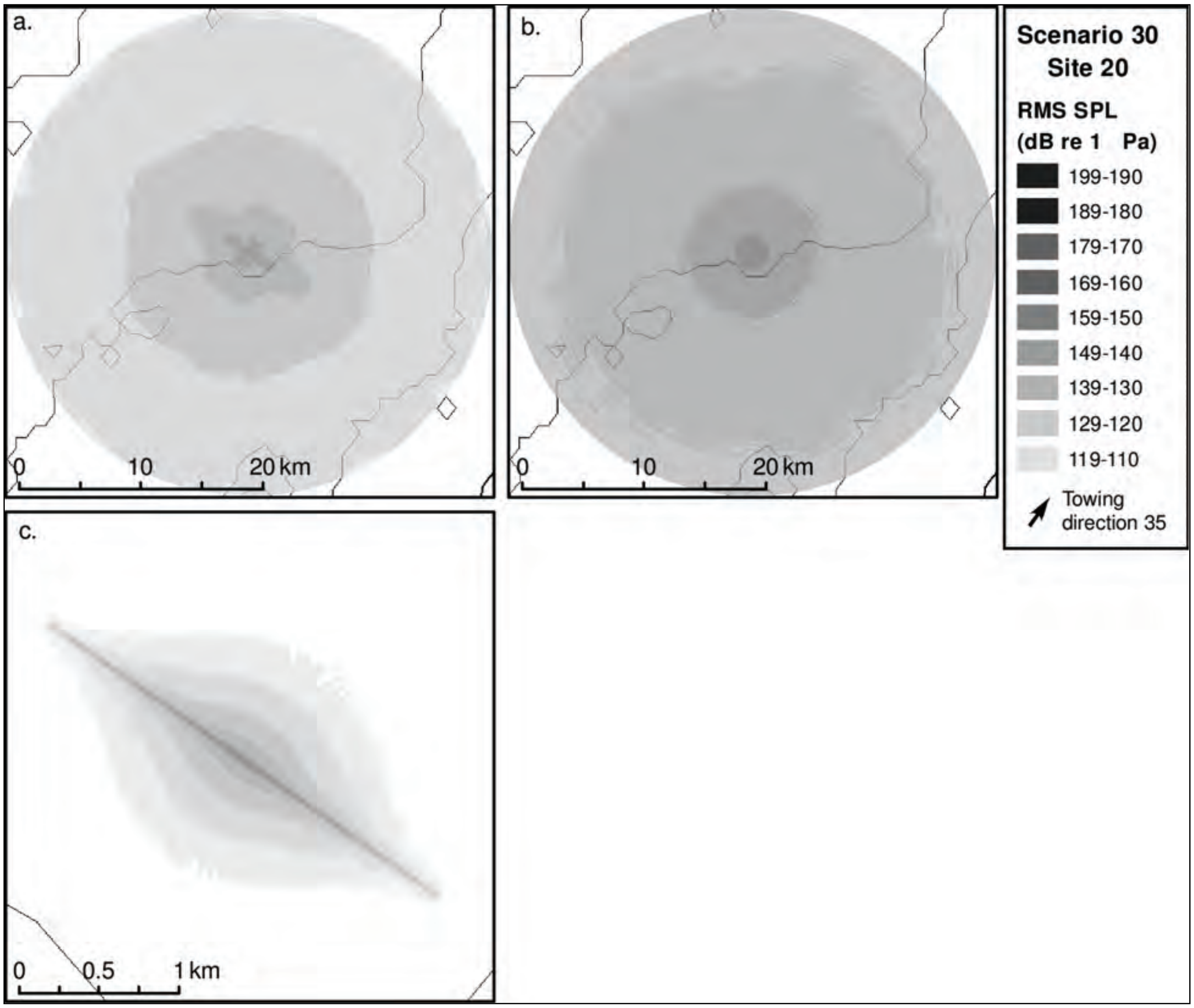

Figure Attachment B-30. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 30 (Water Depth is 30 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, and (c) Side-scan Sonar.

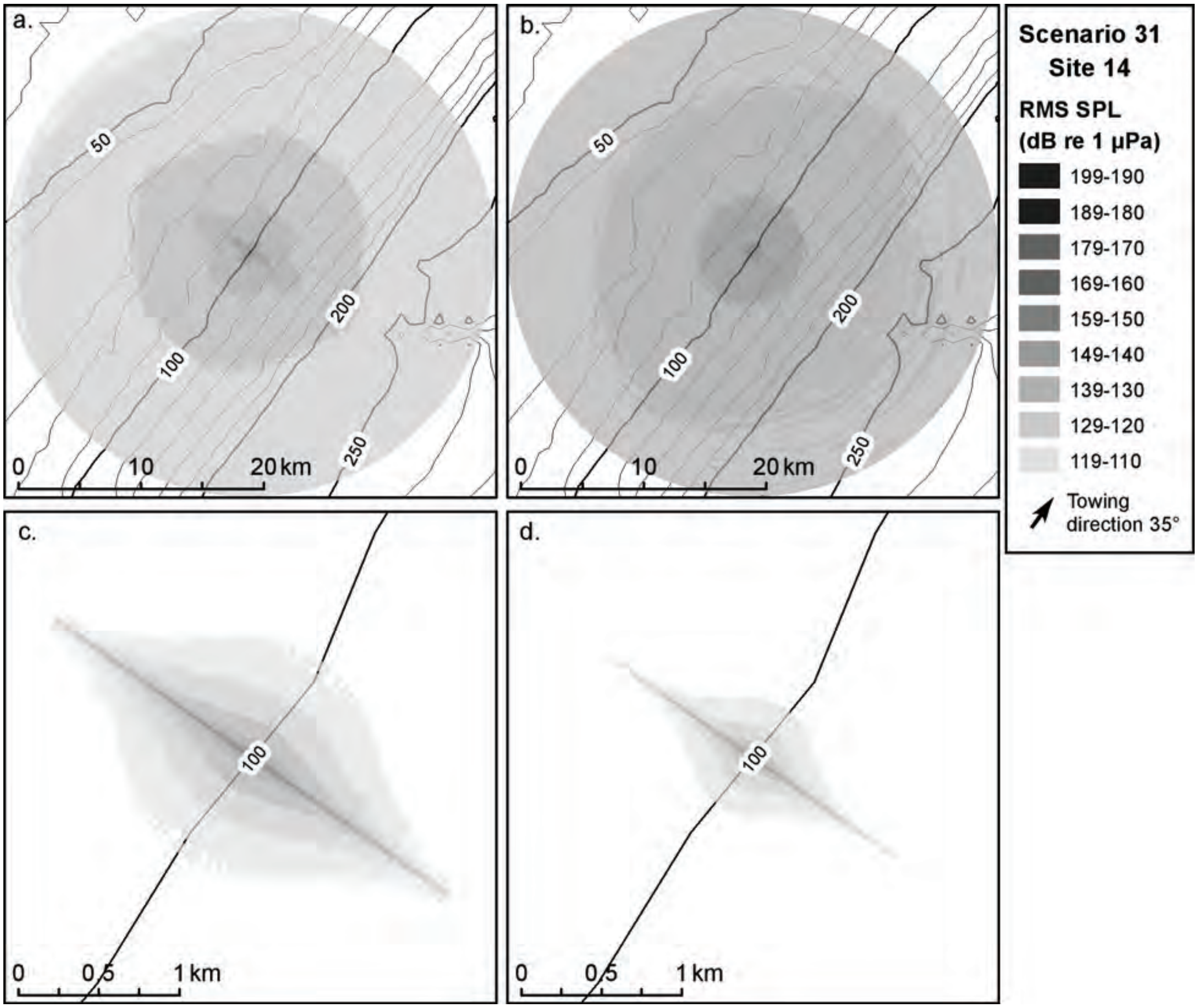

Figure Attachment B-31. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 31 (Water Depth is 100 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, (c) Side-scan Sonar, and (d) Multibeam Depth Sounder.

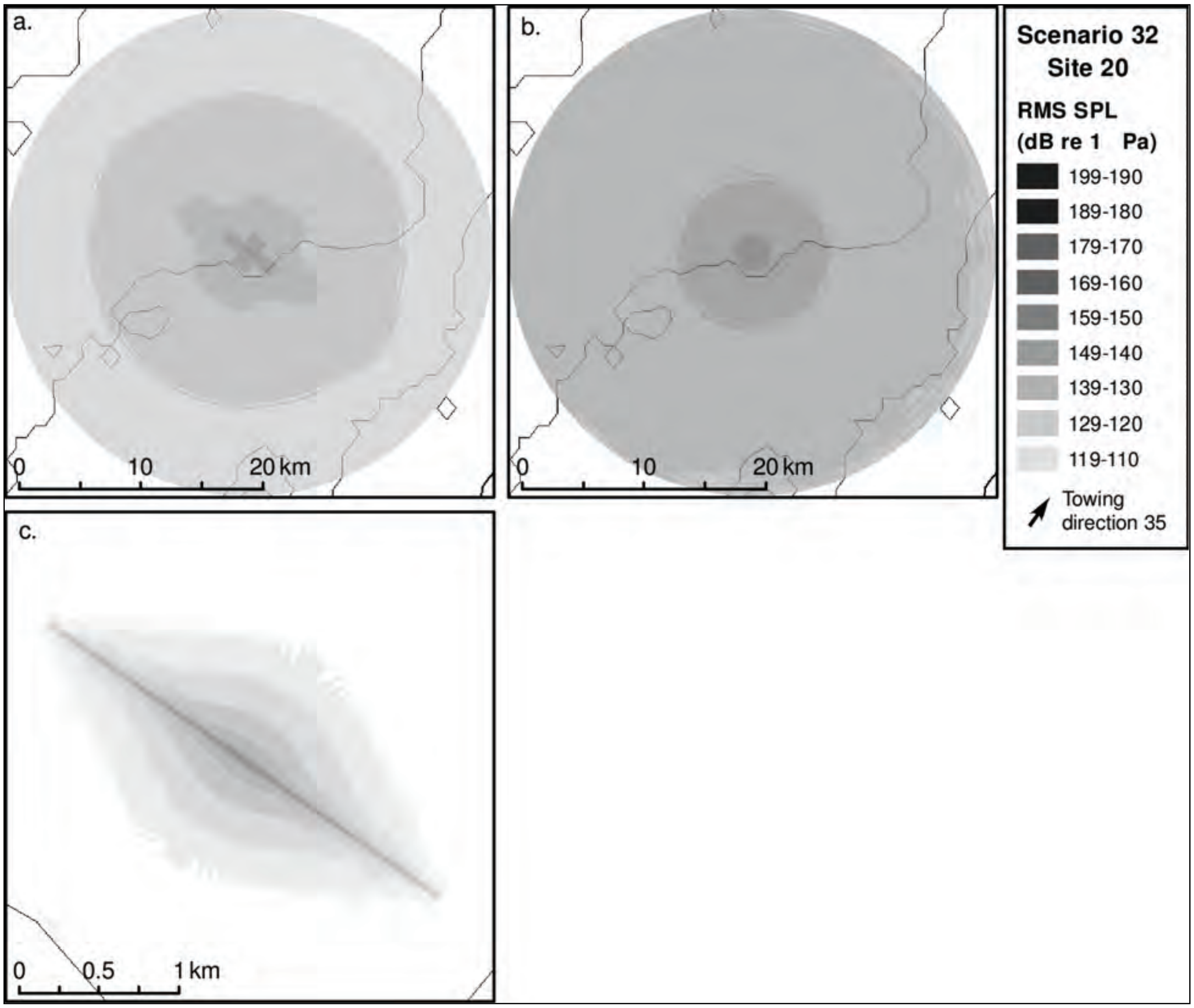

Figure Attachment B-32. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 32 (Water Depth is 30 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, and (c) Side-scan Sonar.

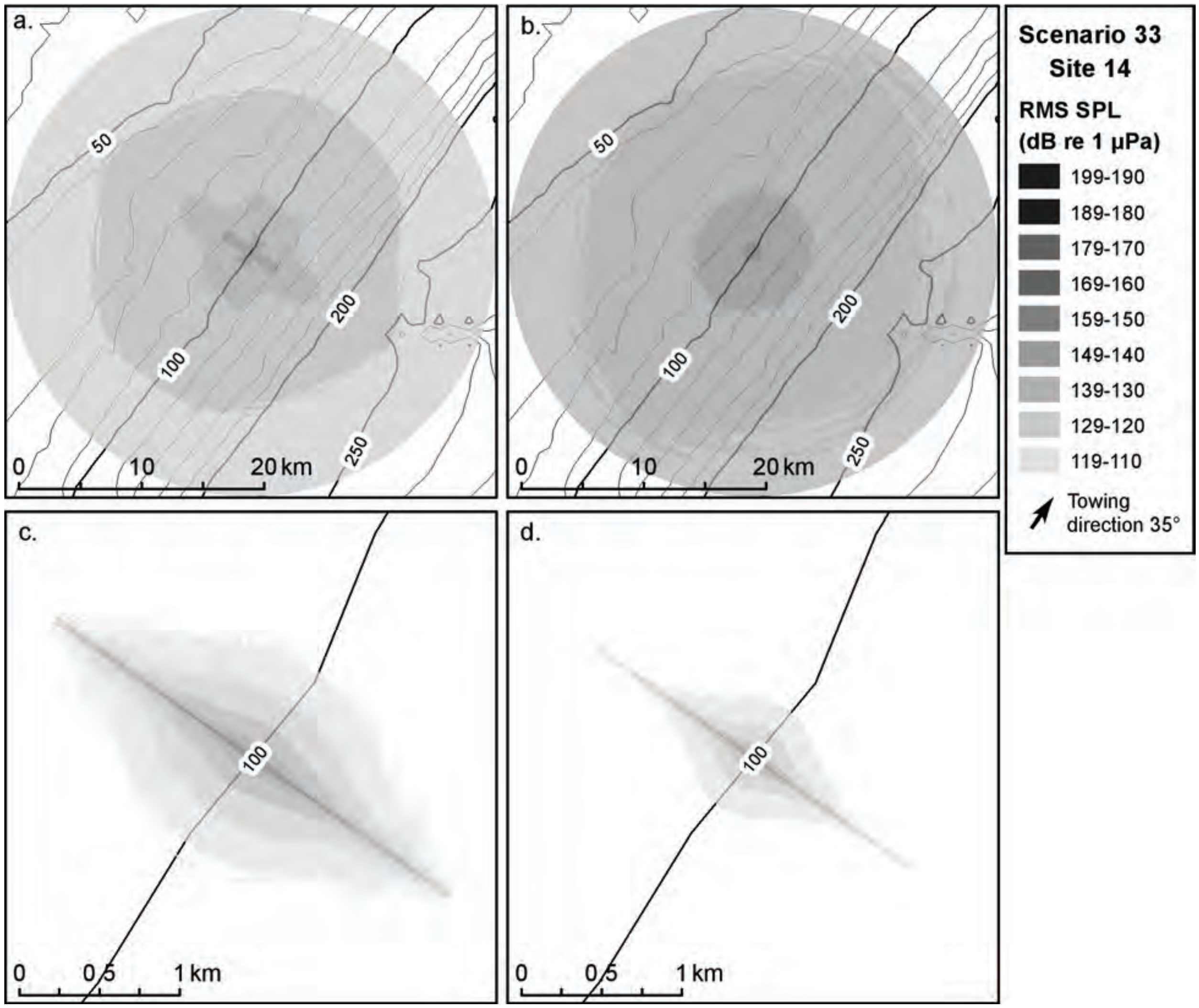

Figure Attachment B-33. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 33 (Water Depth is 100 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, (c) Side-scan Sonar, and (d) Multibeam Depth Sounder.

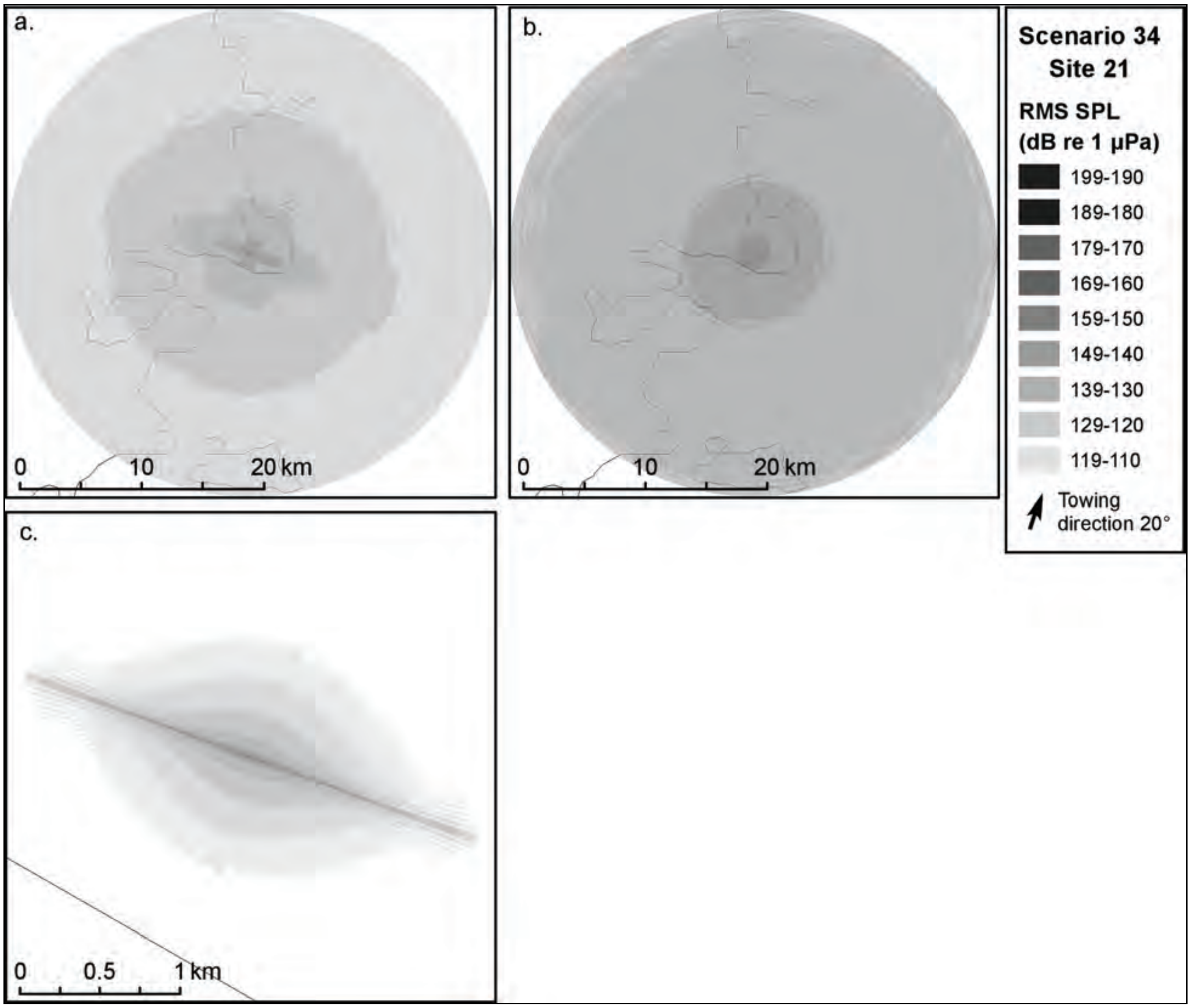

Figure Attachment B-34. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 34 (Water Depth is 30 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, and (c) Side-scan Sonar.

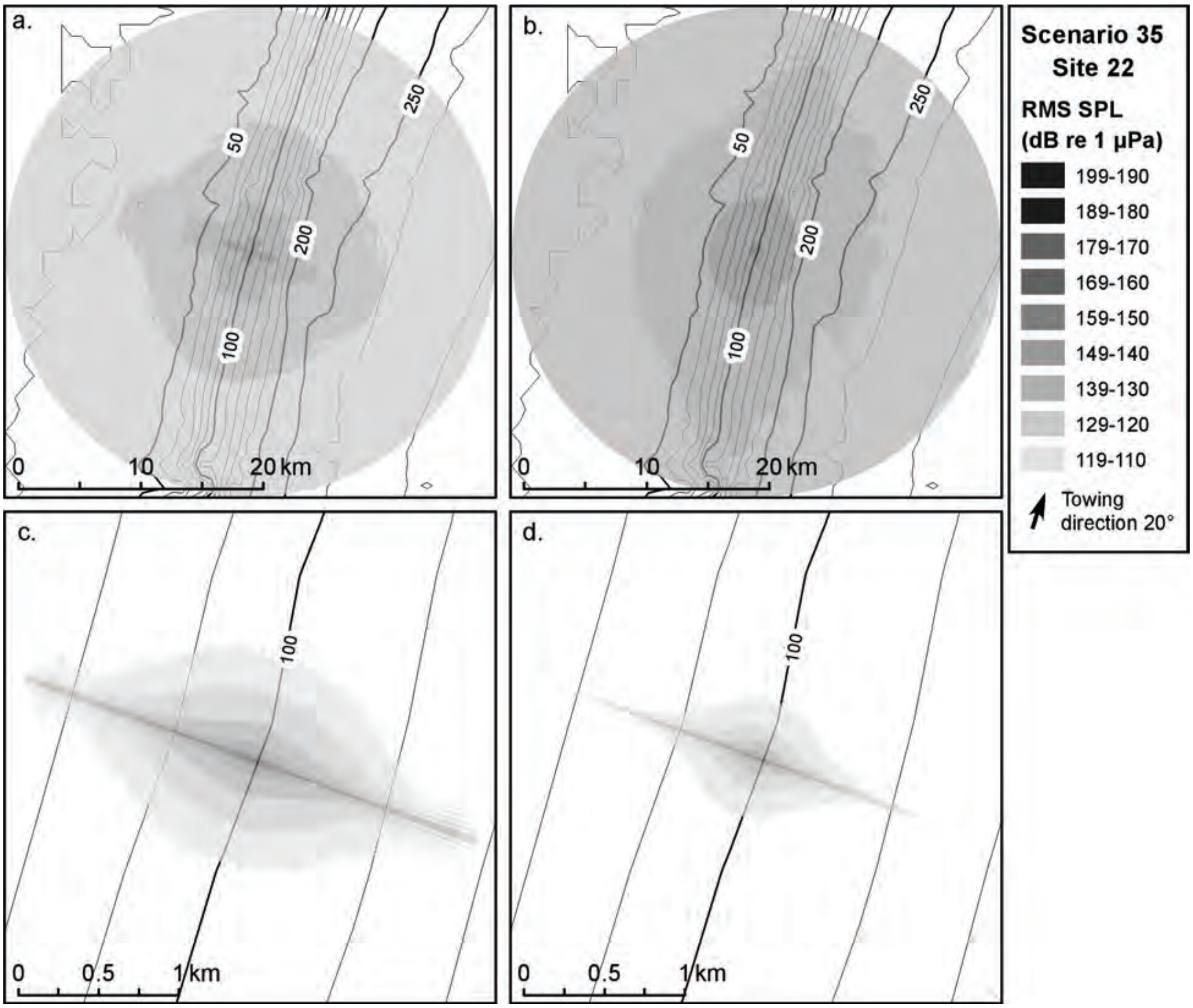

Figure Attachment B-35. Maximum-over-depth broadband (10-2,000 Hz) SPL (rms) around the source for Modeling Scenario 35 (Water Depth is 100 m at the Source). The Sources are (a) Subbottom Profiler, (b) Boomer, (c) Side-scan Sonar, and (d) Multibeam Depth Sounder.

ATTACHMENT C: PREDICTED RANGES TO SPECIFIED THRESHOLD LEVELS

Table Attachment C-1

Predicted Ranges (in Meters) to Specified Threshold Levels for 5,400 in^3 Airgun Array Source

rms dB	210		200		190		180		170		160		150	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
1	29	29	90	87	278	270	835	810	2,297	2,213	5,379	4,969	8,730	8,107
2	29	29	92	89	284	273	876	827	2,557	2,358	5,720	5,184	19,735	16,479
3	30	30	91	89	292	280	1,557	1,093	3,753	3,445	9,329	8,104	>20,000	19,489
4	16	16	46	46	151	145	822	748	3,406	2,793	12,737	8,725	>20,000	19,338
5	16	16	47	45	166	153	816	742	3,635	2,709	13,337	8,896	>20,000	19,265
6	29	29	90	87	278	270	837	811	2,298	2,215	5,379	4,989	8,740	8,146
7	29	29	90	87	285	276	855	829	2,422	2,300	5,322	5,026	19,950	18,775
8	30	30	91	89	292	280	1,556	1,091	3,748	3,452	9,654	8,056	>20,000	19,489
9	16	16	46	46	154	148	801	737	3,305	2,787	11,056	8,593	>20,000	19,327
10	16	16	45	43	152	146	799	752	3,361	2,704	11,695	8,615	>20,000	18,989
11	29	29	89	86	277	269	837	811	2,296	2,212	5,379	4,973	8,320	7,883
12	29	29	89	87	283	275	853	827	2,420	2,291	5,320	5,013	>20,000	19,758
13	30	29	90	88	292	280	1,552	1,082	3,737	3,151	9,316	8,095	>20,000	19,489
14	16	16	45	43	157	150	880	761	3,253	2,648	15,305	9,122	>20,000	19,387
15	30	29	91	89	280	273	841	816	2,365	2,262	5,490	5,121	8,846	8,394
16	30	29	90	87	285	277	871	846	2,456	2,339	5,360	5,098	19,852	16,233
17	29	29	90	88	279	271	838	812	2,281	2,212	5,184	4,959	8,590	8,235
18	30	29	90	87	278	270	845	819	2,362	2,267	5,450	5,069	8,912	8,384
19	30	30	91	89	292	280	1,559	1,094	3,754	3,497	9,304	8,083	>20,000	19,489
20	16	16	49	47	292	275	1,134	992	4,127	3,282	12,022	8,531	>20,000	19,151
21	21	21	92	87	460	434	2,109	1,677	5,257	4,441	11,380	8,384	>20,000	18,421

Table Attachment C-2

Predicted Ranges (in Meters) to Specified Threshold Levels for 90 in^3 Airgun Array Source

rms dB	200		190		180		170		160		150	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
1	16	16	46	46	148	144	450	437	1,295	1,256	3,412	3,205
2	16	16	46	46	148	143	458	441	1,363	1,291	3,719	3,355
3	16	16	47	47	148	145	486	460	2,210	2,038	5,537	4,786
4	7	7	22	22	76	75	325	293	1,452	1,342	4,990	4,154
5	7	7	22	22	76	74	395	328	1,568	1,286	5,324	3,927
6	16	16	46	46	148	144	450	437	1,295	1,256	3,412	3,202
7	16	16	46	46	146	142	453	439	1,322	1,281	3,565	3,302
8	16	16	47	47	148	145	483	459	2,212	2,039	5,516	4,810
9	7	7	22	22	76	74	332	306	1,464	1,331	4,910	4,374
10	7	7	25	25	76	75	310	291	1,512	1,108	5,189	4,126
11	16	16	46	46	146	143	448	435	1,295	1,255	3,412	3,203
12	16	16	46	46	146	141	450	437	1,321	1,280	3,425	3,307
13	16	16	47	46	147	143	482	458	2,211	2,036	5,197	4,623
14	7	7	25	25	76	74	336	308	1,371	1,100	5,456	3,947
15	16	16	47	46	146	143	450	436	1,315	1,258	3,403	3,284
16	16	16	46	46	149	145	455	442	1,325	1,285	3,529	3,404
17	16	16	46	46	149	145	455	442	1,294	1,255	3,351	3,194
18	16	16	46	46	148	145	456	443	1,329	1,289	3,510	3,294
19	16	16	47	47	149	145	483	459	2,212	2,040	5,518	4,859
20	7	7	25	25	90	86	371	341	2,051	1,681	5,181	4,356
21	11	11	35	35	186	177	852	755	3,056	2,493	6,464	5,888

Table Attachment C-3

Predicted Ranges (in Meters) to Specified Threshold Levels for Boomer Source.
No Adjustment for Pulse Duration Has Been Applied

rms dB	200		190		180		170		160		150	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
22	<5	<5	7	7	43	43	386	336	1,737	1,490	8,243	6,088
23	<5	<5	7	7	39	38	140	135	1,060	818	6,655	4,757
24	<5	<5	7	7	43	42	364	299	1,956	1,444	6,280	5,056
25	<5	<5	7	7	38	36	142	132	1,566	1,342	7,820	4,792
26	<5	<5	7	7	43	41	386	317	1,712	1,428	7,293	5,752
27	<5	<5	7	7	40	40	141	135	1,054	807	6,003	4,519
28	<5	<5	7	7	41	40	259	252	1,860	1,468	8,202	6,252
29	<5	<5	7	7	39	38	144	137	1,129	799	6,484	4,805
30	<5	<5	7	7	43	41	315	310	1,730	1,435	6,776	5,563
31	<5	<5	10	10	40	39	146	137	1,155	840	6,480	4,550
32	<5	<5	7	7	45	43	377	318	2,138	1,552	7,802	6,287
33	<5	<5	7	7	39	38	148	142	1,655	898	7,089	5,046
34	<5	<5	7	7	43	43	376	313	1,844	1,467	7,755	6,011
35	<5	<5	7	7	40	38	143	137	1,035	669	6,085	4,339

Table Attachment C-4

Predicted Ranges (in Meters) to Specified Threshold Levels for Side-scan Sonar Source.
No Adjustment for Pulse Duration Has Been Applied

rms dB	210		200		190		180		170		160		150	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
22	<5	<5	18	16	70	66	192	180	376	334	604	534	856	732
23	<5	<5	12	8	47	36	128	116	280	250	512	440	760	650
24	<5	<5	18	16	70	66	186	176	376	336	602	532	864	752
25	<5	<5	12	8	47	36	138	116	290	256	532	455	812	715
26	<5	<5	18	16	70	66	190	176	374	330	600	530	852	728
27	<5	<5	12	8	47	36	128	116	280	246	500	438	770	651
28	<5	<5	14	12	50	47	177	156	379	345	655	528	919	791
29	<5	<5	14	12	50	47	133	125	348	330	650	499	867	774
30	<5	<5	13	9	49	42	171	154	356	319	576	510	850	737
31	<5	<5	13	9	49	39	129	115	286	247	537	462	816	702
32	<5	<5	13	9	49	42	178	156	366	323	600	539	903	745
33	<5	<5	13	9	49	39	132	119	293	256	567	492	806	697
34	<5	<5	13	9	53	40	175	159	362	324	592	526	836	719
35	<5	<5	13	9	47	30	134	121	281	249	538	458	768	655

Table Attachment C-5

Predicted Ranges (in Meters) to Specified Threshold Levels for Chirp Subbottom Profiler.
No Adjustment for Pulse Duration Has Been Applied

rms dB	200		190		180		170		160		150	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
22	<5	<5	12	12	32	28	136	110	808	682	2,863	2,325
23	<5	<5	13	13	38	35	106	90	380	303	2,456	1,781
24	<5	<5	12	12	32	28	138	112	874	772	2,908	2,379
25	<5	<5	13	13	37	35	108	90	376	317	2,855	2,357
26	<5	<5	12	12	32	28	128	107	764	664	2,839	2,275
27	<5	<5	13	13	37	35	106	90	359	297	2,480	1,741
28	<5	<5	13	12	33	29	122	102	971	876	3,222	2,857
29	<5	<5	13	13	42	37	110	91	854	677	3,189	2,704
30	<5	<5	13	12	33	29	122	103	831	644	2,680	2,199
31	<5	<5	13	13	42	39	112	91	557	313	2,324	1,969
32	<5	<5	13	12	33	29	125	104	962	811	3,494	2,519
33	<5	<5	13	13	42	39	112	92	684	363	2,889	2,446
34	<5	<5	13	12	32	29	123	104	724	634	2,869	2,590
35	<5	<5	13	13	42	38	108	90	401	300	2,766	2,086

Table Attachment C-6

Predicted Ranges (in Meters) to Specified Threshold Levels for Multibeam Depth Sounder.
No Adjustment for Pulse Duration Has Been Applied

rms, dB	210		200		190		180		170		160		150	
Scenario	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
23	0	0	<5	<5	10	10	27	25	61	57	147	142	320	275
25	0	0	<5	<5	10	10	27	25	61	57	147	142	320	275
27	0	0	<5	<5	10	10	27	25	61	57	147	142	315	269
29	0	0	<5	<5	10	10	27	25	55	51	156	149	359	337
31	0	0	<5	<5	10	10	27	25	61	57	147	140	294	262
33	0	0	<5	<5	10	10	27	25	61	57	147	140	305	273
35	0	0	<5	<5	10	10	27	25	59	55	149	144	293	266

APPENDIX E

ACOUSTIC MODELING AND MARINE MAMMAL INCIDENTAL TAKE METHODOLOGY, ANALYSIS, AND RESULTS

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LIST OF ACRONYMS AND ABBREVIATIONS

µPa	micropascal
2D	two-dimensional
3D	three-dimensional
4D	four-dimensional
AIM	Acoustic Integration Model©
ANSI	American National Standards Institute
AOI	Area of Interest
BOEM	Bureau of Ocean Energy Management
CIE	Center for Independent Experts
CZ	convergence zone
dB	decibel
DTAG	digital acoustic recording tag
EIS	Environmental Impact Statement
ft	feet
G&G	geological and geophysical
GDEM	Generalized Digital Environmental Model
GDEM_V	Generalized Digital Environmental Model Variable Resolution
GIS	geographic information system
hr	hour
HRG	high-resolution geophysical
Hz	hertz
ITA	incidental take authorization
JASCO	JASCO Applied Sciences
kHz	kilohertz
km	kilometer
LFA	low-frequency active
LOE	level of effort
m	meter
min	minute
MMPA	Marine Mammal Protection Act
MONM	Marine Operations Noise Model
NGDC	National Geophysical Data Center
NMFS	National Marine Fisheries Service
nmi	nautical mile
NODE	Navy Operating Area Density Estimates
NRC	National Research Council
OCS	Outer Continental Shelf
OPAREA	operating area
Pa	pascal
PTS	permanent threshold shift
rms	root-mean-square
s	second
SD	standard deviation
SE	standard error
SEFSC	Southeast Fisheries Science Center
SEL	sound exposure level
SL	source level
SoundMap	Underwater Sound Field Working Group
SPL	sound pressure level
SURTASS	Surveillance Towed Array Sensor System
SVP	sound velocity profile
TDR	time-depth recorder
TL	transmission loss
TTS	temporary threshold shift
VSP	vertical seismic profile
WAZ	wide azimuth

1. INTRODUCTION AND OVERVIEW

The Bureau of Ocean Energy Management (BOEM) has prepared this Programmatic Environmental Impact Statement (EIS) to evaluate the potential environmental effects of geological and geophysical (G&G) activities on the Mid- and South Atlantic Outer Continental Shelf (OCS) and adjacent State waters. The purpose of this appendix is to explain the methodology that was used to calculate incidental takes of marine mammals for the Programmatic EIS. This appendix documents the overall approach and identifies the specific models, acoustic sources, and modeling techniques that were used, as well as the operational, environmental, and biological data that were needed to support the modeling. Some of the details of this analysis are specific to the work performed by JASCO as part of their acoustic source and acoustic propagation loss modeling; in those instances, this appendix refers to **Appendix D**, which covers those details.

The term "incidental take" derives from Section 101(a)(5) (A-D) of the Marine Mammal Protection Act of 1972 (MMPA), as amended (16 U.S.C. 1371(a)(5)), which provides a mechanism for allowing, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographic region. Under the 1994 amendments to the MMPA, harassment is statutorily defined as, "any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild" (Level A harassment); "or 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 but which does not have the potential to injure a marine mammal or marine mammal stock in the wild" (Level B harassment).

Accurate predictive modeling of potential acoustic impacts requires knowledge of (1) the specific source(s) that would be used at each site of survey operations; (2) the exact environmental acoustic conditions present at each site; (3) the timing and type of each survey; and (4) the marine animals present at each site. Because these facts could not be known ahead of time (without extensive surveys immediately prior to or during the survey) and particularly not for the period of this document (i.e., through the year 2020), the following analytical estimation is necessary. The reasonable approach described in this report, in general, examines the potential range of each variable and identifies typical values expected to be used during the proposed action.

There are many instances where the numerous permutations needed to capture the effects of the range of values for a variable may be able to be reduced because of minimal effects on the results, or because the low occurrence of some of the values in the range allows an obvious selection for modeling. For example, nearly all of the deepwater sites have very fine silts, clayey silt, and clay as the predominant bottom types, and the use of clay characteristics in the acoustic propagation modeling for all of these deep sites is adequate, because the bottom properties of the other sediments would be similar. Similarly, in the case of the airgun source used for modeling, there are numerous possible source arrays that could be used based on the company performing the survey, the location, the ships available, etc. In this case, a nominal source identified by the BOEM as a typical source for these surveys was used in the modeling. Although it is not necessarily the strongest source identified, it better represents a typical source array and its potential impacts. It is estimated that the percentage of time that strong and weak sources are used over the duration of the proposed action would only slightly change the overall estimated impacts and, over time, tend to average out to an impact similar to that predicted for the modeled array. As can be seen in **Appendix D**, the 5,400 cubic in airgun is conservatively used for all survey types (e.g., a two-dimensional [2D] survey might be expected to typically use a smaller and less powerful source), with the source level only being corrected for the water depth and M-weighting.

Given the reasons above, the acoustic and impact modeling conducted to support this Programmatic EIS is by its very nature conservative and complex. It requires numerous assumptions to predict results in scenarios. Each of the inputs into the models is purposely developed to be conservative, and this conservativeness accumulates throughout the analysis. Further, the models do not take into account all of the extensive mitigation measures summarized in **Table S-1** or other caveats discussed below. They should not be considered as expected levels of actual take.

These take estimates do not alone reflect BOEM's determination of the impact to marine mammals. The impact assessment approach used by BOEM is described in detail in **Chapter 4**. It considers the modeled take estimates, the best available information on marine mammal distribution, current science assessing the potential effects of G&G surveys on marine mammals, and an evaluation of how employed mitigation can reduce these effects. Although all mitigations cannot be effective 100 percent of the time, these measures undoubtedly will contribute to species protection, and they will be refined as environmental impacts are evaluated in environmental review for site-specific authorizations, including ESA and MMPA consultation. This assessment is then compared against the significance criteria (described in **Chapter 4.2.2.2.1**) to identify an anticipated level of impact. Future site-specific actions proposed by operators will, as necessary, follow the MMPA procedures for issuance of an Incidental Take Authorization (ITA), which will again evaluate the potential impacts.

The basic acoustic terminology used in this report is presented in numerous published sources (e.g., American National Standards Institute [ANSI], 1984, 1986, 2004; Richardson et al., 1995; National Research Council [NRC], 2003; Southall et al., 2007). The main definitions used in this assessment are provided below, from Southall et al. (2007):

- **Pulses:** Pulses are brief, broadband, atonal, transient sounds; e.g., explosions, gun shots, airgun pulses, and pile driving strikes. Pulses are characterized by a rapid rise from ambient pressure to maximal pressure, and (at least near the source) by short duration.
- **Nonpulse (intermittent or continuous) Sounds:** Nonpulse sounds can be tonal, broadband, or both. Nonpulse sounds can be of short duration but they lack the rapid rise times of true pulses. Nonpulse sounds include those from shipping, aircraft, drilling, and active sonar systems. Due to certain propagation effects, it is possible that a sound that is pulsed near the source may be perceived by a distant receiver (e.g., an animal) as a nonpulse sound.
- **Peak Sound Pressure:** This is the maximum instantaneous sound pressure measurable in the water at a specified distance from the source airgun. The units of pressure are typically bars (English) or, in metric units, either Pascals (Pa) or microPascals (μPa). The metric values are commonly expressed in logarithmic form as decibels relative to 1 μPa (dB re 1 μPa).
- **Peak-to-Peak Sound Pressure:** This is the algebraic difference between the peak positive and peak negative sound pressures. Units are the same as for peak pressure. When expressed in dB, peak-to-peak pressure is typically ~6 dB higher than peak pressure.
- **Root-Mean-Square (rms) Sound Pressure:** In simple terms, this is an average sound pressure over some specified time interval. For airgun pulses, the averaging time is commonly taken to be the approximate duration of one pulse, which in turn is commonly assumed to be the time interval within which 90 percent of the pulse energy arrives. The rms sound pressure level (in dB) is typically ~10 dB less than the peak level, and ~16 dB less than the peak-to-peak level.
- **Sound Pressure Levels (SPLs):** The SPLs are given as the dB measures of the pressure metrics defined above. The rms SPL is given as dB re: 1 μPa for underwater sound and dB re: 20 μPa for aerial sound.
- **Source Level (SL):** The SL is the received level measured or estimated at a nominal distance of 1 meter (m) from the source. It is often expressed as dB re: 1 μPa at 1 m or in bar-m. For a distributed source, such as an array of airguns, the nominal overall SL, as used in predicting received levels at long distances, exceeds the level measurable at any one point in the water near the sources.
- **Sound Exposure Level (SEL or energy flux density):** This measure represents the total energy contained within a pulse, and is in the units dB re 1 μPa^2-s. For a single airgun pulse, the numerical value of the SEL measurement, in these units, is usually 5–15 dB lower than the rms sound pressure in dB re 1 μPa, with the "rms – SEL" difference often tending to decrease with increasing range (Greene, 1997; McCauley et al., 1998).
- **Duration:** Duration is the length of the sound, usually measured in seconds. For an impulsive sound such as an airgun pulse, the duration may be calculated in a number

of different ways. Greene (1997) described duration of an airgun pulse as the interval over which 90 percent of the sound energy arrives at the receiver.

Over the past decade, the National Marine Fisheries Service (NMFS) guidelines regarding levels of impulsive sound that might cause injury or behavioral disturbance have been based on the "rms sound pressure" metric. However, the rms value depends on the extent to which the sound pulse has been "stretched" in duration during propagation, which varies with environmental conditions, so the rms measure is often criticized (e.g., Madsen, 2005). There is now reason to believe that auditory effects (especially physiological effects like permanent threshold shift [PTS] and temporary threshold shift [TTS]) of transient sounds on marine mammals are better correlated with the amount of received energy than with the level of the strongest pulse and therefore SEL is increasingly the unit of choice in evaluations (Southall et al., 2007).

2. ACOUSTIC MODELING APPROACH

There are two steps to the modeling effort: (1) the determination of the three-dimensional (3D) acoustic field emanating from the sound sources and how it propagates through the water; and (2) the determination of the net exposure of marine animals that reside in the exposed volume.

Historically, the geophysical community and NMFS have used a simplified approach (referred to here as the "transect methodology") to estimate the potential impacts to marine mammals for airgun sources. Essentially, this methodology consisted of the following: (1) determination of the estimated threshold isopleth range from the source for harassment under the MMPA for the airgun sources. Nominally these thresholds were the 160 dB received level for Level B harassment of any marine mammal and the 180 and 190 dB received levels for Level A harassment of cetaceans and pinnipeds, respectively; (2) assumption that a cylinder whose radius matched the range to these isopleths and encompassed the entire water column was ensonified to that threshold; (3) calculating the surface area ensonified by this water column as the source moved along its track; and (4) multiplying that resultant ensonified surface area by the density of each marine mammal species present to estimate that species' numbers of MMPA Level A and B potential harassment takes. This methodology was not used in the Programmatic EIS.

For the Programmatic EIS a more sophisticated approach was used. This approach used a more detailed modeling of the source and its properties, the acoustic propagation field in 3D, and 3D animal placement and movement to better calculate the potential impacts to marine mammals. For this methodology, the first step is largely controlled by properties of the source, such as its movement in time and space, and the sound field it generates at any point in time. This is a function of the geometric organization (array configuration) of its sound generators, and the spatial, spectral, and temporal properties of the sound field that they produce. Propagation modeling further analyzes the effects of the physical properties of the ocean, the bottom and the surface, on the sound field as it propagates out from the source.

The second step requires knowledge of the diving and movement characteristics of the animals residing in the exposed region. Time-based integration models, such as the Acoustic Integration Model© (AIM)[1], as used in this modeling effort, are necessary to fully evaluate the exposure. The advantage of these tools is that they not only provide a more accurate and detailed model of the exposures of a population of marine animals in 3D and time, but they also provide the following: (1) statistical data on each individually modeled animal and the population as a whole; (2) rate of exposure (sounds per unit of time) over the duration of a survey; and (3) the data necessary to determine effects based on more sophisticated thresholds, such as SEL.

[1] MAI's Acoustic Integration Model©, or AIM, is a software package developed to predict the acoustic exposure of marine animals from an underwater sound source. The unique and principal component of AIM is a 3D movement engine, which programs the geographic and vertical movements of sound sources and simulated marine animals. In 2006, the Center for Independent Experts (CIE) conducted a review and assessment of AIM. The CIE panel concluded that AIM is a credible tool for developing application models (Independent System for Peer Review, 2006).

2.1. PROPAGATION MODELING

2.1.1. Overall Modeling Assumptions

For the more complex modeling effort in this appendix, the following general assumptions were made:

- the far-field broadband signal from the typical airgun array nominally includes significant components up to 2,000 hertz (Hz), with the peak amplitude in the far-field near-horizontal spectrum typically occurring between 50 and 100 Hz;
- the modeling needs to address all of the seismic airgun survey types identified in the scope of work for this effort – i.e., 2D and 3D surveys, wide azimuth (WAZ) surveys, vertical seismic profiles (VSP), and high-resolution geophysical (HRG) surveys;
- the modeling also needs to address HRG surveys for renewable energy and marine minerals sites, which use non-airgun active acoustic sources including side-scan sonars, boomers, chirp subbottom profilers, and single or multibeam depth sounders;
- there would also be non-acoustic surveys (i.e., controlled source electromagnetic surveys, magnetotelluric surveys, gravity and gradiometry surveys, magnetic surveys, deep stratigraphic and shallow test drilling, bottom sampling, and several remote sensing methods), but they are not addressed by this acoustic modeling effort;
- nominal or representative sources, as identified by the BOEM, were used for source modeling and source specification identification;
- conditions to be modeled include all potential survey areas in the Area of Interest (AOI) for the Programmatic EIS, including all water depths from the coastline (outside of estuaries) to 350 nautical miles (nmi) (648 kilometers [km]) from shore and including all four seasons;
- animal density estimates would use the best available data, specified by location and season for the modeling effort; and
- animal movement modeling would use the best available input data.

2.1.2. Acoustic Propagation Model Selection

The details of the acoustic propagation modeling are provided in **Appendix D** and will not be repeated here.

2.2. OVERALL MODELING APPROACH

The following step-wise modeling approach is included to illustrate the overall approach to predict the acoustic impacts of G&G activities in the Mid- and South Atlantic for the proposed action:

- The Generalized Digital Environmental Model (GDEM) database was used to extract sound velocity profiles (SVPs) for the Mid- and South Atlantic Planning Areas to characterize the entire water body into a discreet number of specific SVP regions, or propagation regions;
- The SVPs for winter, spring, summer, and fall were then examined for the entire area covered by this Programmatic EIS. After examination of the SVPs, it was determined each season had unique characteristics which prevented any combination of seasons with similar propagation characteristics. Additionally, the SVPs for each season were grouped into about 17 areas or regions with similar propagation characteristics and representative SVPs for each region were selected. Finally, the bottom characteristics for each of these 17 regions were examined to determine if any region needed to be divided to accommodate the influence of the various bottom types on that regions propagation. The result was 21 separate modeling regions that taken in total captured the propagation for the entire area covered by this Programmatic EIS for all four seasons;

- Additionally, the seasonal distribution of marine mammals was examined using the best available databases to see if there was any additional correlation with bathymetry and SVP regions. Using this database, the seasonal distribution for each species was examined by overlaying the charts of the 21 acoustic modeling regions; the average density of each species was then numerically determined for each region.
- One final acoustic characterization was then conducted in order to allow the correct acoustic modeling for the shallowest water activities. Of the 21 modeling regions, 7 regions covered the area of the continental shelf, but these areas included water depths of up to approximately 200 m (656 feet [ft]). Since all of the marine mineral and renewable energy HRG surveys would be conducted in water less than 100 m (328 ft) deep, a refined propagation analysis using 50 and 100 m (164 and 328 ft) deep sites were identified for each of these seven shallow water regions. The acoustics modeling would use these 14 additional sites to properly capture the acoustic propagation for these two categories of non-airgun HRG surveys;
- JASCO Applied Sciences (JASCO) provided the acoustic propagation modeling and results for all sources and the regions that G&G surveys would potentially occur in as described in **Appendix D**;
- The AIM was used to estimate the impacts per survey block for each species, based on the typical planned geometry for each type of survey in each modeled area where the surveys would be conducted, using the appropriate thresholds for that species.

3. ACOUSTIC THRESHOLDS

3.1. Historical and Proposed Current Criteria

Since the mid-1990's, the NMFS has specified that marine mammals exposed to sounds with received levels exceeding 180 or 190 dB re 1 µPa (rms) for cetaceans and pinnipeds, respectively, were considered to exceed Level A (Injury) levels. Similarly, NMFS specifies that for pulsed sounds, cetaceans and pinnipeds exposed to levels exceeding 160 dB re 1 µPa (rms) were considered to exceed Level B (Behavioral Harassment) criteria (**Table E-1**). For all of these criteria, the exposure level was the maximum acoustic rms pressure level received by an animal.

Table E-1

Historical Injury and Behavioral Disturbance Criteria for Cetaceans and Pinnipeds for Airgun Signals, as Recognized and Used by the National Marine Fisheries Service

Group	Level A (Injury) Pressure (dB re 1 µPa rms)	Level B (Behavioral Disturbance) Pressure (dB re 1 µPa rms)
Cetaceans	180	160
Pinnipeds	190	160

3.1.1. Injury Criteria

The 180- and 190-dB re 1 µPa (rms) criteria were determined before there was specific information about the received levels of underwater sound that would cause temporary or permanent hearing damage in marine mammals. Subsequently, data on received levels that cause the onset of TTS have been obtained for certain toothed whales and pinnipeds (Kastak et al., 1999, 2005; Finneran et al., 2002, 2005). A group of specialists in marine mammal acoustics, the "noise criteria group," has recommended new criteria, based on current scientific knowledge, to replace the somewhat arbitrary 180 and 190 dB (rms) criteria (Southall et al., 2007).

Recently acquired data indicate that TTS-onset in marine mammals is more closely correlated with the received energy levels than with rms levels. In odontocetes and the more sensitive pinnipeds exposed to nonpulse sound, TTS onset occurs near 195 and 183 dB re 1 μPa^2 -s, respectively (Southall et al., 2007). In odontocetes exposed to impulse sounds, the TTS threshold can be as low as approximately 186 dB re 1 μPa^2-s. The corresponding value for pinnipeds is less well defined. There are published data on levels of nonpulse sound (Kastak et al., 1999, 2005) but not of impulse sound eliciting TTS in pinnipeds. Based on the results for nonpulse sound, plus the known tendency in other mammals for lower TTS thresholds with impulse than with nonpulse sound, the TTS thresholds for pinnipeds exposed to impulse sound may be as low as 171 dB re 1 μPa^2-s in the more sensitive species, such as the harbor seal.

There are no specific data concerning the levels of underwater sound necessary to cause PTS in any species of marine mammal. However, data from terrestrial mammals provide a basis for estimating the difference between the (unmeasured) PTS thresholds and the measured TTS thresholds. A conservative (precautionary) estimate of this offset between TTS and PTS thresholds, when sound exposure is measured on a SEL basis (received energy levels), is to add 15 dB to the TTS value for impulsive sounds and 20 dB for nonpulse sounds (Southall et al., 2007). Thus, now-available data indicate that the lowest received levels of impulsive sounds (e.g., airgun pulses) that might elicit slight auditory injury (i.e., PTS) are 198 dB re 1 μPa^2-s in cetaceans (i.e., 183 + 15 dB), and 186 dB re 1 μPa^2-s in the more sensitive pinnipeds (i.e., 171 + 15 dB). Corresponding values for nonpulse sounds (e.g., boomers, side-scan sonars, chirp subbottom profilers, and single beam or multibeam depth sounders) are 215 re 1 μPa^2-s in cetaceans (i.e., 195 + 20 dB) and 203 dB re 1 μPa^2-s in the more sensitive pinnipeds (e.g., 183 + 20 dB) (Southall et al., 2007). These SEL measures are all assumed to be taken using M-weighting; i.e., somewhat down-weighting the energy for frequencies near and especially beyond the lower and upper frequency limits of hearing in the relevant marine mammal group (Southall et al., 2007).

The noise criteria group also concluded that receipt of an instantaneous flat-weighted peak pressure exceeding 230 dB re 1 μPa (peak) for cetaceans or 218 dB re 1 μPa (peak) for pinnipeds might also lead to auditory injury even if the aforementioned cumulative energy-based criterion was not exceeded (**Table E-2**).

The primary measure of sound used in the proposed new criteria is the received sound energy, not just in the single strongest pulse, but accumulated over time. The most appropriate interval over which the received airgun signal should be accumulated is not well defined. However, pending the availability of additional relevant information, the noise criteria group has suggested considering noise exposure over 24-hour (hr) periods.

Included in Southall et al. (2007) is a discussion and proposed application of M-weighting, which would be used to adjust a species' threshold slightly in order to account for its relative sensitivity to signals at various frequencies. M-weighting was used as described in **Appendix D**.

Table E-2

Injury and Behavioral Disturbance Exposure Criteria for Cetaceans and Pinnipeds,
as proposed by Southall et al. (2007)

Group	Level A (Injury)		Level B (Behavioral Disturbance)
	Pressure (dB re 1 μPa rms) (peak) (flat weighted)	Energy (dB re 1 μPa2-s)	Pressure (dB re 1 μPa rms)
Pulsed Signals/Systems			
Low-frequency Cetaceans	230	198	*
Mid-frequency Cetaceans	230	198	*
High-frequency Cetaceans	230	198	*
Pinnipeds (in water)	218	186	*
Nonpulsed Signals/Systems			
Low-frequency Cetaceans	230	215	*
Mid-frequency Cetaceans	230	215	*
High-frequency Cetaceans	230	215	*
Pinnipeds (in water)	218	203	*

* = not specified in Southall et al., 2007.

3.1.2. Behavioral Disturbance Criteria

As noted above, the existing NMFS criterion for potential behavioral disturbance to marine mammals from airgun-based seismic surveys is 160 dB re 1 μPa (rms). The noise criteria group concluded that available data are insufficient as a basis for recommending any specific alternative behavioral disturbance criteria applicable to multiple-pulse sounds like airgun array sounds (Southall et al., 2007). Behavioral reactions to acoustic exposure are generally more variable, context-dependent, and less predictable than effects of noise exposure on hearing or physiology (Southall et al., 2007). There is no consensus on the appropriate noise exposure metric for assessing behavioral reactions, and it is recognized that many variables other than exposure level affect the nature and extent of responses to a particular stimulus (Southall et al., 2007). Finally, it is often difficult to differentiate brief, minor, biologically unimportant reactions from profound, sustained, and/or biologically meaningful responses related to growth, survival, and reproduction (NRC, 2005; Southall et al., 2007; Ellison et al., 2011). Therefore, in the Programmatic EIS, only the 160 dB criterion was used for the calculation of Level B incidental takes. This criterion applies to both multiple pulse signals/systems including (1) the large (5,400 cubic in) seismic airgun array and (2) the small (90 cubic in) airgun array; as well as the nonpulsed electromechanical sources/systems including (1) boomers, (2) multibeam depth sounders, (3) side-scan sonars, and (4) chirp subbottom profilers. The justification for the use of this criterion for the seismic airgun sources is that it has historic precedent. For the nonpulse systems, this threshold has also been historically used for nonpulsed systems and even extended to continuous nonpulsed systems. Even though these systems are not technically "continuously" transmitting, they can transmit very short signals (i.e., signals that are tens of thousandths to tenths of a second long) every second but in different beams or frequencies. Additionally, it should be pointed out that many of the transmission frequencies of these nonpulsed systems are greater than 200 kilohertz (kHz), and therefore are above the hearing spectrum of nearly all of the marine species, with the exception of the harbour porpoise. Thus, the use of the 160 dB SPL criterion for the Level B threshold for both the multiple pulsed and nonpulsed systems is a reasonable combination of the historic values used and best current science and precedents available. Other methodologies, including the possible use of a risk continuum function as was used in the Surveillance Towed Array Sensor System (SURTASS) Low-Frequency Active (LFA) Sonar Final EIS and Final Supplemental EIS (U.S. Dept. of the Navy, 2001, 2007a) have been examined for Level B impact assessment for various sources, but none has been applied to the impact analysis for this Programmatic EIS. NMFS is developing acoustic guidelines for assessing the effects of anthropogenic sound on marine mammal species under its jurisdiction (http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm). The draft guidelines have undergone an internal review; an external peer review began in July 2013. After peer review, NMFS will seek public comment on the scientific and implementation aspects of the document. Once the peer review and public comments are addressed, NMFS will finalize and release the acoustic guidelines.

Acoustic impact criteria applicable to other types of biota are less well-developed than the criteria for cetaceans and pinnipeds. There is an ongoing effort to develop science-based criteria for fish and sea turtles.

In November 2012, NMFS informed BOEM about their plan to update acoustic criteria for injury (for all sources) and behavioral harassment criteria (for seismic surveys using airguns). Subsequent discussions with NMFS held in December 2012 outlined that the updated acoustic criteria will be taxa-specific and source- or activity- specific. In March 2013, NMFS released a Supplemental Draft EIS on the *Effects of Oil and Gas Activities in the Arctic Ocean* (see http://www.nmfs.noaa.gov/pr/permits/eis/arctic.htm), which contained very brief and limited information on NMFS's plans to update the acoustic criteria. Further, in this Supplemental Draft EIS, NMFS stated that the "acoustic criteria process will (separate from this EIS process) include both a public and external peer review process" and that NMFS was "still in the internal review process." In late September 2013, after an external peer review, NMFS provided a draft version of the new criteria for a Federal agency review and comment period. This document outlined new Level A criteria for all sources and new Level B criteria for seismic surveys (mainly airguns). BOEM provided comments on this draft version of the criteria, including noting additional information BOEM needed to evaluate the methodology. Further, this version did not contain NMFS's plan for implementing any new criteria.

As of the publication of this Final Programmatic EIS, the criteria still remain in draft form. BOEM continues to provide NMFS with comments as requested. However, analysis of the criteria within this Final Programmatic EIS is not possible given the uncertainty that still remains on the final content of the criteria. However, if NMFS finalizes new criteria, BOEM will evaluate the criteria in the context of any site-specific analysis under OCSLA and NEPA. NMFS will also apply any new criteria at this site-specific level through any undertaken MMPA authorization process.

4. ACOUSTIC SOURCE MODELING

A detailed discussion of acoustic sources, including both airguns and electromechanical sources, as well as how they were modeled acoustically, can be found in **Appendix D**. Sources modeled in **Appendix D** include a large (5,400 cubic in) airgun array, small (90 cubic in) airgun array, boomer, side-scan sonar, chirp subbottom profiler, and multibeam depth sounder.

5. AREA ACOUSTIC PROPAGATION CHARACTERIZATION

5.1. General Characterization of All Operational Areas

This section discusses the methodology used to characterize the underwater acoustic propagation environment of the Area of Interest (AOI) (**Figure E-1**) for propagation modeling to be used for impact analysis of underwater acoustic source transmissions. This characterization attempts to eliminate the need to account for existing environmental features that do not impact the final analysis while maintaining an adequate representation of the environment of the AOI that impacts the analysis. The characterization was conducted in two parts. First, the sound speed environment was sorted into areas of like propagation for each of the four seasons. Second, bottom sediments were examined and classified as two sub-areas to account for the different acoustic bottom loss areas expected in the study. The two parts were then combined to yield defined subareas of unique propagation modes and bottom loss.

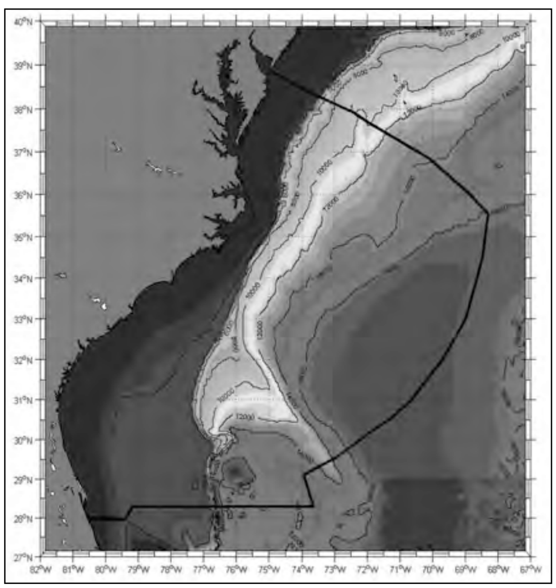


Figure E-1. Area of Interest (black line) Plotted over Bathymetry from the Digital Bathymetric Data Base Variable Resolution Database (depth in feet).

5.1.1. Propagation

Available sound speed profile databases were evaluated to find an appropriate database to use that contained data for the AOI throughout the year. The Provinced (GDEM) monthly sound speed database was selected to characterize the sound speed environment of the deep water modeling regions (water depths greater than 1,000 ft). The Provinced GDEM database represents the AOI using 13 sound speed areas or provinces and groups like-sound speed profiles in provinces for each month of the year

(**Figure E-2**). This database does not have a shallow water component. The GDEM Variable Resolution (GDEM_V) database was selected to characterize the sound speed environment of the shallow water regions (water depths less than 305 m [1,000 ft]). The GDEM_V database was interrogated at a 15-minute (min) spacing to yield sound speed profiles in the shallow water portion of the AOI for water depth from 9 to 305 m (30 to 1,000 ft).

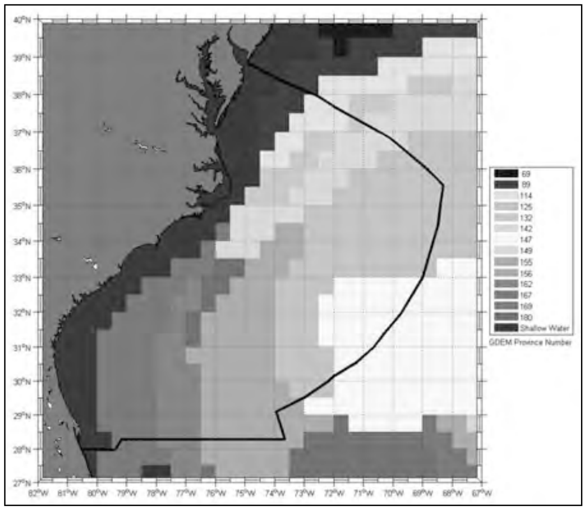


Figure E-2. Provinced Generalized Digital Environmental Model (GDEM) Areas within the Area of Interest (black line).

Profiles were examined from each database using the months presented in **Table E-3** to represent each season. To eliminate the redundant effort needed to conduct impact analysis on each sound speed profile extracted for the AOI, each profile was examined and grouped into areas of similar acoustic propagation and therefore similar acoustic impact. The acoustic propagation was modeled for each profile, for each season, using a standard raytrace model. An acoustic raytrace will show the propagation path for acoustic energy as it travels from a source and through the water. The representative sound source used for this raytrace modeling was omni-directional at a depth of 6 m (20 ft). The propagation paths were modeled by computing all ray paths (±90°) of the acoustic energy along an environmentally range-independent radial (one sound speed profile and a flat bottom) for each profile and each season.

Table E-3

Month Used to Represent Each Season in Sound Speed Database Extraction

Season	Representative Month
Winter	February
Spring	May
Summer	August
Fall	November

The raytraces for each season were examined and grouped into like propagation areas which yielded areas with similar acoustic propagation for both shallow and deep water areas. The distinguishing characteristics of acoustic propagation paths in the AOI can be grouped into the following:

1. *Presence of a Surface Duct*

The presence or absence of a surface layer that trapped some energy from a shallow source depth is the first discriminator of propagation characteristics. A surface layer that traps acoustic energy is also called a surface duct. A surface duct occurs when the sound speed increases with depth from the surface to a depth below the source depth. Generally this occurs in colder seasons where colder air temperature and higher winds cool and mix waters in the surface layer. Surface ducts can also occur when water masses of different densities mix, such as north-flowing Gulf Stream water mixing with south-flowing North Atlantic waters. The acoustic ray paths trapped in the surface duct do not hit the bottom, but are either turned upward to reflect off the surface over-and-over (**Figure E-3**) or turned downward to be trapped again. Not all transmitted acoustic energy is trapped in a surface duct. In fact, most transmitted energy from shallow source in a surface duct is reflected off the bottom. But surface layer trapped energy propagations with less loss than bottom bounce paths, therefore increasing the potential range of impact of the transmitted acoustic energy from the source.

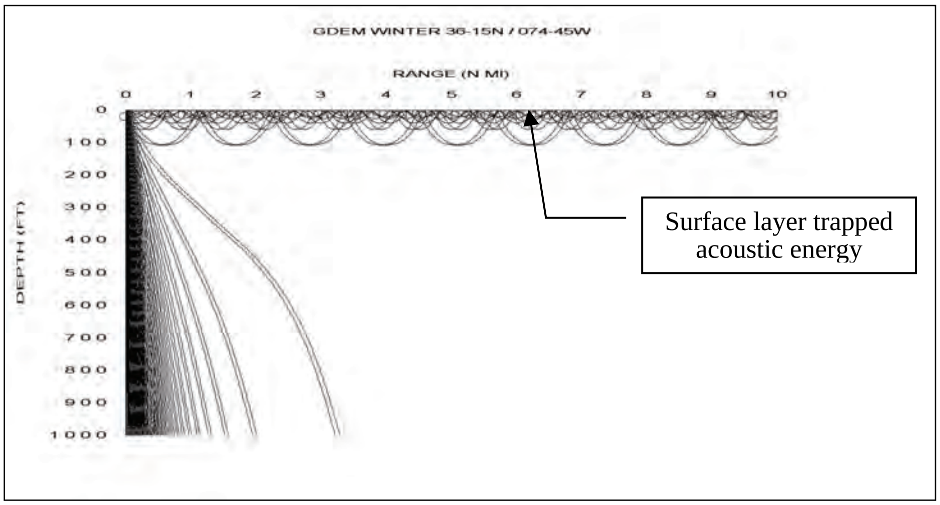


Figure E-3. Example of Surface Layer Trapped Acoustic Energy.

2. *Strength of the Surface Duct*

If a surface layer is present, the relative amount of acoustic angles that are trapped in the surface duct is the next discriminator of propagation characteristics. Generally, the deeper the surface layer, the more acoustic angles are trapped in the layer; additional angles can be trapped if the gradient of sound speed is greater, but this is not seen in the AOI. The more acoustic source angles trapped in the surface duct, the more energy is transmitted from the source to the surrounding environment without attenuation from bottom reflection and therefore have more potential to effect the environment.

3. *Presence of a Convergence Zone*

The third discriminator of propagation characteristics is the presence of a Convergence Zone (CZ). The CZ propagation only occurs in very deep water where the sound speed eventually increases with great depth (due to pressure) and the deep-going acoustic propagation rays are bent back toward the surface (**Figure E-4**). These deep-going rays will travel back to the source depth (usually at a range of 30-40 nmi from the source) and turn toward the deep again or be reflected off the surface and travel deep again. The deeper the water depth, more rays will travel in the CZ. These deep-going rays travel a relatively great distance without reflection off the bottom and without the corresponding reflection loss. The water depth needed for a CZ to occur varies with the season and the depth of the source. If the source depth is constant, the water depth needed increases with warmer seasons. The presence of a CZ will support propagation of acoustic energy to relatively long distances without attention of bottom reflection and could increase the potential to effect the environment at a relatively long range. The presence or absence of surface ducts is independent of CZ propagation.

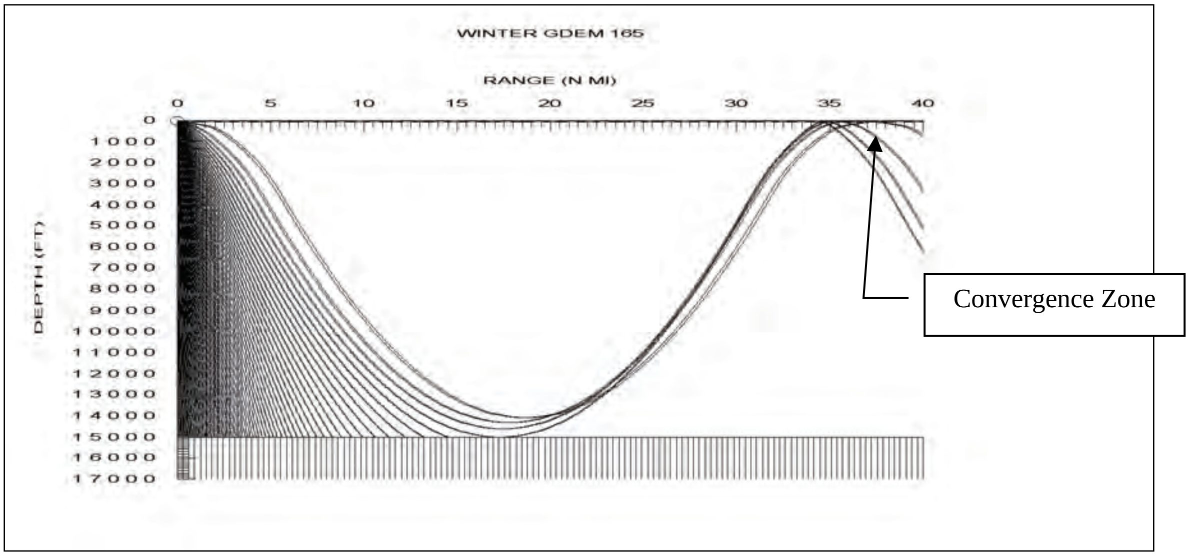


Figure E-4. Example of the Convergence Zone Propagation.

4. *Bottom Bounce Paths*

The last acoustic propagation discriminator, and the most dominate in the AOI, is total bottom bounce propagation. Total bottom bounce propagation is not trapped in a surface layer nor CZ propagated, but travels downward from the source to reflect off the bottom. The amount of acoustic energy reflected off the bottom back into the water is dependent on the composition of the bottom. A rocky bottom reflects more energy back into the water than a muddy bottom. Therefore, the bottom composition must be considered when estimating the environmental impact of bottom bounce acoustic energy that is of sufficient strength to contribute to the environmental impact.

5.1.1.1. Winter

The acoustic propagation environment of the AOI in winter can be characterized with a single profile for deep water areas and two unique sound speed profiles for shallow water areas. The winter profile from GDEM Province 180 is selected to represent all deep water areas (>305 m [1,000 ft]) of the AOI. This profile supports only shallow angles in ducted propagation, but does support CZ propagation in water depths greater than 4,267 m (14,000 ft). Therefore, there are four unique types used to characterize winter propagation in the AOI (**Figure E-5**):

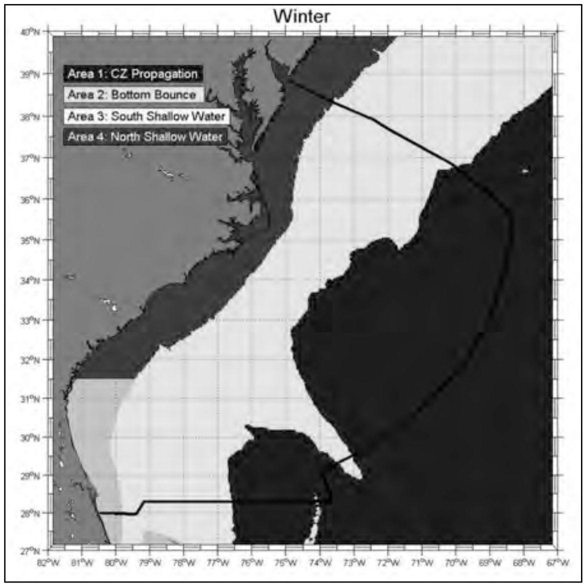


Figure E-5. Winter Propagation Characteristics of the Area of Interest (black line).

1. *Deep Water CZ propagation*, represented by GDEM Province 180/February, for water depths greater than 4,267 m (14,000 ft) in the AOI. The representative location for this propagation type is 32-00° N/72-00° W. Only acoustic energy transmitted at shallow angles (0° to ±1°) from the source is trapped in the surface duct, if any. Steep source angles are transmitted into the bottom. Source angles between ±1° and ±6° (or more depending on water depth) are converted to CZ propagation.
2. *Deep Water Bottom Bounce propagation*, represented by GDEM Province 180/February, for water depths greater than 305 m (1,000 ft), but less than 4,267 m (14,000 ft), in the AOI. The representative location for this propagation type is 32-45°N/76-00°W. Only acoustic energy transmitted at shallow angles (0° to ±1°) from the source is propagated in the surface duct, if any. All other source angles are transmitted into the bottom.
3. *Southern Shallow Waters*, represented by the GDEM February profile at 30-30° N/80-15° W, for water depths less than 1,000 ft (305 m) and south of 31-30° N. Only acoustic energy transmitted at shallow angles (0° to ±1°) from the source is propagated in the surface duct, if any. All other source angle paths are transmitted into the bottom.
4. *Northern Shallow Waters*, represented by the GDEM February profile at 36-15° N/74-45° W, for water depths less than 305 m (1,000 ft) and north of 31-30°N. This profile traps a moderate amount of acoustic energy in the surface duct. At least ±2° of source energy paths are trapped in the surface layer, but generally ±4° are trapped. All other source angle paths are transmitted into the bottom.

5.1.1.2. Spring

The acoustic propagation environment of the AOI in spring can be characterized with a single profile for deep water areas and two unique sound speed profiles for shallow water areas. The spring profile from GDEM Province 156 is selected to represent all deep water areas of the AOI. This profile supports only shallow angles in ducted propagation, but does support CZ propagation in water depths greater than

4,267 m (14,000 ft). Therefore there are four unique types used to characterize spring propagation in the AOI (**Figure E-6**):

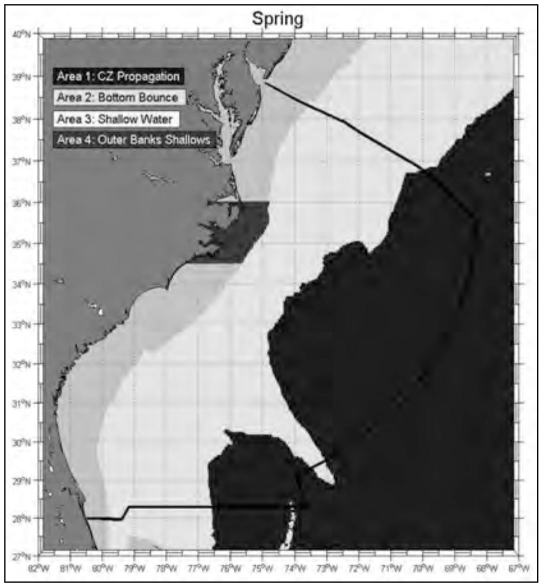


Figure E-6. Spring Propagation Characteristics of the Area of Interest (black line).

1. *Deep Water CZ propagation*, represented by GDEM Province 156/May, for water depths greater than 4,267 m (14,000 ft) in the AOI. The representative location for this propagation type is 32-00° N/72-00° W. Only acoustic energy transmitted at the shallowest angles from the source is propagated in the surface duct, if any. Steep source angles are transmitted into the bottom. Source angles between ±1° and ±4° (or more, depending on water depth) are converted to CZ propagation.
2. *Deep Water Bottom Bounce propagation*, represented by GDEM Province 156/May, for water depths greater than 305 m (1,000 ft), but less than 4,267 m (14,000 ft), in the AOI. The representative location for this propagation type is 31-30° N/75-00° W. Only acoustic energy transmitted at the shallowest angles from the source is trapped in the surface duct, if any. All other source angles are transmitted into the bottom.
3. *Bottom Bounce Shallow Waters*, represented by the GDEM May profile at 32-00° N/79-15° W, for water depths less than 305 m (1,000 ft, south of 34-30° N or north of 36-00° N. Only acoustic energy transmitted at shallow angles (0° to ±1°) from the source is trapped in the surface duct, if any. All other source angles paths are transmitted into the bottom.
4. *Moderately-ducted (Outer Banks) Shallow Waters*, represented by the GDEM May profile at 35-00° N/76-15° W, for water depths less than 305 m (1,000 ft), between 36-00° N and 34-30° N. This area is roughly the Outer Banks area of North Carolina. This profile traps a moderate amount of acoustic energy in the surface duct. At least ±2° of source energy paths are trapped in the surface duct, but generally ±4° are trapped. All other source angle paths are transmitted into the bottom.

5.1.1.3. Summer

The acoustic propagation environment of the AOI in summer can be characterized with a single profile for deep water areas and one sound speed profile for shallow water areas. The summer profile from GDEM Province 156 is selected to represent all deep water areas of the AOI. This profile supports only the shallowest angle in ducted propagation, but does support CZ propagation in water depths greater than 4,877 m (16,000 ft). The depth of CZ propagation has increased from spring because of surface warming of waters in the AOI. There are three unique types used to characterize summer propagation in the AOI (**Figure E-7**):

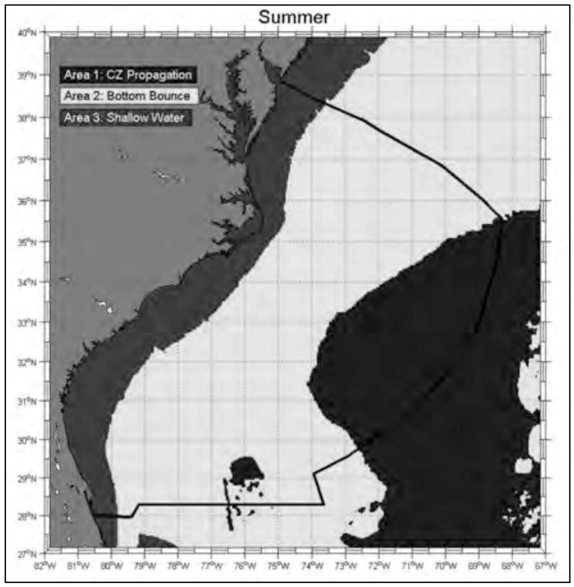


Figure E-7. Summer Propagation Characteristics of the Area of Interest (black line).

1. *Deep Water CZ propagation*, represented by GDEM Province 156/August, for water depths greater than 4,877 m (16,000 ft) in the AOI. The representative location for this propagation type is 32-00° N/72-00° W. Only acoustic energy transmitted at the shallowest angles from the source is propagated in the surface duct, if any. Steep source angles are transmitted into the bottom. Source angles between ±1° and ±4° (or more depending on water depth) are converted to CZ propagation.
2. *Deep Water Bottom Bounce propagation*, represented by GDEM Province 156/August, for water depths greater than 305 m (1,000 ft), but less than 4,877 m (16,000 ft), in the AOI. The representative location for this propagation type is 31-30° N/75-00° W. Only acoustic energy transmitted at the shallowest angles from the source is propagated in the surface duct, if any. All other source angles are transmitted into the bottom.
3. *Shallow Waters*, represented by the GDEM August profile at 36-00° N/74-45° W, for water depths in water depths less than 305 m (1,000 ft). Only acoustic energy transmitted at the shallowest angle from the source is propagated in the surface duct, if any. All other source angle paths are transmitted into the bottom.

5.1.1.4. Fall

Fall is the most complex season for underwater sound propagation characterization within the AOI. The southern portion of the AOI still exhibits summer-like propagation while the northern portion has transitioned toward winter-like propagation. The acoustic propagation environment of the AOI in fall is characterized by two deep water areas and two shallow water areas. Each of the deep water areas supports either bottom bounce or CZ propagation. There are six unique propagation types used to characterize fall propagation in the AOI (**Figure E-8**):

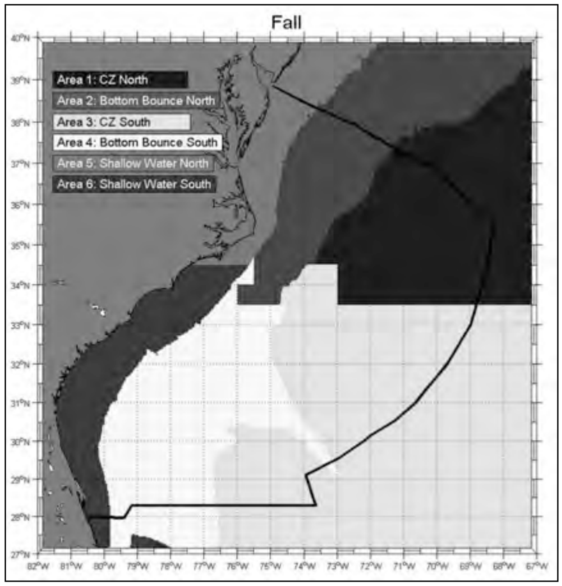


Figure E-8. Fall Propagation Characteristics of the Area of Interest (black line).

1. *Northern Deep Water CZ propagation*, represented by GDEM Province 142/November, for water depths greater than 3,810 m (12,500 ft) in the AOI. The representative location for this propagation type is 36-30° N/71-30° W. Only acoustic energy transmitted at shallow angles (0°-±2°) from the source is propagated in the surface duct. Steep source angles are transmitted into the bottom. The narrow range of source angles between ±2° and ±4° (or more depending on water depth) are converted to CZ propagation.

2. *Northern Deep Water Bottom Bounce propagation*, represented by GDEM Province 142/November, for water depths greater than 305 m (1,000 ft), but less than 3,810 m (12,500 ft), in the AOI. The representative location for this propagation type is 36-30° N/72-30° W. Only acoustic energy transmitted at shallow angles (0°- ±2°) from the source is propagated in the surface duct. All other source angles are transmitted into the bottom.

3. *Southern Deep Water CZ propagation*, represented by GDEM Province 156/November, for water depths greater than 4,115 m (13,500 ft) in the AOI. The representative location for this propagation type is 29-30° N/75-30° W. Only acoustic energy transmitted at the shallowest angles from the source is propagated in the surface duct, if any. Steep source angles are transmitted into the bottom. The narrow range of source angles between ±2° and ±4° (or more depending on water depth) are converted to CZ propagation.

4. *Southern Deep Water Bottom Bounce propagation*, represented by GDEM Province 156/November, for water depths greater than 305 m (1,000 ft), but less than 4,115 m (13,500 ft), in the AOI. The representative location for this propagation type is 31-00° N/75-30° W. Only acoustic energy transmitted at the shallowest angles from the source is propagated in the surface duct, if any. All other source angles are transmitted into the bottom.

5. *Southern Shallow Waters*, represented by the GDEM November profile at 32-00° N/79-15° W, for water depths in water depths less than 305 m (1,000 ft) and areas south of 34-30° N. Only acoustic energy transmitted at the shallowest angle from the source is propagated in the surface duct, if any. All other source angle paths are transmitted into the bottom.

6. *Northern Shallow Waters*, represented by the GDEM November profile at 36-30° N/74-45° W, for water depths in water depths less than 305 m (1,000 ft) and areas northern of 34-30° N. A moderate amount of acoustic energy is trapped in the surface duct for source angle transmitted up to ±5°. All other source angle paths are transmitted into the bottom.

5.1.2. Bottom Loss

The above work shows that a great deal of acoustic energy transmitted in the AOI will reflect off the bottom. In addition, the nature of the intended acoustic work will "aim" the transmitted energy toward the bottom. Therefore, acoustic bottom loss should be considered to evaluate the impact of transmitted acoustic energy in the AOI.

Bottom loss is dependent on the type of sediment that reflects the acoustic energy, along with the frequency of the sound reflecting off the bottom and the angle that the sound reflects off the bottom. This study assumes that frequency and angle do not change with location and examines changes in sediment type over location to understand the bottom loss in the AOI. More than 10,000 observations from the National Geophysical Data Center (NGDC) Surficial Sea Floor Sediment database were used to characterize sediments in the study. Bottom sediment grain size index was assigned to each observation (**Table E-4**) according to the University of Washington Applied Physics Laboratory Technical Report 9407 on bottom loss modeling (University of Washington Applied Physics Laboratory, 1994).

The results of the above processing yielded an irregularly spaced dataset of observation location and grain size throughout the AOI. This dataset was used to create a 1 nmi spacing grid to represent the geographic distribution of grain size for the AOI by using the closest measured data for each grid point (**Figure E-9**).

Fine grain sediment, such as clays (with high grain size index) can be seen to dominate the areas of water depth greater than 1,219 m (4,000 ft). Coarser sediments, such as sand and gravel (lower grain size index) can be seen to dominate areas of water depth less than 1,219 m (4,000 ft). Bottom loss curves were computed with the Rayleigh Bottom Loss Model using the dominate grain size indexes seen in the AOI (**Figure E-10**).

A mix of gravels and sands dominate the sediment types in water depths less than 1,219 m (4,000 ft). These corresponding grain size indexes (-1 and 1) result in very similar bottom loss curves (**Figure E-10**). The difference seen is insignificant when considering impact analysis. A grain size index of -1 is selected to represent the sediment for areas of water depth less than 1,219 m (4,000 ft). The bottom loss for a -1 grain size index is less, resulting in more energy reflected back into the water column, and therefore is the worst case for impact analysis.

Bottom loss in deep water areas has little effect on impact analysis because results are driven by the direct path propagation from the source directly to the animal. Propagation losses of the sound traveling to the bottom and back are very high compared to direct path losses. In water depths greater than 1,219 m (4,000 ft), spherical spreading loss of acoustic energy traveling from a near-surface source to the bottom and back to the near surface is at least 67 dB. Therefore efforts to model the details of different bottom loss regions in deep water would have no consequence in impact analysis. A sediment grain size index of 7 is therefore used characterized areas of water depth greater than 1,219 m (4,000 ft).

Table E-4

Grain Size Index for Sediment Type

Sediment Type	Bottom Sediment Grain Size Index
Rough Rock	-9.0
Rock	-7.0
Cobble	-3.0
Gravel	-3.0
Pebble	-3.0
Sandy Gravel	-1.0
Very Coarse Sand	-0.5
Muddy Sandy Gravel	0.0
Coarse Sand	0.5
Gravelly Sand	0.5
Gravelly Muddy Sand	1.0
Sand	1.5
Medium Sand	1.5
Muddy Gravel	2.0
Fine Sand	2.5
Silty Sand	2.5
Muddy Sand	3.0
Very Fine Sand	3.5
Clayey Sand	4.0
Coarse Silt	4.5
Sandy Silt	5.0
Medium Silt	5.5
Sand-Silt-Clay	5.5
Silt	6.0
Sandy Mud	6.0
Fine Silt	6.5
Clayey Silt	6.5
Sandy Clay	7.0
Very Fine Silt	7.5
Silty Clay	8.0
Clay	9.0

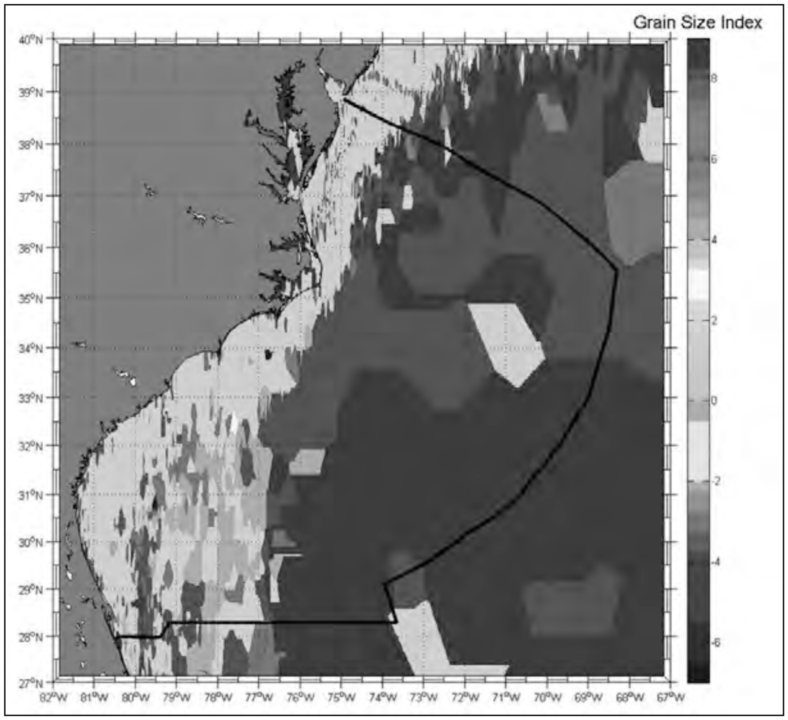


Figure E-9. Grain Size Index for the Area of Interest.

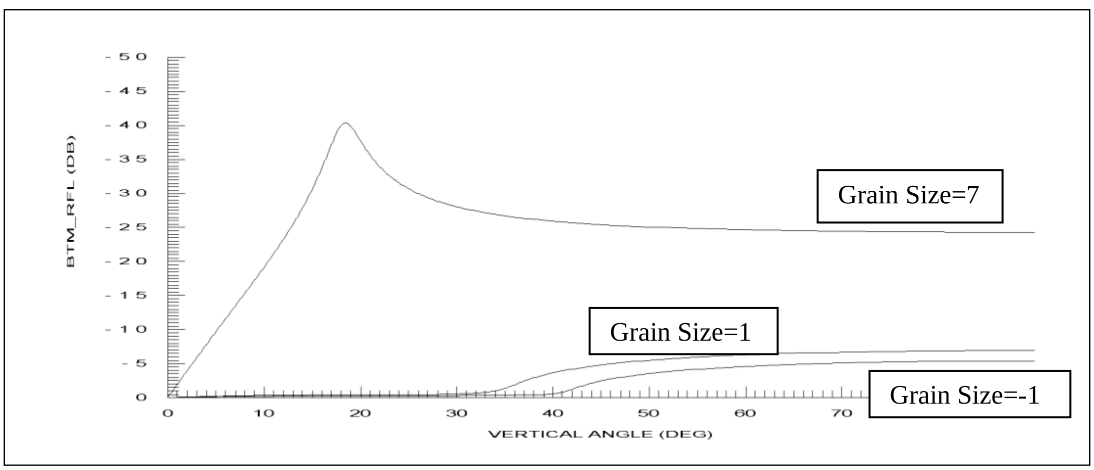


Figure E-10. Rayleigh Bottom Loss Estimates for Grain Size Index 7, 1, and -1.

5.1.3. General Characterization Summary

Combining the defined area of sound speed profiles and bottom sediments presented above results in a definition of 21 unique propagation modes and bottom loss regions in the AOI. These 21 modeling regions are defined in **Table E-5** and cover all four seasons. Each region is intended to define one sound speed profile and grain size index to be used for each transmission loss (TL) model run to be used for impact analysis. The SVPs used for this characterization are specified in **Table E-6**. The resulting seasonal plots show these 21 modeling regions (**Figures E-11** through **E-14**).

This study defines the change between shallow and deep sound speed environments at 305 m (1,000 ft) water depth. This is because the deep water database of sound speed does not extend into water depths less than 305 m (1,000 ft). This study also defined a change in the sediment type at 1,219 m

(4,000 ft) water depth. This change is defined from direct observation of the sediment grain size data. Where appropriate, a unique propagation/sediment region has been assigned to this area between 305-1,219 m (1,000-4,000 ft) of water depth. This is especially true for the Blake Plateau areas of the southern portion of the AOI, south of 33-30° N (**Figure E-1**). However, north of 33-30° N, the distance between the 305 m and 1,219 m (1,000 ft and 4,000 ft) isobaths is a relatively small area; no distinction has been drawn between areas defined by the these isobaths north of 33-30° N. This can be seen in the water depth definition of the Fall Northern Deep Bottom Bounce area.

Table E-5

Summary of Propagation and Bottom Loss Characterization in the Area of Interest

Modeling Region	Season	Propagation Characterization	Water Depth (kft)	GDEM Profile	Representative Location	Sediment	Grain Size Index
1	Winter	Convergence Zone	>14	Province 180/February	32-00N 72-00W	Clay	7
2	Winter	Bottom Bounce (Clay)	4-14	Province 180/February	32-45N 76-00W	Clay	7
3	Winter	Bottom Bounce (Sand)	1-4	Province 180/February	31-00N 78-00W	Sand	-1
4	Winter	Southern Shallow Water	<1	February @ representative location	30-30N 80-15W	Sand	-1
5	Winter	Northern Shallow Water	<1	February @ representative location	36-15N 74-45W	Sand	-1
6	Spring	Convergence Zone	>14	Province 156/May	32-00N 72-00W	Clay	7
7	Spring	Bottom Bounce (Clay)	4-14	Province 156/May	31-30N 75-00W	Clay	7
8	Spring	Bottom Bounce (Sand)	1-4	Province 156/May	31-00N 78-00W	Sand	-1
9	Spring	Bottom Bounce Shallow Water	<1	May @ representative location	32-00N 79-15W	Sand	-1
10	Spring	Moderately-ducted (Outer Banks) shallow water	<1	May @ representative location	35-00N 76-15W	Sand	-1
11	Summer	Convergence Zone	>16	Province 156/August	32-00N 72-00W	Clay	7
12	Summer	Bottom Bounce (Clay)	4-16	Province 156/August	31-30N 75-00W	Clay	7
13	Summer	Bottom Bounce (Sand)	1-4	Province 156/August	31-00N 78-00W	Sand	-1
14	Summer	Shallow Water	<1	August @ representative location	36-00N 74-45W	Sand	-1
15	Fall	Northern Convergence Zone	>12.5	Province 142/November	36-30N 71-00W	Clay	7
16	Fall	Northern Deep Bottom Bounce	1-12.5 [a]	Province 142/November	36-30N 72-00W	Clay	7
17	Fall	Southern Convergence Zone	>13.5	Province 156/November	29-30N 75-30W	Clay	7
18	Fall	Southern Deep Bottom Bounce (Clay)	4-13.5	Province 156/November	31-00N 75-30W	Clay	7
19	Fall	Southern Deep Bottom Bounce (Sand)	1-4	Province 156/November	31-00N 78-00W	Sand	-1
20	Fall	Southern Shallow Water	<1	November @ representative location	32-00N 79-15W	Sand	-1
21	Fall	Northern Shallow Water	<1	November @ representative location	36-30N 74-45W	Sand	-1

[a] Note: In the Fall Northern Deep Bottom Bounce sub-area, the area defined by the 305 m and 1,219 m (1,000 ft and 4,000 ft) isobaths, occurs on the shelf break and occupies a relatively small area, therefore this sub-area is re-defined as starting at 305 m (1,000 ft) water depth.

Table E-6

Summary Table of the Sound Velocity Profiles Used in the Characterization of the Area

	Sound Velocities (m/s)											
	Modeling Regions											
Depth (m)	1,2,3	4	5	6,7,8	9	10	11,12,13	14	15,16	17,18, 19	20	21
0	1532.9	1527.3	1524.6	1533.7	1532.6	1529.3	1544.3	1533.6	1524.7	1529.3	1516.2	1535.5
2		1527.4	1524.6		1532.6	1529.5		1533.7			1516.3	1535.6
4		1527.4	1524.6		1532.5	1529.7		1533.8			1516.4	1535.7
6		1527.5	1524.6		1532.5	1529.9		1533.8			1516.5	1535.7
8		1527.5	1524.6		1532.5	1530.2		1533.9			1516.6	1535.7
10	1533.1	1527.6	1524.6	1533.8	1532.5	1530.5	1544.5	1533.8	1524.9	1529.5	1516.7	1535.7
15		1527.8	1524.5		1532.4	1531.3		1532.5			1517.4	1535.7
20	1533.3	1527.8	1524.5	1533.6	1532.3	1531.8	1544.3	1530.3	1525.1	1529.6	1517.6	1535.7
25		1527.7	1524.4		1531.9	1531.9		1527.5			1517.2	1535.7
30	1533.4	1527.7	1524.3	1532.9	1531.4	1531.9	1543.0	1524.5	1525.2	1529.8	1516.5	1535.6
35		1527.5	1524.1		1530.8	1531.7		1522.2			1515.1	1535.5
40		1527.3	1523.8		1530.2	1531.3		1519.7			1513.3	1535.4
45		1527.0	1523.6		1529.4	1531.0		1517.4			1511.4	1535.1
50	1533.6	1526.8	1523.3	1530.4	1528.7	1530.5	1536.4	1515.5	1525.6	1530.1	1509.8	1534.8
55		1526.4	1523.0		1528.1	1530.0		1514.5			1509.4	1534.4
60		1526.1	1522.6		1527.4	1529.4		1513.8			1509.2	1534.0
65		1525.7	1522.2		1526.7	1528.8		1513.1			1508.9	1533.4
70		1525.2	1521.7		1525.9	1528.1		1512.5			1508.7	1532.7
75	1533.4	1524.7	1521.2	1528.1	1525.1	1527.4	1531.1	1512.0	1525.8	1530.2	1508.5	1531.9
80		1524.1	1520.7		1524.4	1526.8		1511.6			1508.4	1530.9
85		1523.5	1520.2		1523.6	1526.1		1511.4			1508.3	1529.8
90		1522.8	1519.7		1522.9	1525.5		1511.3			1508.2	1528.5
95		1522.2	1519.1		1522.1	1524.9		1511.0			1508.0	1527.3
100	1532.0	1521.4	1518.5	1527.3	1521.2	1524.3	1529.8	1510.7	1525.4	1529.6	1507.9	1526.1
110		1520.0	1517.4		1519.6	1523.2		1509.9			1507.4	1523.8
120		1518.4	1516.2		1517.9	1522.0		1509.0			1506.9	1521.6
125	1529.9			1527.0			1529.0		1524.3	1528.2		
130		1516.8	1514.9		1516.2	1521.0		1508.2			1506.3	1519.3
140		1515.0	1513.5		1514.4	1520.0		1507.3			1505.7	1517.3
150	1527.9	1513.3	1512.0	1526.6	1512.7	1519.0	1528.0	1506.4	1522.7	1526.7	1505.1	1515.3
160		1511.6	1510.5		1511.1	1518.0		1505.6			1504.3	1513.5
170		1509.8	1509.1		1509.6	1517.1		1504.7			1503.5	1511.6
180		1508.0	1507.7		1508.1	1516.1		1503.7			1502.6	1509.8
190		1506.1	1506.3		1506.6	1515.2		1502.8			1501.7	1508.1
200	1526.2		1504.9	1525.8	1505.2	1514.4	1525.9	1501.9	1520.1	1525.2	1500.9	1506.6
220			1502.5		1502.8	1512.8		1500.0			1499.0	1504.0
240			1500.2		1500.5	1511.2		1498.1			1497.2	1501.7
250	1525.0			1525.1			1524.1		1519.0	1524.7		
260			1498.0		1498.5	1509.7		1496.3			1495.4	1499.5
280			1496.1		1496.6	1508.3		1494.6			1493.8	1497.4
300	1523.9		1494.3	1524.2	1495.0	1506.9	1522.8	1493.1	1518.1	1524.0	1492.2	1495.5
350						1503.8		1489.7			1488.5	
400	1521.1			1522.4			1522.4		1515.1	1522.4	1485.4	
500	1518.4			1520.8			1520.8		1512.3	1520.8	1481.1	
600	1514.5			1517.7			1517.7		1508.6	1517.7	1480.0	
700	1508.8			1512.2			1512.2		1503.8	1512.2	1480.3	
800	1502.9			1506.1			1506.1		1499.2	1506.1	1481.1	
900	1497.7			1500.1			1500.1		1495.1	1500.1	1482.3	
1000	1493.6			1495.1			1495.1		1492.0	1495.1		
1100	1491.0			1491.7			1491.7		1490.0	1491.7		
1200	1489.9			1490.0			1490.0		1489.3	1490.0		
1300	1490.1			1489.9			1489.9		1489.5	1489.9		
1400	1491.1			1490.9			1490.9		1490.5	1490.9		
1500	1492.6			1492.6			1492.6		1492.0	1492.6		
1750	1495.9			1496.3			1496.3		1495.7	1496.3		
2000	1499.0			1499.5			1499.5		1499.2	1499.5		
2500	1505.3			1505.7			1505.7		1505.7	1505.7		
3000	1512.0			1512.0			1512.0		1512.4	1512.0		
4000	1527.6			1527.4			1527.4		1527.8	1527.4		
5000	1545.2			1545.2			1545.2		1545.0	1545.2		
6000	1562.6			1562.6			1562.6		1561.8	1562.6		

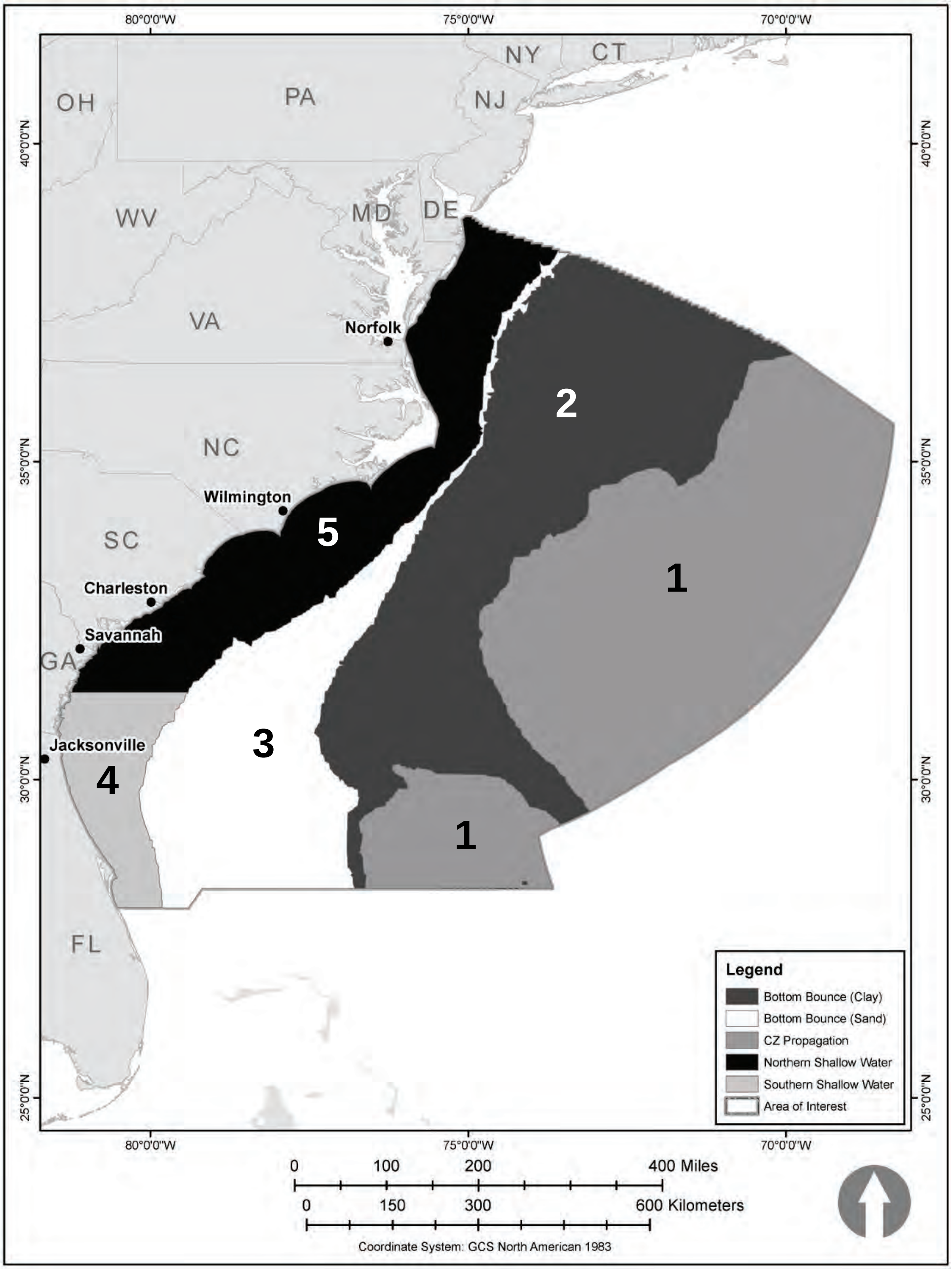


Figure E-11. Final Modeling Regions for the Winter.

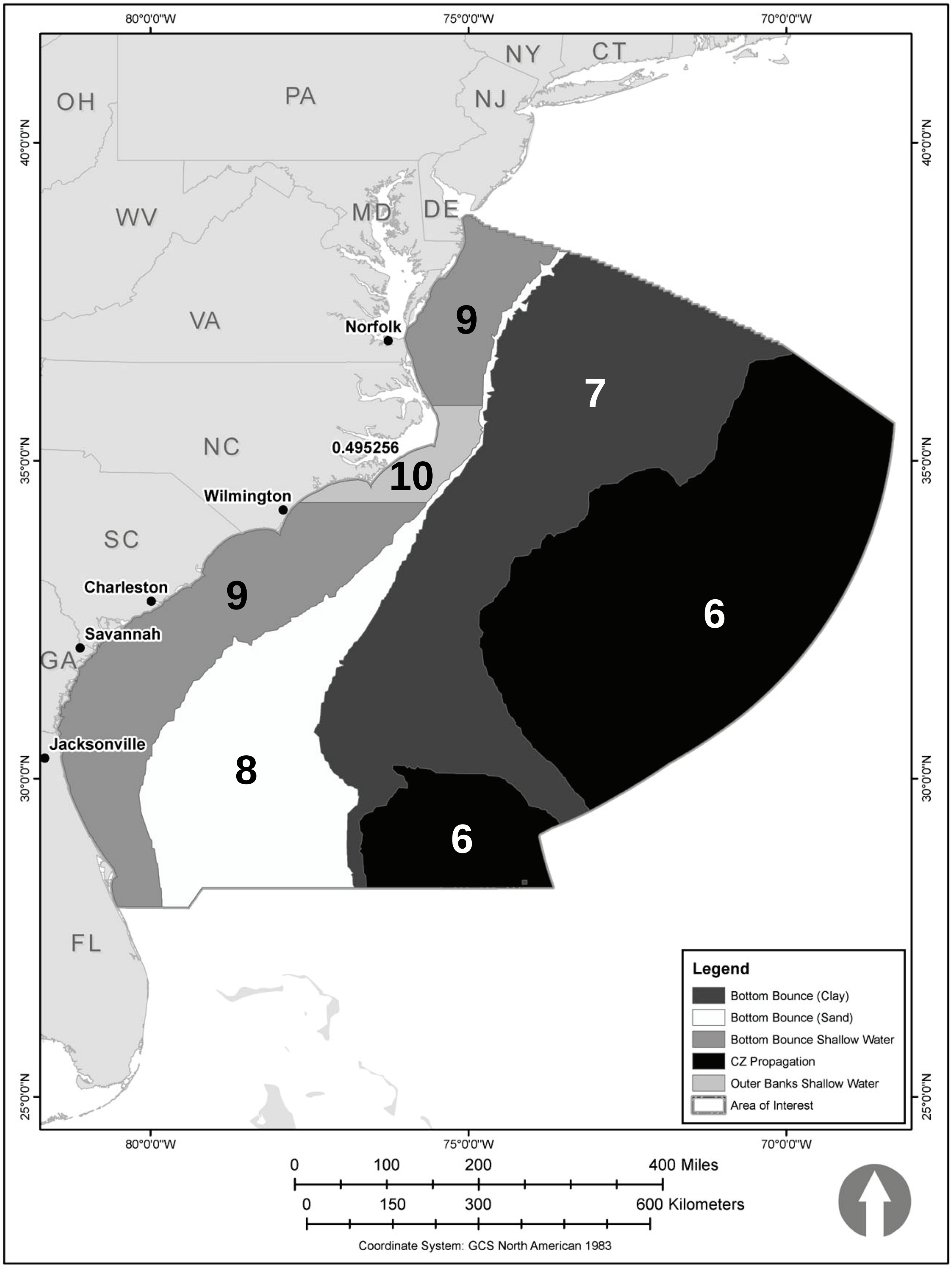


Figure E-12. Final Modeling Regions for the Spring.

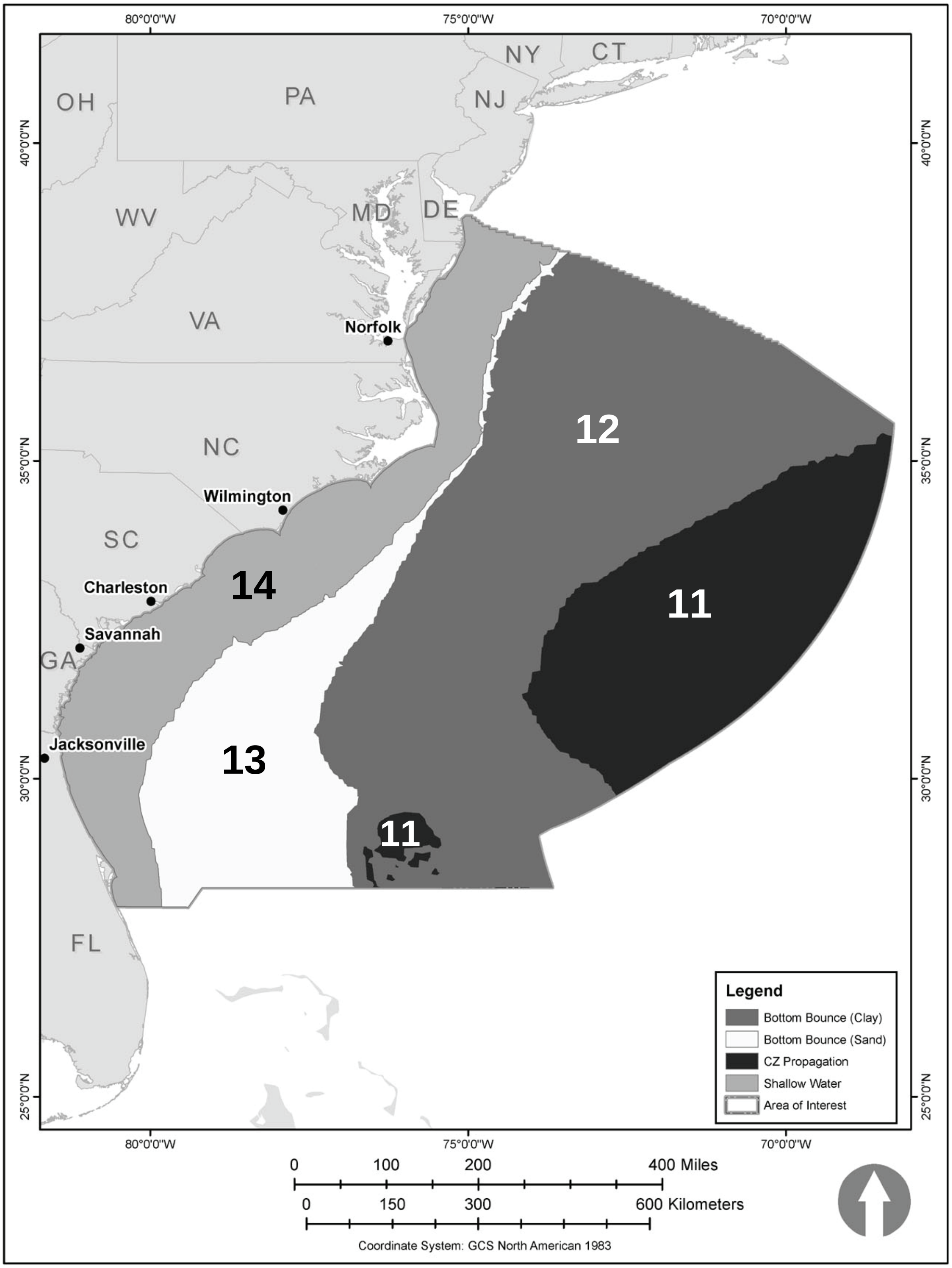


Figure E-13. Final Modeling Regions for the Summer.

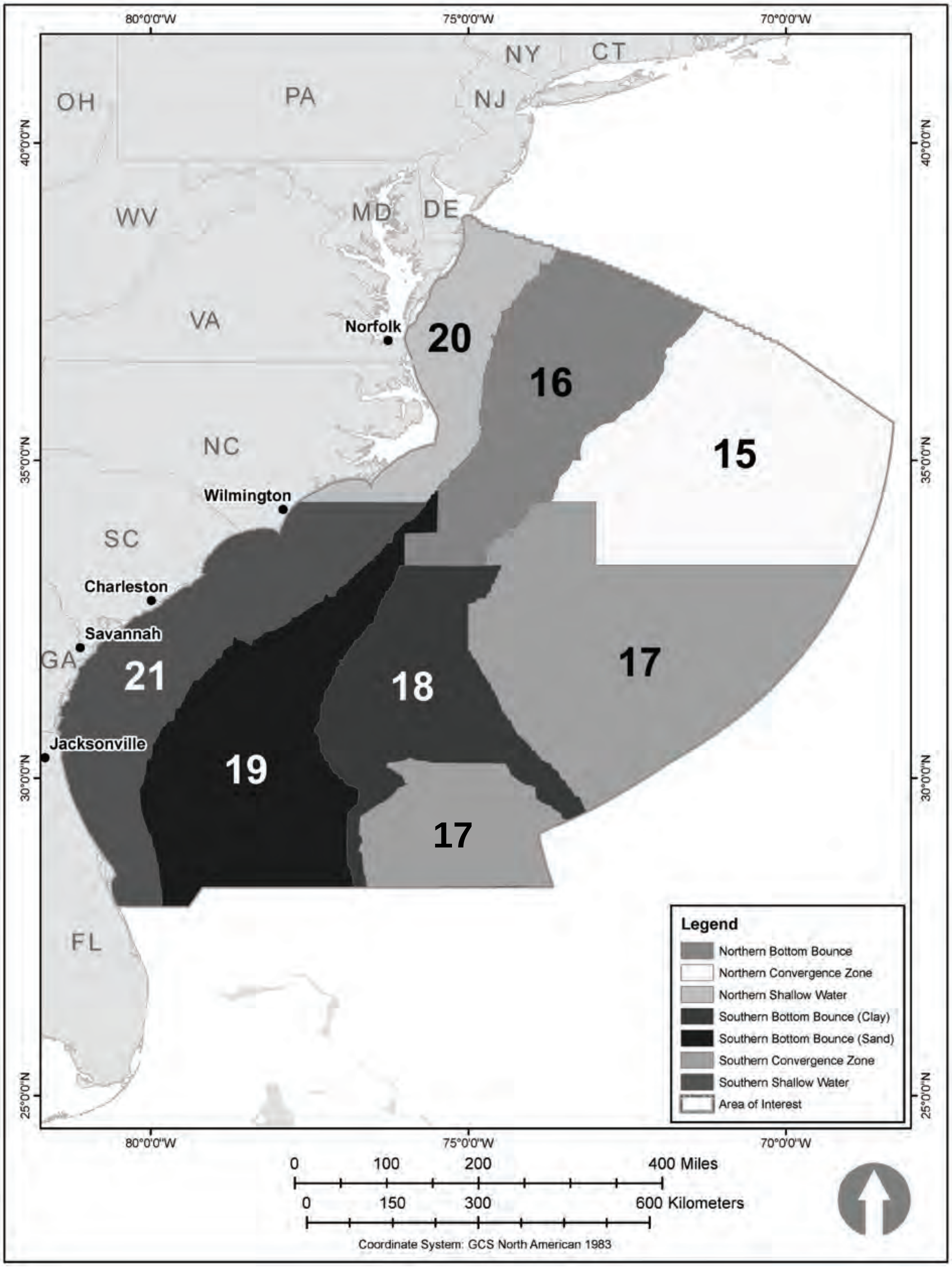


Figure E-14. Final Modeling Regions for the Fall.

5.2. SHALLOW WATER MODELING FOR MARINE MINERALS AND RENEWABLE ENERGY

The characterization of the acoustic propagation conducted in the previous section was designed to capture the variability and the general sound field structure produced by large and small airgun arrays used in support of oil and gas exploration and development throughout the proposed areas covered by this Programmatic EIS. However, acoustic modeling was also conducted to address the potential impacts for the active acoustic sound sources (e.g., side-scan sonars, boomers, chirp subbottom profilers, and single or multibeam depth sounders) used in conjunction with the other two programs covered by this Programmatic EIS, marine minerals and renewable energy. Not only do these programs use different acoustic systems than those typically used in oil and gas seismic surveys (i.e., airguns are not expected to be used), but these programs are only conducted in water nominally 100 m (328 ft) deep or less. This, therefore, limits their activities to the shallowest regions of the continental shelf, which are nominally within about 30 nmi (56 km) from the coast.

The location and depth of water used for these programs effectively constitutes a change in several of the basic assumptions made for the general characterization of the area including: (1) a significant change in the range of water depth covered; (2) a very large reduction in the area covered; (3) a concentration of the sources in waters that only allow strong and repeated interactions of the acoustic sound field with the ocean surface and bottom; (4) a change in signal type from multiple pulsed to nonpulse; (5) a significant change in the typical frequencies used by the systems; and (6) the utilization of systems using higher frequencies which allows finer acoustic beam patterns (and in general better special resolution of the areas being examined). The result of these differences was that an additional set of acoustic sites were added to the original 21 from the general characterization in order to examine and ensure that the propagation modeling in the shallow water for these two programs was adequate.

This subsequent shallow water characterization built on the existing work by using the seven shallow water sites (i.e., sites # 4, 5, 9, 10, 14, 20, and 21 as shown in **Table E-6**), and selecting two additional sites near the original "representative" location for that area. These new sites would therefore have the same SVP and propagation characteristics, but the additional stipulation was that these sites be located in 30 and 100 m (98 and 328 ft) water depths. By examining the propagation in these two water depths for each source used, the analysts would ensure that a conservative estimation of the sound propagation field (i.e., the larger impacts) was used in the impact analysis and that the potential for local variability in the bathymetry would not cause an underestimation of the potential impacts. Subsequent analysis has shown that variability of the impacts for all of the sources examined in this Programmatic EIS only varied a few percentage points (i.e., <5 percent) for the two water depths examined. Therefore, the use of the larger impact values were conservative, but not excessively so.

Table E-7 provides the details of the 14 additional shallow water sites used for this characterization.

Table E-7

Summary of Details of the Sites Identified in the Shallow Water Characterization

Modeling Region	Season	Propagation Characterization	Water Depth (m)	Original Region	Representative Location	Sediment	Grain Size Index
22	Winter	Southern Shallow Water	30	4	30-33N 80-38W	Sand	-1
23	Winter	Northern Shallow Water	30	5	36-10N 75-15W	Sand	-1
24	Spring	Bottom Bounce Shallow Water	30	9	32-18N 79-31W	Sand	-1
25	Spring	Moderately-ducted (Outer Banks) Shallow Water	30	10	34-48N 75-53W	Sand	-1
26	Summer	Shallow Water	30	14	36-10N 75-14W	Sand	-1
27	Fall	Southern Shallow Water	30	20	32-18N 79-31W	Sand	-1
28	Fall	Northern Shallow Water	30	21	36-10N 75-14W	Sand	-1
29	Winter	Southern Shallow Water	100	4	30-29N 80-10W	Sand	-1
30	Winter	Northern Shallow Water	100	5	36-06N 74-50W	Sand	-1
31	Spring	Bottom Bounce Shallow Water	100	9	32-00N 79-15W	Sand	-1
32	Spring	Moderately-ducted (Outer Banks) Shallow Water	100	10	34-42N 75-37W	Sand	-1
33	Summer	Shallow Water	100	14	36-06N 74-50W	Sand	-1
34	Fall	Southern Shallow Water	100	20	32-00N 79-15W	Sand	-1
35	Fall	Northern Shallow Water	100	21	36-06N 74-50W	Sand	-1

Note: These shallow-water modeling regions were re-ordered after the completion of the JASCO propagation modeling and may be in a different order than reported by JASCO in **Appendix D**. This was done to (1) mirror the order of the general regions these sites refine and (2) to group the model results by depth. All subsequent impact analyses and reported take numbers use this re-ordered numbering assignment.

6. MARINE MAMMAL ABUNDANCES AND DENSITIES

At the time of this analysis, the best available marine mammal density estimates for the Western Atlantic Ocean, and specifically for the BOEM Mid- and South Atlantic Planning Areas were the U.S. Navy's Navy Operating Area (OPAREA) Density Estimates (NODE) database (U.S. Dept. of the Navy, 2007b). These density estimates were based on the NMFS-Southeast Fisheries Science Center (SEFSC) shipboard surveys conducted between 1994 and 2006, and were derived using a model-based approach and statistical analysis of the existing survey data using the model DISTANCE (Buckland et al., 2001). The outputs from the NODE database are four seasonal surface density plots of the Western Atlantic Ocean for each of the marine mammal species occurring there. **Figure E-15** is an example of the fall surface density plots for the Atlantic spotted dolphins. The resolution or grid size in these plots is dependent on the amount of data available for each species. For a fairly common species, like the Atlantic spotted dolphin, the grid has a fairly high-resolution (i.e., each displayed grid box is approximately 10 nmi^2). Additionally, the actual density values for this species range from 0.0 (very light shading) to 3.6 animals per square nmi (darkest shading). The density gradations are specific to each plot, but the higher value for each gradation is used in the subsequent analysis. This figure has been overlaid with the boundaries of the seven fall acoustic model regions used in this analysis. For each of these seven regions, the average density was computed. The resulting densities for each species and all 21 modeling regions are presented in **Table E-8**.

An examination of **Figure E-15** shows that the existing NODE database does not provide data for the entire region of this Programmatic EIS; specifically, the most seaward areas of Regions 15, 17, and 18 show as white (i.e., no data was available). In instances like this, the general known densities were extrapolated outward to cover data-less areas. In this instance, the occurrence of this species appears to have a strong dependency on the location of the Gulf Stream, even when it moves offshore north of Cape Hatteras. Therefore, the extrapolation of the near-zero densities at the eastern edge of the known data appears reasonable. For more pelagic species, it is also reasonable to extend their relatively higher offshore densities into these areas without data.

It should be noted that while the U.S. Navy was creating the NODE database, NMFS was routinely consulted on the process, provided much of the data on which the analysis is based, and reviewed the resulting database. Additionally, the Atlantic data were used in the Final EIS for Atlantic Fleet Active Sonar Training (U.S. Dept. of the Navy, 2008). NMFS is currently developing new cetacean density maps that were not available at the time that the modeling for this Programmatic EIS was performed and have not become available during the 12-month period following the close of the 90-day public comment period. Even though those data were not available for incorporation into either the Draft or the Final Programmatic EIS, BOEM will use the CetMap and Underwater Sound Field Working Group (SoundMap) information for future G&G exploration permit reviews when the new CetMap cetacean density data and noise modeling from SoundMap becomes available.

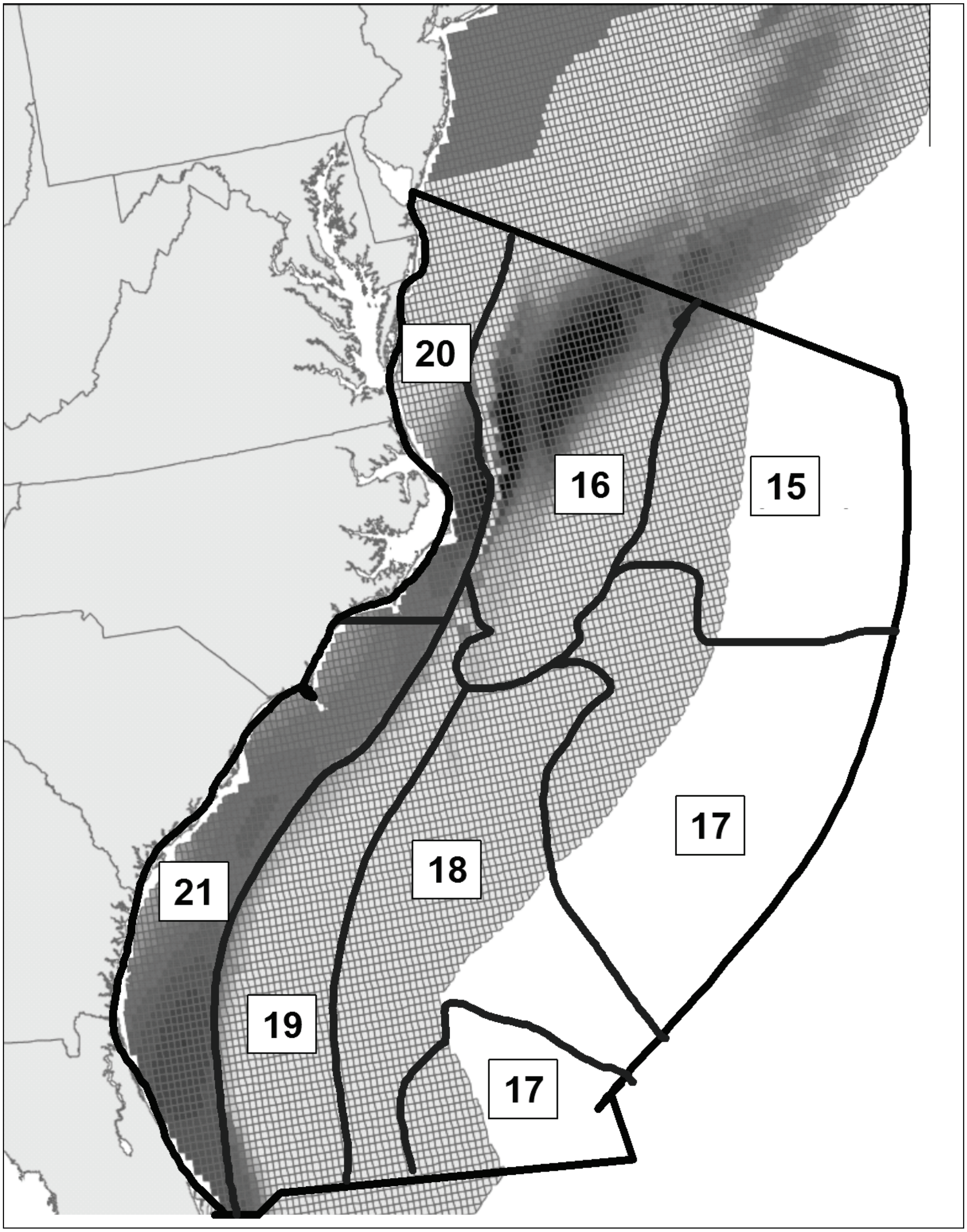


Figure E-15. Density Plot for Atlantic Spotted Dolphin for Fall Based on the Navy Operating Area Density Estimate Database (U.S. Dept. of the Navy, 2007b). Density Values Range from 0.0 (Very Light Shading) to 3.6 (Darkest Shading) (Animals/nmi2).

Table E-8

Marine Mammal Densities for the 21 Modeling Regions (animals/nmi^2)
(U.S. Dept. of the Navy, 2007b)

	Modeling Regions																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Mysticetes																					
Minke whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sei whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Bryde's whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Blue whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Fin whale	0.0001	0.0001	0.0005	0.0001	0.0001	0.0001	0.0001	0.0001	0.0005	0.0001	0.0001	0.0001	0.0005	0.0001	0.0001	0.0005	0.0001	0.0001	0.0001	0.0002	0.0001
North Atlantic right whale	0.0000	0.0000	0.0000	0.0038	0.0021	0.0000	0.0000	0.0000	0.0005	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0001
Humpback whale	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Odontocetes																					
Common dolphin	0.0547	0.0653	0.1808	0.0547	0.1808	0.0547	0.0653	0.1808	0.1808	0.0547	0.0547	0.0547	0.1808	0.1808	0.0547	0.1914	0.0547	0.0547	0.0547	0.1808	0.0547
Pygmy killer whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Short-finned pilot whale	0.0084	0.0826	0.1505	0.0018	0.0021	0.0025	0.0527	0.1490	0.0878	0.0019	0.0012	0.0527	0.0914	0.0296	0.0527	0.0100	0.0024	0.0839	0.0982	0.0014	0.0017
Long-finned pilot whale	0.0028	0.0207	0.0191	0.0000	0.0005	0.0008	0.0164	0.0213	0.0125	0.0006	0.0004	0.0164	0.0131	0.0052	0.0176	0.0033	0.0008	0.0194	0.0094	0.0005	0.0001
Risso's dolphin	0.0226	0.0451	0.0897	0.0239	0.0664	0.0014	0.0460	0.1104	0.0455	0.0005	0.0006	0.0880	0.1110	0.0447	0.0012	0.0882	0.0009	0.0230	0.0902	0.0236	0.0447
Northern bottlenose whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Pygmy sperm whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Dwarf sperm whale	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Atlantic white-sided dolphin	0.0017	0.0014	0.0008	0.0000	0.0013	0.0005	0.0005	0.0003	0.0003	0.0005	0.0005	0.0005	0.0003	0.0003	0.0005	0.0005	0.0005	0.0004	0.0002	0.0005	0.0001
Fraser's dolphin	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sowerby's beaked whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Blainville's beaked whale	0.0000	0.0032	0.0032	0.0000	0.0000	0.0000	0.0025	0.0028	0.0000	0.0000	0.0000	0.0021	0.0014	0.0000	0.0021	0.0028	0.0000	0.0021	0.0028	0.0000	0.0000
Gervais' beaked whale	0.0000	0.0032	0.0032	0.0000	0.0000	0.0000	0.0025	0.0028	0.0000	0.0000	0.0000	0.0021	0.0014	0.0000	0.0021	0.0028	0.0000	0.0021	0.0028	0.0000	0.0000
True's beaked whale	0.0000	0.0032	0.0032	0.0000	0.0000	0.0000	0.0025	0.0028	0.0000	0.0000	0.0000	0.0021	0.0014	0.0000	0.0021	0.0028	0.0000	0.0021	0.0028	0.0000	0.0000
Killer whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Melon-headed whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Harbor porpoise	0.0010	0.0008	0.0005	0.0000	0.0008	0.0005	0.0005	0.0003	0.0003	0.0005	0.0001	0.0001	0.0001	0.0001	0.0005	0.0005	0.0005	0.0004	0.0002	0.0005	0.0001
Sperm whale	0.0002	0.0138	0.0182	0.0001	0.0001	0.0002	0.0138	0.0093	0.0001	0.0001	0.0001	0.0183	0.0092	0.0001	0.0092	0.0184	0.0002	0.0002	0.0002	0.0001	0.0001
False killer whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Pantropical spotted dolphin	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223
Clymene dolphin	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106	0.0106
Striped dolphin	0.0269	0.2312	0.2312	0.0269	0.0332	0.0269	0.2092	0.0269	0.0269	0.0269	0.0269	0.0552	0.2092	0.0332	0.0495	0.2658	0.0269	0.0269	0.0269	0.0269	0.0269
Atlantic spotted dolphin	0.0021	0.2070	0.1870	0.2918	0.3168	0.0021	0.1570	0.0880	0.2019	0.2518	0.0021	0.1870	0.1970	0.3168	0.0221	0.2469	0.0021	0.0021	0.0121	0.2669	0.1918
Spinner dolphin	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Rough-toothed dolphin	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Bottlenose dolphin	0.0179	0.0413	0.2829	0.2829	0.0647	0.0179	0.2595	0.2946	0.0296	0.0296	0.0179	0.2595	0.3764	0.2743	0.0296	0.2946	0.0179	0.2829	0.3414	0.1816	0.2283
Cuvier's beaked whale	0.0001	0.0221	0.0222	0.0001	0.0001	0.0001	0.0173	0.0198	0.0001	0.0001	0.0001	0.0148	0.0100	0.0001	0.0148	0.0197	0.0001	0.0148	0.0197	0.0001	0.0001
Sirenians																					
West Indian manatee	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Pinnipeds																					
Hooded seal	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Harbor seal	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Gray seal	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

7. IMPACT MODELING APPROACHES

7.1. AIM Modeling and Methodology

The AIM is a four-dimensional (4D), individual-based, Monte Carlo-based statistical model designed to predict the exposure of receivers (e.g., an animal) to any stimulus propagating through space and time. The central component of AIM is the animat movement engine, which moves the stimulus source and animal receivers through four dimensions (time and space) according to user inputs. AIM uses external range-dependent stimulus propagation models (e.g., the Marine Operations Noise Model [MONM] model for this modeling effort) and additional propagation models can be integrated to accommodate any class of propagation stimuli, including acoustic or explosive signal.

To estimate how changing the acoustic source characteristics affects the acoustic exposure of animals, the AIM was utilized (Frankel et al., 2002). The AIM is strongly based on two earlier models: a whale movement and tracking model developed for the census of the bowhead whale (Ellison et al., 1987), and an underwater acoustic back-scattering model for a moving sound source in an under-ice Arctic environment (Bishop et al., 1987). Because the exact positions at which sound sources and animals (sound receivers for the purpose of this analysis) will occur during proposed future activities cannot be known, multiple runs of realistic predictions are used to bound the range of potential occurrences and provide statistical validity to the modeled predictions. The movement and/or behavioral patterns of sources and receivers can be modeled based on measured field data, and these patterns can be incorporated into the model. Each source and/or receiver is modeled via the “animat” concept, where each has parameters that control its speed and direction in three dimensions. In the case of the source, it is also imbued with the parameters describing its source operation over time (i.e., SL, signal duration, and spectral characteristics). It is also possible to simulate the type of diving pattern that an animal exhibits in the real world. Furthermore, the movement of the animat can be programmed to respond to environmental factors, such as water depth and sound level (this latter feature was not used in this analysis). In this way, species that normally inhabit specific environments can be constrained in the model to stay within that habitat.

Once the behavior of the animats has been programmed, the model is run. The run consists of a user-specified number of steps forward in time. For each time step, each animat is moved according to the rules describing its behavior. For each time step of the model run, the received sound levels at each receiver (i.e., each marine mammal) animat are calculated. For this analysis, AIM returns the movement patterns of the animats, and the received sound levels are calculated separately using the acoustic propagation predictions provided by JASCO (see details in **Appendix D**) for the different source types at different locations.

At the end of each time step, each animat “evaluates” its environment, including its 3D location, the time, and the received sound level (if anthropogenic sound is present). If an environmental variable has exceeded the user-specified boundary value (e.g., water too shallow), then the animat will alter its course to react to the environment. These responses to the environment are entitled “aversions.” There are a number of potential aversion variables that can be used to build an animat’s behavioral pattern. For this modeling effort they primarily consisted of bathymetric aversions and modeled area boundary aversions.

A separate simulation was created and run for each combination of location, movement pattern, and marine mammal species. Marine mammals were simulated by creating animats that were programmed with behavioral values describing dive depth, surfacing and dive durations, swimming speed, and course change. A minimum and maximum value for each of these parameters was specified. These data were extracted from the behavioral database. These data were used to simulate movements and dive characteristics of individual animats for each species or species group relative to the simulated vessel source tracks at both modeling locations.

After the animats’ movement patterns were defined, the animats were randomly distributed over each simulation area. The simulation area was delineated by four boundaries composed of a combination of latitude and longitude lines. These boundaries extend at least one degree of latitude or longitude beyond the extent of the vessel track to ensure an adequate number of animats in all directions, and to ensure that the simulation areas extended beyond the area where substantial behavioral reactions might be anticipated. Each simulation had approximately 4,000 animats representing each species. In most cases, this represents a higher density of animats in the simulation (0.1 animats/km^2) than occurs in the real environment. This "over-population" allowed the calculation of smoother distribution tails and in the final analysis, all results were normalized back to actual predicted population counts by species. During the AIM modeling, animats were programmed to remain within the simulation area boundaries. This behavior was incorporated to prevent the animats from diffusing out of the simulation, the result of which, if allowed, would be a systematic decrease in animat density over time. Thus, the simulations modeled the animals as a closed population with a high residency factor. This approach is clearly conservative in terms of allowing for more prolonged exposures than would be expected from species with a lower residency factor.

The AIM simulations created a realistic animal movement track for each animat and were based on the best available animal behavioral data. It was assumed that, collectively, the ~4,000 animat tracks derived for each simulation (area/species combination) were a reasonable representation of the movements of the animals in the population under consideration. Animat positions along each of these tracks were converted to polar coordinates (range and bearing) from the source to the receivers. These data, along with the depth of the receiver, were used to extract received level estimates from the acoustic propagation modeling results provided by JASCO for each source type. Specific to the modeling effort for this Programmatic EIS, the source levels, and therefore subsequently the received levels, include the embedded corrections for signal pulse length and M-weighting as discussed in **Appendix D**. For each bearing, distance, and depth from the source when it was operating at that site, the received level values were expressed as SPLs (rms) with units of dB re 1µ Pa.

Each animat's received levels were converted back to intensity and summed over the duration of the exercise to generate the integrated energy level. These were expressed in terms of dB re 1 μPa^2-sec or dB SEL. These exposure metrics were evaluated with the following criteria.

The acoustic threshold criteria, previously discussed in **Section 3.0** of this appendix, were then applied to the results of the AIM modeling, then the number of animats per species that exceeded each criterion was determined. These values were then scaled by the ratio of model-to-real world densities per species and corrected for the number of blocks or square kilometers modeled. These scaled values were reported as the predicted impact of each survey type, at each location, for each applicable source.

The output results from AIM provided the number of Level A and Level B harassment takes for each species, by season, modeled region, and survey type that exceed the specific threshold considered. These results will then be corrected to adjust for two parameters in the modeling: (1) the density of animats/animals in the modeled area; and (2) actual number of blocks that would be surveyed in each modeled region. The animal densities used in the AIM modeling are deliberately kept high to ensure that a statistically valid result is obtained. Typically, these "modeled" densities are at least an order of magnitude greater than the actual marine mammal density present in the region. Therefore, the modeling result is corrected or scaled by the ratio of the actual density divided by the modeled density. Similarly, the number of potential impacts is also scaled to derive a "per block survey" level of potential impacts. The predicted potential impacts can then be calculated by multiplying this value by the number of surveys of that type to be performed in that year, and summing the potential impacts to that species from all survey types combined.

7.2. AIM MODELING OF THE SOURCE MOVEMENT

For this assessment, the creation of each modeling simulation began with the creation of a movement pattern for the seismic airgun source vessel representing a different survey type. The seismic airgun survey types modeled included 2D, 3D, WAZ, VSP, and HRG. (Note that these last two surveys use the small array airgun only.) The parameters for each survey type are provided in **Table E-9**. The column labeled "Gridded" indicates whether the source movement pattern included both north-south (vertical) and east-west (horizontal) lines of travel (gridded=yes) or just east-west (horizontal) survey lines (grided=no).

The marine mineral and renewable energy programs also conduct HRG surveys, but these surveys are not expected to use airguns; they would use active acoustic sound sources such as boomer and chirp subbottom profilers, side-scan sonars, and multi-beam depth sounders. The details of how these sources were modeled in AIM are provided in **Table E-10**.

Table E-9

Seismic Airgun Source Vessel Parameters for AIM Simulations

Survey Type	Spacing of Horizontal and Vertical Lines (km)	Gridded?	Comments	Number of Blocks Modeled	Shot Interval (seconds)
2D	2.0 x (NA)	No		5 x 5 = 25	15
3D	1.0 x 1.0	Yes		2 x 2 = 4	15
Wide Azimuth (WAZ)	1.0 x 1.0	Yes	Use multiples of 3D surveys	2 x 2 = 4	15 (per survey)
Vertical Seismic Profile (VSP)	1.0 x 1.0	Yes	Use 3D surveys	1 x 2 = 2	15
High-Resolution Geophysical (HRG)	0.08 x NA	No	Uses small airgun	1 x 1 = 1	variable

The marine mineral and renewable energy programs also conduct HRG surveys, but those surveys are not expected to use airguns; they would use active acoustic sound sources such as boomer and chirp subbottom profilers, side-scan sonars, and multibeam depth sounders. The details of how these sources were modeled in AIM are provided in **Table E-10**.

Table E-10

Marine Mineral and Renewable Resource Source Vessel Parameters for AIM Simulations

Survey Type	Area Modeled (km)	Spacing of Horizontal and Vertical Lines (km)	Gridded?	Comments
Marine Mineral Exploration	1.8 x 1.8	0.03 x (NA)	No	Multiple electromechanical sources (no airguns)
Marine Mineral Exploration	1.8 x 1.8	0.2 x (NA)	No	Multiple electromechanical sources (no airguns)
Renewable Energy Hazard	3.5 x 3.5	0.15 x 0.15	Yes	Multiple electromechanical sources (no airguns)
Renewable Energy Exploration	2.1 x 2.0	0.03 x 0.15	Yes	Multiple electromechanical sources (no airguns)

7.3. AIM Modeling of the Animal Movement

7.3.1. Movement

Animals move through four dimensions: 3D space plus time. Several movement parameters are used in the model to produce a movement pattern that simulates real animal movements. A typical dive pattern is shown in **Figure E-16**. It consists of two phases: a shallow respiratory sequence, followed by a deeper, longer dive.

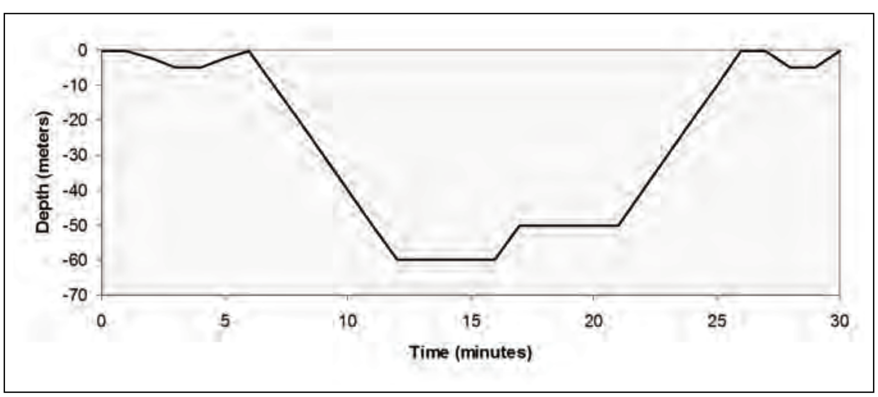
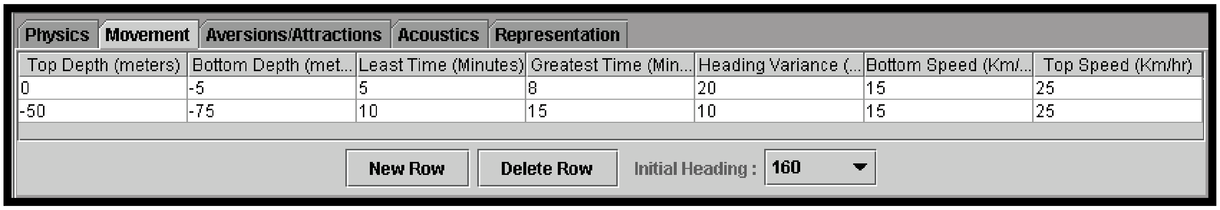


Figure E-16. Typical Dive Pattern.

These two phases are represented in the model with the values as input into the box in **Figure E-17**.


Physics | Movement | Aversions/Attractions | Acoustics | Representation

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

New Row | Delete Row | Initial Heading : 160

Figure E-17. Parameters Used to Specify the Typical Dive Pattern Shown in Figure E-16.

The top row has the values for the shallow, respiratory dives. In this case, the animal dives from the surface to a maximum depth of 5 m. The second row describes the second phase of the dive. In this phase the animal dives to a depth between 50 and 75 m (164 and 246 ft). In this example, the animal spends time at both 60 and 50 m (197 and 164 ft) before surfacing. The pattern then repeats.

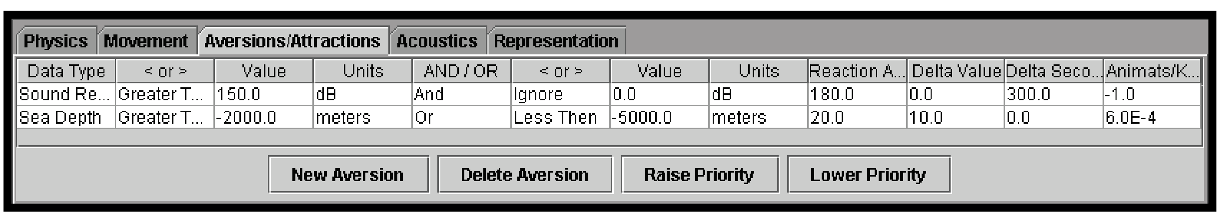
The horizontal component of the course is handled with the "heading variance" term. It allows the animal to turn up to a certain number of degrees at each movement step. In this case, the animal can change course 20 degrees on the surface, but only 10 degrees underwater. This example is for a narrowly constrained set of variables, appropriate for a migratory animal.

7.3.2. Heading Variance

There are few published data that summarize marine mammal movement in terms of heading variance, or the amount of course change per unit time. The default setting allows the course to deviate between 0 and 30 degrees per min.

7.3.3. Aversions

In addition to movement patterns, the animats can be programmed to avoid certain environmental situations. For example, this option can be used to constrain an animal to a particular depth regime. The following example (**Figure E-18**) constrains the animal to waters between 2,000 and 5,000 m (6,562 and 16,404 ft) deep. One modification was made for these simulations in the animal's habitat. Normally deep-water species were allowed to move into waters as shallow as 100 m (328 ft).


Physics | Movement | Aversions/Attractions | Acoustics | Representation

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

New Aversion | Delete Aversion | Raise Priority | Lower Priority

Figure E-18. Example Showing the Aversions to Limit an Animat to Waters between 2,000 and 5,000 m (6,562 and 16,404 ft).

7.3.4. Species Behavior Parameters

The specific animal behavioral parameters that were used in this analysis are provided below. Where the "Surfacing/Dive Angle" column is empty, there were no meaningful data available so, 75º was used as a default value. Under the "Speed Distribution" column, "Normal" indicates that the distribution of speed values between the limits was normally distributed. Under the "Depth Limit/Reaction Angle" column, the first number indicates the minimum depth limit in meters, and "reflect" indicates that if an animat moves to that shallow water limit, it will move away from the shallow water and back into deeper water.

7.3.4.1. Minke Whale

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Minke Whale	1/3	75°	20/100	2/6	Surface 45 Dive 20	1/18	Gamma (3.25,2)	10/reflect

Surface Time

A mean surface time of 1.72 min with a range of 0.63-2.35 min was reported for minke whales by Stern (1992).

Dive Depth

Dive depths for minke whales were inferred from other species, however reduced in maximum depth because minkes are likely to be pelagic feeders and feed on species found near the surface (Olsen and Holst, 2001).

Dive Time

The mean dive time for minke whales reported by Stern (1992) was 4.43 (±2.7) min. Dive times measured off Norway ranged from approximately 1-6 min (Joyce et al., 1989). Dive times also show small diel and seasonal variability (Stockin et al., 2001), but the variability is small enough to be considered not significant for AIM modeling. Dive times were non-normal, with dives of durations less than 1 min comprising at least 45 percent of all dives (Øien et al., 1990).

Speed

The mean speed value for minke whales in Monterey Bay was 4.5 (±3.45) knots (kn) (8.3 ±6.4 km/hr) (Stern, 1992). Satellite tagging studies have shown movement of up to 79 km/day (49 mi/day) (3.3 km/hr [2.1 mi/hr]). Minke whales being pursued by killer whales were able to swim at 15-30 km/hr (Ford et al., 2005).

A gamma function was fit to the available speed data. The modal speed of this function is 4.5 km/hr (2.8 mi/hr), matching the Stern (1992) data, and has a maximum of 18 km/hr (11 mi/hr), somewhat less than the maximum speed achievable (30 km/hr [19 mi/hr]), observed during predation. "Cruising" minkes have been reported at 3.25 m/s (10.66 ft/s) (Blix and Folkow, 1995).

Habitat

Minke whales in Monterey Bay were reported to be in a median depth of 48.6 m (159.4 ft) (Stern, 1992). They are known to move into very shallow water as well as deep oceanic basins. The 10-m (33-ft) limit and reflection aversion are intended to let minkes roam freely but to stay off the beach.

Group Size

A mean group size of 1.6 individuals was reported for minke whales in the Antarctic (Blix and Folkow, 1995).

Residency

Foraging minke whales have been shown to exhibit small-scale site fidelity (Morris and Tscherter, 2006). Therefore, course change parameters for foraging minke whales should be set to be variable to allow for small net movements.

7.3.4.2. Sei/Bryde's Whale

A paucity of data exists for sei and Bryde's whales. Data for the two species have been pooled to derive parameters for both species.

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Sei/Bryde's Whale	1/1	90/75°	10/40 (80) 50/267 (20)	2/11	30/300 (50%) 90/300 (50%)	1/20	5/1

Surface Time

No direct data for these species were available; fin whale values were used.

Dive Depth

A limited number of Bryde's whales have been tagged with time-depth recorders (TDRs) (Alves et al., 2010). Shallow dives less than 40 m (131 ft) were recorded 85 percent of the time, while deep dives occurred 15 percent of the time. The maximum dive depth reported was 267 m (876 ft).

Two distinct dive types were noted for Bryde's whales. The whales were observed to make a long series of shallow dives of less than 40 m (131 ft) until 1.5 hr before sunset. During the night, sequential deep dives took place, with foraging lunges recorded during about half of these nighttime dives.

Dive Time

Sei whale dive times ranged between 0.75 and 11 min, with a mean duration of 1.5 min (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 s and 15 min. The maximum dive time reported for two Bryde's whales was 9.4 min (Alves et al., 2010) with mean durations of 4-6 min.

Heading Variance

Observations of foraging sei whales showed 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 4.6 km/hr (2.9 mi/hr) (Brown, 1977). The highest speed reported for a Bryde's whale was 20 km/hr (Cummings, 1985). A Bryde's whale being attacked by killer whales traveled ~9 km in 94 min, with most of the travel occurring in first 50 min, producing an estimated speed of 10.8 km/hr (6.7 mi/hr) (Silber et al., 1990). The maximum speed of sei whales reported from a satellite tracking study was 7.6 m/s (25 ft/s), although the distribution of speeds was highly skewed toward lower values (Olsen et al., 2009). The speed parameters used in AIM are 0-20 km/hr (0-12.4 mi/hr), using a gamma distribution with alpha and beta parameters of 5 and 1. These values produce the following distribution, which covers the reported range of speed (Olsen et al., 2009) and approximated the mean value reported by Brown (1977).

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.

Group Size

Sei whales in the Gulf of Maine were seen in groups of 1-6 animals, with a mean group size of 1.8 whales (Schilling et al., 1992). Bryde's whales in the Gulf of California were seen in groups of 1-2 animals, with a mean size of 1.2 whales (Silber et al., 1994).

7.3.4.3. Blue Whale

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Blue Whale (non-foraging)	1/2	75^o	20/100	2/18	30/300 (50%) 90/300 (50%)	3/14	Norm.	100/reflect
Blue Whale (foraging)	1/2	75^o	20/100 (50) 100/300 (50)	2/18 4/18	30/300 90/90	3/14	Norm.	100/reflect

Surface Time

Surface intervals for one of four satellite-tagged blue whales ranged from 7-90 s, with a mean of 48 s. Intervals >60 s were not reported for the other three individuals, indicating that the surface time was short (Lagerquist et al., 2000).

Dive Depth

Croll et al. (2001) reported a mean dive depth of 140 (±46.01) m (459 [±151] ft) for non-foraging animals, while foraging whales had a mean dive depth of 67.6 (±51.46) m (221.8 [±168.8] ft). Satellite-tagged whales off California had a maximum dive depth of 192 m (630 ft) (Lagerquist et al., 2000). The distribution of dive depths was bimodal (note that this is reported from one animal). The maximum dive depth reported for a series of blue whales with "crittercams" attached to them off California and Mexico was 293 m (961 ft) (Calambokidis et al., 2008). Many of these animals had deep feeding dives, with lunges occurring 200-260 m (656-853 ft). Notably, one animal transitioned from deep feeding dives of decreasing depth as the sun set to shallow non-feeding dives, which indicated that there may be a diurnal character to some blue whale behavior.

Separate animats for foraging and non-foraging blue whales were created. Foraging animats will have a 50:50 distribution between deep dives (200-300 m [656-984 ft]) and shallower dives (20-100 m [66-328 ft]).

Dive Time

Mean dive times of 4.3, 7.8, 4.9 5.7, 10, and 7 min have been reported for blue whales (Laurie, 1933; Doi, 1974; Lockyer, 1976; Croll et al., 1998; Croll et al., 2001). The best estimate of the maximum dive time is 14.7 min (Croll et al., 2001), although a maximum time of 30 min was reported by (Laurie, 1933). The longest dive reported for satellite-tagged whales was 18 min, although the mean dive time for all whales was 5.8 (±1.5) min (Lagerquist et al., 2000).

Speed

Dive descent rates of 1.26 m/s (4.13 ft/s) have been recorded (Williams et al., 2000). A mean surface speed of 1.25 m/s (4.10 ft/s) with a maximum speed of 2.0 m/s (6.6 ft/s) was reported from satellite tags (Mate et al., 1999), although satellite data tend to smooth the track and therefore underestimate speed. A second satellite tag study found straight-line speed (under) estimates from 1.3-14.2 km/hr (0.8-8.8 mi/hr).

Group Size

Blue whales in the eastern tropical Pacific had a modal group size of one, although pods of two were somewhat common (Reilly and Thayer, 1990). The mean size of blue whale (*B. m. brevicauda*) groups off Australia was 1.55 (Gill, 2002).

7.3.4.4. Fin Whale

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Fin Whale	1/1	75°	20/250 (90) 250/470 (10)	5/8 1/20	20	1/16	Norm.	30/reflect

Surface Time

Remarkably good data for surface times exist for fin whales. A log survivorship analysis of all inter-blow intervals was used to determine an inflection point of 28 and 31 s between surface and dive activity for feeding and non-feeding animals, respectively (Kopelman and Sadove, 1995). The mean surface duration for fin whales without boats present off Maine was 54.63 s (standard deviation [SD]=59.61) while dive times were 200.84 s (SD=192.91) (Stone et al., 1992).

Dive Depth

Foraging fin whales had mean dive depths of 97.9 ±32.59 m, while traveling fin whales had mean dive depths of 59.3 ±29.67 m (Croll et al., 2001). Migrating fin whales were determined to have a maximal dive depth of 364 m (1,194 ft), (Charif et al., 2002). Fin whales in the Mediterranean Sea typically dove to ~100 m (~382 ft) and occasionally dove to 470 m (1,542 ft) or more (Panigada et al., 1999), however these are unusually deep dives. The animats here model the more typical dive pattern 90 percent of the time. Foraging fin whales off California had a mean maximum dive depth of 248 m (814 ft) (Goldbogen et al., 2006). Based on this study, the most frequent AIM dive depth is extended to 250 m.

Dive Time

Foraging fin whales had mean dive times of 6.3 ±1.53 min, while traveling fin whales had mean dive times of 4.2 ±1.67 min (Croll et al., 2001). The maximum dive time observed was 16.9 min. Fin whales off the east coast of the U.S. were observed to have mean dive times of 2.9 min. Ranges for feeding animals ranged from 29-1,001 s, while non-feeding animals had longer dives between 32 and 1,212 s (Kopelman and Sadove, 1995). Panigada et al. (1999) found that shallow (<100 m [<328 ft]) dives had a mean dive time of 7.1 min, while deeper dives had dive times of 11.7 and 12.6 min. Fin whales foraging on Jeffrey's Ledge in the Gulf of Maine had mean dive times of 5.83-5.89 min (Ramirez et al., 2006).

Speed

Watkins (1981) reported a mean speed of 10 km/hr (6 mi/hr) ranging from 1-16 km/hr (0.6-10 mi/hr) with bursts of 20 km/hr (12 mi/hr) reported. Mean descent speeds of 3.2 m/s (10.5 ft/s) (SD=1.82) and ascent speeds of 2.1 m/s (6.9 ft/s) (SD=0.82) have been reported from fin whales in the Mediterranean (Panigada et al., 1999).

Habitat

Fin whales are found feeding on shallow banks and in bays (Woodley and Gaskin, 1996) as well as in the abyssal plains of the ocean (Watkins, 1981). Fin whales are allowed to move into shallow water in AIM, with a 30-m (98-ft) inshore limit to keep them out of the very shallow waters.

Group Size

Mean group size for fin whales in the Gulf of Mexico was 5.7 whales, with group size ranging from 1-50 whales (Silber et al., 1994). Mean group size in the Mediterranean Sea over a number of years was 1.75 animals (Panigada et al., 2005).

7.3.4.5. North Atlantic Right Whale

Model Parameters

	Min/Max Surface Time (min)	Surface/ Dive Angle	Dive Depth (m) Min/Max (percentage)	Min/ Max Dive Time (min)	Heading Variance (angle/time)	Min /Max Speed (km/h)	Speed Distribution	Depth Limit/ Reaction Angle
Right Whale Feeder	4/5	75	113/130 (50) 113/130 (50)	11/13 11/13	90/90 30/90	3/6	Normal	5/reflect
Right Whale Migrator	1/1	75	10/200 (10) 10/35 (90)	1/10 1/7	90/60 30/300	1/8	Normal	5/reflect
Right Whale Breeding	1/5	75	10/50 (50) 10/50 (50)	5/10 5/10	30/300 90/90	0/5	Normal	5/reflect

Surface Time

Mean surface time for right whales reported by Winn et al. (1995) was less than 60 s; therefore, a 1-min surface time was used for AIM for migrating whales.

Mean surface intervals for wintering right whales reported for shallow and deep dives was 0.91 and 2.44 min, respectively (Nousek McGregor, 2010). Thus, the surface interval for wintering right whales was set to vary between 1 and 3 min.

Dive Depth

Right whale feeding dives in the northwest Atlantic were characterized by rapid descent to depths between 80 and 175 m (262 and 574 ft). The median depth was 119 m (390 ft), with a 90 percent confidence interval between 113 and 130 m (371 and 427 ft) (Baumgartner and Mate, 2003). This 90 percent confidence range was used for the dive depth range. In a nearby area, right whales dove to depths between approximately 120 and 180 m (394 and 591 ft) (Nowacek et al., 2004).

Wintering right whales are most often found in shallow water. The observed distribution of dive depths was bimodal, showing a separation between dives less than and greater than 10 m (33 ft). The overall mean was 7.96 m (26.1 ft), approximately 9.8 m (32.1 ft) above the seafloor (Nousek McGregor, 2010). Therefore, the range of dive depths for AIM animats was set to vary between 2 and 25 m (6.6 and 82 ft).

Dive Time

The median dive time for foraging right whales was 12.65 min, with a 95 percent confidence interval of 11.4-12.9 min (Baumgartner and Mate, 2003).

Mean dive durations for wintering right whales were 1.83 min for shallow dives and 6.58 min for deep dives (Nousek McGregor, 2010). Therefore, the AIM animat dive times were allowed to vary between 1 and 8 min.

Speed

Descent speed of diving right whales had a 95 percent confidence interval of 1.3-1.5 m/s (4.3-4.5 ft/s) while the ascent speed was 1.4-1.7 m/s (4.6-5.6 ft/s) (Baumgartner and Mate, 2003). Radio-tagged whales that remained in the Bay of Fundy had a mean speed of 1.1 km/hr, while those that left the bay had a mean speed of 3.5 km/hr (2.2 mi/hr) (Mate et al., 1997). Note that radio tagging tends to underestimate whale speed because the data greatly smooth the recorded course of the animal.

Habitat

Northern right whales are currently found in the northwest Atlantic Ocean and the North Pacific. In the North Atlantic, they are found offshore eastern Canada and the U.S. northeast coast during the summer foraging season. They migrate along the coast to a breeding area in the shallow waters offshore of Florida and Georgia. It is believed that a portion of the population migrates to an undiscovered location.

Group Size

The group size of surface active groups (SAGs) in the Bay of Fundy ranged from 2-15 animals (Parks and Tyack, 2005).

7.3.4.6. Humpback Whale (Feeding)

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Feeding Humpback Whale	1/2	75^{o}	10/60 (20) 40/100 (75) 100/150 (5)	5/10	90/300 90/90 90/90	1/8	Norm.	(Min = 100)/ reflect

Surface Time

Approximately 65 percent of all surface times for humpback whales observed in Alaska were 2 min in length or less (Dolphin, 1987a). Surface times in Hawaii are similar with the exception of surface active groups (Frankel, pers. obs.).

Dive Depth

Humpback whale dive depths have been measured on the feeding grounds. Seventy-five percent of their dives were to 40 m (131 ft) or less with a maximum depth of 150 m (492 ft) (Dolphin, 1988). Dive depth appears to be determined by prey distribution. Whales in this study were primarily foraging upon euphausiids. There is also a strong correlation of dive depth and dive time and is described by the following equation (Dolphin, 1987a):

$$\text{Time (s)} = 0.52 * \text{depth (m)} + 3.95,\ r^2 = 0.93$$

Feeding humpbacks off Kodiak Alaska had a mean maximum depth of 106.2 m (348 ft) with 62 percent of the dives occurring between 92 and 120 m (302 and 394 ft) with a maximum of ~160 m (~348 ft) (Witteveen et al., 2008). The humpbacks appeared to be feeding largely on capelin and pollock.

There are strong differences in the data between these two studies. This difference may reflect the distribution of prey rather than behavioral abilities of the whales.

Dive Time

The maximum of the continuous portion of the distribution of dive times was 15 min (Dolphin, 1987a). The distribution was skewed toward shorter dives. Several dive steps can be programmed in AIM to capture this variability.

Heading Variance

Satellite tracking of feeding humpback whales in the Southern Ocean showed very erratic travel, and animals frequently remained in a specific area for up to a week at a time. There were periodic movements between feeding areas (Dalla Rosa et al., 2008). Therefore, the heading variance for feeding humpbacks was set relatively high, for 80 percent of the time. Twenty percent of the time the heading variance was set as low to simulate movement between feeding areas.

Speed

Mean speeds for humpbacks are near 4.5 km/hr (2.8 mi/hr). The measured range is 2-11.4 km/hr (1-7 mi/hr) (excluding stationary pods) (Gabriele et al., 1996). Feeding humpbacks in the Southern Ocean had mean measured speeds between 2.26 and 4.03 km/hr (1.4 and 2.5 mi/hr) (Dalla Rosa et al., 2008). These values were derived from short segments of satellite tracking data; therefore, they are likely underestimates of speed.

Ascent rates during dives range from 1.5-2.5 m/s (4.8-8.2 ft) while descent rates range between 1.25 and 2 m/s (4.1 and 6.6 ft/s) (Dolphin, 1987b). The mean speed for all pod types in Glacier Bay was 3.31 km/hr (1 mi/hr) (Baker and Herman, 1989).

Habitat

Migrating humpbacks swim both along the coast (California population) as well as through the abyssal plains. Humpbacks swim along coastal regions are known to swim further offshore than gray whales. Therefore, the minimum depth for this species has been set at 100 m (328 ft).

Group Size

Ninety-six percent of 27,252 pods in the Gulf of Maine were composed of 1-3 animals with a modal size of one adult (Clapham, 1993).

7.3.4.7. Humpback Whale (Winter Grounds: Singer)

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Humpback Singer	1/1	75°	10/25	5/25	20	0/1	Norm.	>1,000/reflect

Surface Time

Singers typically surface for <1 min. Singers in the Caribbean blew between 2 and 8 times per surfacing (Chu, 1988).

Dive Depth

Humpback singers have relatively shallow depths.

Dive Time

Dive times typically range from 10-25 min. Observations of 20 singers in the Caribbean found dive times between five and 20 min in duration (Chu, 1988).

Heading Variance

The heading variance is set very low for singers. While traveling very slow to stationary, they tend to swim along the coast.

Speed

Most singers are stationary although very few move at high speeds.

Habitat

On the wintering grounds most singers are found within the 100-fathom contour, but a few are found in deeper waters.

Group Size

The vast majority of singers are found alone. The largest pod reported containing a singer was four animals (Frankel et al., 1995).

7.3.4.8. Humpback Whale (Migrating)

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Migrating Humpback Whale	1/2	75°	10/40	5/10	10	2/10	Norm.	(Min =100)/ reflect

Dive Depth

Humpback whale dive depths have been measured on the feeding grounds. Seventy-five percent of their dives were to 40 m (131 ft) or less (Dolphin, 1988). It is likely that migrating animals would also predominantly dive to these shallow depths. Humpbacks foraging off California had a mean maximum dive depth of 156 m (512 ft) (Goldbogen et al., 2008).

Dive Time

Surface times range between 1 and 2 min while dive times range between 5 and 10 min (Gabriele et al., 1996). Foraging humpbacks off California had mean dive times of 7.8 ±2.0 min (Goldbogen et al., 2008).

Heading Variance

The heading variance was set very low for migrating animals. Most non-competitive group breeding animals also have linear travel. Migrating humpbacks swam very close to magnetic north from Hawaii with very little deviation (Mate et al., 1998).

Speed

Mean speeds for humpbacks are near 4.5 km/hr (2.8 mi/hr). The measured range is 2-11.4 km/hr (1.2-7.1 mi/hr) (excluding stationary pods) (Gabriele et al., 1996). Satellite tracked migrating humpback whales moved at a minimum of 150 km/day (93 mi/day) (6.25 km/hr [3.9 mi/hr]) for a mother and calf pod, while another two whales moved 110 km/day (68 mi/day) (4.5 km/hr [2.8 mi/hr]). Humpbacks off Australia were estimated to migrate at a mean speed of 8 km/hr (5 mi/hr), with a range between 4.8 and 14.2 km/hr (3 and 9 mi/hr) (Chittleborough, 1953). More recent studies of Australian humpbacks found a mean northern migration speed of 5.47 km/hr (3.4 mi/hr), while the southern migration speed had a mean of 5.02 km/hr (3.12 mi/hr) for non-calf pods, while calf pods had mean speeds of 5.03 and 4.25 km/hr respectively (Chaudry, 2006).

Habitat

Migrating humpbacks swim both along the coast (California population) as well as through the abyssal plains. Humpbacks swim along coastal regions are known to swim further offshore than gray whales. Therefore, the minimum depth for this species has been set at 100 m (328 ft). Non-calf pods migrating off Australian had a mean offshore distance of 3,177 m (10,423 ft) during the northern migration and 2,560 m (8,399 ft) during the southern migration. Calf pods migrated “significantly” closer inshore (Chaudry, 2006).

7.3.4.9. Common Dolphin

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Common Dolphin	1/1	75°	50/200	1/5	30	2/9	Norm.	100-1,000/ reflect

Dive Depth

Dive depths are reported to be between 50 and 200 m (164 and 656 ft) (Evans, 1994).

Dive Time

The maximum dive time reported was five min (Heyning and Perrin, 1994).

Speed

The maximum sustainable speed for common dolphins was measured at 2.5 m/s (8.2 ft/s) (9 km/hr [5.6 mi/hr]) (Hui, 1987).

Habitat

Common dolphins off the northeast United States were concentrated along the shelf edge between 100 and 200 m (328 and 656 ft) (Selzer and Payne, 1988). In the Mediterranean common dolphins were found in waters between 25 and 1,300 m (82 and 4,265 ft) deep with 95 percent of the animals in water between 247 and 326 m (810 and 1,070 ft) (Cañadas et al., 2002).

Group Size

Common dolphins in the Gulf of California were found in groups of 4-1,100 animals, with a mean size of 254.3 dolphins (Silber et al., 1994). Off the Pacific Coast of Costa Rica, the mean group size was 220.67 (SD=220.6) (May-Collado et al., 2005).

7.3.4.10. Blackfish: False Killer Whale, Pygmy Killer Whale, Melon-headed 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.

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
False/Pygmy killer whales	1/1	75°	5/50 (80) 50/100 (20)	2/12	30	2/22.4	Gamma.	200/reflect

Surface Time

Individual melon-headed whales spend less than one min on the surface although the group may remain near the surface for long periods of time (Frankel, pers. obs.).

Dive Depth

The maximum dive depth of a single false killer whale off the Madeira Islands was 72 m (236 ft). Most of the time was spent at depths deeper than 20 m (66 ft) and the dives were V-shaped (Alves et al., 2006). Three false killer whales in Hawaii had shallow dives as well with maximum depths of 22, 52, and 53 m (72, 171, and 174 ft) (Ligon and Baird, 2001). It should be noted that these animals were feeding on fish.

Dive Time

No directly measured data were available for "blackfish" whales so data from pilot whales was used for dive time.

Speed

Maximum speed recorded for false killer whales was 28.8 km/hr (17.9 mi/hr) (Rohr et al., 2002), although the typical cruising speed is typically 20-24 percent less than the maximum speed (Fish and Rohr, 1999). This "typical" maximum of 22 km/hr (14 mi/hr) was used as the maximum speed for AIM.

Habitat

False killer whales off the Madeira Islands were found in water depths from 900 to 2,000 m (900 to 6,562 ft) (Alves et al., 2006).

Group Size

False killer whales in the Gulf of Mexico had group sizes between 20 and 35 (mean=27.5, standard error [SE]=7.5, n=2) (Mullin et al., 2004). False killer whales off Costa Rica had a mean group size of 36.16 (±52.38) (May-Collado et al., 2005).

7.3.4.11. Shortfin and Longfin Pilot Whales

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Pilot Whales	1/1	75^o	5/100 (80) 10/1,000 (20)	1/10 5/21	30	2/12	Norm.	200/reflect

Surface Time

A rehabilitated long-finned pilot whale in the North Atlantic was equipped with a satellite tag and a TDR. The log survivorship plot of dive time from this animal had an inflection point at about 40 s (Mate et al., 2005). The authors did not feel that this qualified as a breakpoint to separate surface and dive behavior. However, it does suggest that most surface intervals are less than one min.

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 m (52 ft). However, at night, they dove to maximum depths of 360 and 648 m (1,181 and 2,126 ft) with mean depth of 308 and 416 m (1,011 and 1,365 ft) (Baird et al., 2002). Rehabilitated long-finned pilot whales dove to 312 m

(1,024 ft) on Georges Bank which has a depth of 360 m (1,181 ft), so these values should not be taken as the maximum. The distribution of dive depths was also skewed toward lower values (Nawojchik et al., 2003).

Short-finned pilot whales off the Canary Islands had maximum depth of 1,019 m (3,343 ft) (Aguilar Soto et al., 2008). The majority of these were to depths of less than 100 m (328 ft) while the remainder of depths were approximately evenly distributed between 100 and 1,000 m (328 and 3,281 ft).

Dive Time

Baird et al. (2002) reported on dives of two individual long-finned pilot whales and dive times varied between 2.14 and 12.7 min during the night. During the day animals spent all of their time in the top 16 m (52 ft).

A rehabilitated long-finned pilot whale in the North Atlantic had dive times between 1 and 6 min (Mate et al., 2005). Other rehabilitated long-finned whales were reported to dive to at least 25 min although the distribution is skewed toward shorter dives with most lasting about two min (Nawojchik et al., 2003). Long-finned pilot whales off the Faroe Islands never dove longer than 18 min (Heide-Jørgensen et al., 2002).

Short-finned pilot whales off the Canary Islands had maximum foraging dive times of 21 min (Aguilar Soto et al., 2008). They demonstrated a near-linear relationship between dive depth and dive duration. Therefore shallow dives had times ranging between 1 and 10 min, while deep dives were set to have times between 5 and 21 min.

Speed

Shane (1995) reported a minimum speed of 2 km/hr (1.24 mi/hr) and a maximum of 12 km/hr (7.5 mi/hr) for pilot whales. During the day in the Mediterranean, animals slowly swam, with mean values for two animals of 2.85 and 3.18 km/hr (1.8 and 2 mi/hr), while at night, they swam faster at 6.83 and 5.48 km/hr (4.24 and 3.4 mi/hr) (Baird et al., 2002). A single satellite tracked long-finned pilot whale had a minimum speed of 1.4 km/hr (0.9 mi/hr) (Mate et al., 2005). The speed of traveling pilot whales (*G. scammoni*) was estimated at 4-5 kn (Norris and Prescott, 1961, cited in Mate et al., 2005). Vertical dive speeds of three TDR tagged long-finned pilot whales ranged from 0.79-3.38 m/s (2.6-11.1 ft/s) with a mean of 1.99 m/s (6.5 ft/s) (Heide-Jørgensen et al., 2002).

Habitat

The minimum water depth for pilot whales in the Gulf of Mexico was 246 m (807 ft) (Davis et al., 1998), while off of Spain, they preferred water deeper than 600 m (1,969 ft) (Cañadas et al., 2002).

Group Size

Short-finned pilot whales in the Gulf of Mexico ranged in group size between 5 and 50 (mean=20.4, SE=3.6, n=11) (Mullin et al., 2004). Off the Pacific Coast of Costa Rica the mean group size of pilot whales was 14.22 individuals (SD=12.06) (May-Collado et al., 2005).

7.3.4.12. Risso's Dolphin

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Risso's Dolphin	1/3	75^{o}	150/1,000	2/12	30	2/12	Norm.	150/reflect

Dive Depth

Dive depths of 150-1,000 m (492-3,281 ft) were inferred from the squid-eating habits of Risso's dolphins and from similar species.

Dive Time

No data on dive times 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 ranging between 2 and 12 km/hr (1.24 and 7.5 mi/hr) (Shane, 1995).

Habitat

Risso's dolphins in the Gulf of Mexico were seen in water deeper than 150 m (492 ft), most often observed between 300 and 750 m (984 and 2,461 ft) (Davis et al., 1998). Off Chile Risso's dolphins were seen in waters deeper than 1,000 m (3,281 ft) (Olavarria et al., 2001), and off Spain they were found deeper than 600 m (1,969 ft) (Cañadas et al., 2002). In all cases this association seems to be driven by the local oceanographic upwelling conditions that increase primary productivity.

Group Size

In the Pacific, group sizes were measured between 1 and 220 animals with a geometric mean of 10.7. An estimated 76.4 percent of the groups contained fewer than 20 animals (Leatherwood et al., 1980). Group sizes in the Gulf of Mexico ranged between 2 and 78 animals, with a mean of 12.7 (SE=2.0, n=39) (Mullin et al., 2004). Mean group size off the Pacific Coast of Costa Rica was 11.57 (SD=9.64) (May-Collado et al., 2005).

7.3.4.13. Large Beaked Whales

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Berardius	1/7	75°	800/1,453 (90) 50/200 (10)	48/68 12/70	30/300 (50) 90/300 (50)	3/6	Norm.	253/reflect

Surface Time

Surface times in Arnoux's beaked whales ranged from 1.2-6.8 min (Hobson and Martin, 1996). Sowerby's beaked whales had surface times of 1-2 min, during which they would blow 6-8 times (Hooker and Baird, 1999a).

Dive Depth

Minimum and maximum dive depths measured for a beaked whale were 120 and 1,453 m (394 and 4,767 ft), respectively (Hooker and Baird, 1999b). *Ziphius* tagged off the Canary Islands had foraging dives between 824 and 1,267 m (2,703 and 4,157 ft), while Blainsville's beaked whales dove to depths between 655 and 975 m (2,149 and 3,199 ft) (Johnson et al., 2004).

Northern bottlenose whales performed shallow dives with a range of 41-332 m (135-1,089 ft) (n=33), while deep dives ranged from 493-1,453 m (1,617-4,767 ft) (n=23). Dive depth and dive duration were strongly correlated (Hooker and Baird, 1999b).

Blainsville's beaked whales in Hawaii performed dives to mid-water depth (100-600 m [328-1,969 ft]) approximately six times more frequently than at night. Dives deeper than 800 m (2,625 ft) had no diurnal difference (Baird et al., 2008).

Dive Time

Minimum and maximum dive times recorded for beaked whales were 16 and 70.5 min, respectively (Hooker and Baird, 1999b). Dives ranging between 12 and (at least) 28 min for Sowerby's beaked whales were recorded in the Gully in Canada (Hooker and Baird, 1999a). Modal dive times between 35-65 min (mean=46.4 min, SD=13.1), with a maximum dive time of at least 70 min, were reported for Arnoux's beaked whale (Hobson and Martin, 1996). Tagging results with Cuvier's beaked whale showed one animal diving for 50 min (Johnson et al., 2004). *Mesoplodon stejnegeri* were observed to dive for "10-15 min" in Alaska (Loughlin, 1982).

Blainsville's beaked whales and Cuvier's beaked whales both regularly dove for 48-68 min on deep dives (>800 m [>2,625 ft]) (Tyack et al., 2006).

Heading Variance

Sowerby's beaked whales surfacing in the Gully were reported to have no apparent orientation, and would change orientation up to 180° between surfacing (Hooker and Baird, 1999a).

Speed

Dive rates averaged 1 m/s (3.3 ft/s) or 3.6 km/hr (2.2 mi/hr) (Hooker and Baird, 1999b). A mean surface speed of 5 km/hr (3 mi/hr) was reported by (Kastelein and Gerrits, 1991).

Habitat

The minimum sea depth in which beaked whales were found in the Gulf of Mexico was 253 m (830 ft) (Davis et al., 1998). In the Gully in Canada, Sowerby's beaked whales were found in water ranging from 550-1,500 m (1,804-4,921 ft) in depth (Hooker and Baird, 1999a). Blainsville's beaked whales (*M. densirostris*) were found in water depths of 136-1,319 m (446-4,327 ft) in the Bahamas, and were found most often in areas with a high bathymetric slope (MacLeod and Zuur, 2005). *Mesoplodon* was found in waters from 700 to >1,800 m (2,297 to >5,906 ft) off Scotland and the Faroe Islands (Weir, 2000) and between 680 and 1,933 m (2,231 and 6,342 ft) in the Gulf of Mexico (Davis et al., 1998).

Baird et al. (2006) reported that Blainsville's beaked whales off Hawaii were found in waters from 633-2,050 m (2,077-9,726 ft) deep (mean=1,119), while Cuvier's beaked whales were found in waters from 1,381 to 3,655 m (4,531 to 11,992 ft) deep (mean=2,131).

Group Size

Pod sizes reported for *Mesoplodon stejnegeri* in Alaska ranged between 5 and 15 animals (Loughlin, 1982). Group sizes for Sowerby's beaked whale in the Gully in Canada ranged between 3 and 10 individuals (Hooker and Baird, 1999a). Group sizes for dense-beaked whales off the Canary Islands ranged between 2 and 9 whales, with a mean size of 3.44 whales (Ritter and Brederlau, 1999). Groups sizes for Longman's beaked whale in the western Indian Ocean ranged between 1 and 40 individuals, with a mean size of 7.2 whales (Anderson et al., 2006).

7.3.4.14. Dwarf and Pygmy Sperm Whales (Kogia *spp.)*

Data on dwarf and pygmy sperm whales are rare and have been combined for these two similar species.

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Kogia spp.	1/2	75^{o}	200/1,000	5/12	30	1/11	Norm.	117/reflect

Surface Time

Observations of *Kogia* off Hawaii indicated the animals remained at the surface for up to a "few" minutes and then dove (Baird, 2005).

Dive Depth

Kogia were found in Gulf of Mexico waters of less than 1,000 m (3,281 ft) along the upper continental slope (Baumgartner et al., 2001). The dive limits of 200-1,000 m (656-3,281 ft) 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 waters almost 2,000 m (6,562 ft) deep (Davis et al., 1998), but they may not be diving to the bottom.

Dive Time

Maximum dive time reported for *Kogia* is 12 min (Hohn et al., 1995). A rehabilitated pygmy sperm whale made long dives from 2-11 min in length at night and shorter dives during the day (Scott et al., 2001).

Speed

Tracking of a rehabilitated pygmy sperm whale found that speeds range from 0-6 kn (0-11 km/hr [0-7 mi/hr]), with a mean speed of 3 kn (Scott et al., 2001).

Habitat

Kogia were found in the Gulf of Mexico at a minimum depth of 176 m (577 ft) (Davis et al., 1998). They were found off Hawaii in waters between 450 and 3,200 m (1,476 and 10,499 ft) deep, with a mean of 1,425 m (4,675 ft) (Baird, 2005). *Kogia* in the Philippines were found in waters from 117 to 3,744 m (384 to 12,284 ft) in depth (Dolar and Perrin, 2003).

Group Size

Group sizes off Hawaii ranged between 1 and 6 animals (Baird, 2005). group sizes in the Gulf of Mexico range between 1 and 3 (Mullin et al., 2004).

7.3.4.15. Lagenorhynchus *Species*

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)
Lags	1/1	75^{o}	25/125	1/3	30	2/9	Norm.

Surface Time

Surface times for tagged white-sided dolphins were less than 1 min (Mate et al., 1994).

Dive Depth

No direct data on dive depth are available for any of the *Lagenorhynchus*. However, in the Atlantic they feed on herring and in the Pacific they feed on squid and mesopelagic fishes. For Atlantic white-sided dolphin a maximum dive depth of 125 m (410 ft) is used since this covers the depth range of herring; it is slightly shallower than the other dolphin species due to the *Lagenorhynchus*' short dive time.

Dive Time

Maximum dive time for a tagged white-sided dolphin was 4 min, although the mean time was <1 min (Mate et al., 1994). Peale's dolphin (*L. australis*) dove from 1-130 s (de Haro and Iniguez, 1997).

Speed

The mean minimum speed of 5.7 km/hr (3.5 mi/hr) was estimated by the straight line distance between satellite tag locations, which is almost certainly an underestimate of real-world swimming speeds (Mate et al., 1994). The maximum "minimum speed" was 14.22 km/hr (8.83 mi/hr). A white-sided dolphin in captivity swam between 1.5 and 3.5 m/s (5 and 11.5 ft/s) (5.4 and 12.6 km/hr [3.4 and 7.8 mi/hr) (Curren et al., 1994). Theodolite tracking of dusky dolphins (*L. obscurus*) produced mean speeds between 3.68 and 6.08 km/hr (2.4 and 3.8 mi/hr) with 10th and 90th percentiles of ~2 and ~9 km/hr (~ 1 and ~ 6 mi/hr) (Yin, 1999).

Group Size

The mean size of Atlantic white-sided dolphin groups was 52 (Weinrich et al., 2001). The mean group size of Pacific white-sided dolphins was 30.8 (Barlow, 1995). In Southeast Alaska, the group size was extremely variable, ranging from 1 to 500 animals, with an overall mean of 35.6 animals (Dahlheim and Towell, 1994).

7.3.4.16. Fraser's Dolphin

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Fraser's Dolphin	1/1	75^{o}	10/700	1/6	30	2/9	Norm.	100/reflect

Dive Depth

Fraser's dolphins dive to about 600-700 m (1,969-2,297 ft) to feed, much deeper than spinner dolphins (Dolar et al., 2003). Numerous records indicated that the primary prey of Fraser's dolphins is found at great depth (Caldwell et al., 1976; Miyazaki and Wada, 1978; Robison and Craddock, 1983), although there has been at least one report of near-surface feeding (Watkins et al., 1994). All other behavioral parameters are taken from *Stenella* species since there are no direct data for Fraser's dolphin. The dive time has been increased to 6 min to account for the deeper dives.

Group Size

A single group of Fraser's dolphins comprising of 158 individuals was seen off the Pacific Coast of Costa Rica (May-Collado et al., 2005).

*7.3.4.17. Small Beaked Whales (*Mesoplodon, Ziphius, Tasmacetus*)*

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Beaked Whales	1/7	75°	1,000/1,453 (60) 100/800 (40)	48/68 12/30	30/300 (50) 90/300 (50)	3/6	Norm.	253/reflect

Surface Time

Surface times in Arnoux's beaked whales ranged from 1.2-6.8 min (Hobson and Martin, 1996). Sowerby's beaked whales had surface times of 1-2 min, during which they would blow 6-8 times (Hooker and Baird, 1999a).

Dive Depth

The minimum and maximum dive depth measured for a beaked whale was 120 and 1,453 m (394 and 4,767 ft) respectively (Hooker and Baird, 1999b). Cuvier's beaked whales tagged off the Canary Islands had foraging dives between 824 and 1,267 m (2,703 and 4,157 ft) while Blainsville's beaked whales dove to depths between 655 and 975 m (2,149 and 3,199 ft) (Johnson et al., 2004).

Northern bottlenose whales performed shallow dives with a range of 41-332 m (135-1,089 ft) (n=33), while deep dives ranged from 493-1,453 m (1,617-4,767 ft) (n=23). Dive depth and dive duration were strongly correlated (Hooker and Baird, 1999b).

Blainsville's beaked whales in Hawaii performed dives to mid-water depth (100-600 m [328-1,969 ft]) approximately six times more frequently than at night. Dives deeper than 800 m (2,625 ft) had no diurnal difference (Baird et al., 2008).

Dive Time

The minimum and maximum dive time measured was 16 and 70.5 min respectively (Hooker and Baird, 1999b). Sowerby's beaked whales had dives between 12 and (at least) 28 min in the Gully in Canada (Hooker and Baird, 1999a). Arnoux's beaked whale had modal dive times between 35 and 65 min (mean=46.4 min, SD=13.1) with a maximum dive time of at least 70 min (Hobson and Martin, 1996). Tagging results with *Ziphius* had one animal diving for 50 min (Johnson et al., 2004). *Mesoplodon stejnegeri* were observed to dive for 10-15 min in Alaska (Loughlin, 1982).

Blainsville's beaked whales and Cuvier's beaked whales both regularly dove for 48-68 min on deep dives (>800 m [>2,625 ft]).

Heading Variance

Sowerby's beaked whales surfacing in the Gully were reported to have no apparent orientation, and would change orientation up to 180° between surfacing (Hooker and Baird, 1999a).

Speed

Dive rates averaged 1 m/s (3.3 ft) or 3.6 km/hr (2.2 mi/hr) (Hooker and Baird, 1999b). A mean surface speed of 5 km/hr (3.1 mi/hr) was reported by Kastelein and Gerrits (1991).

Habitat

The minimum sea depth in which beaked whales were found in the Gulf of Mexico was 253 m (830 ft) (Davis et al., 1998). Sowerby's beaked whales in the Gully in Canada were found in water ranging from 550-1,500 m (1,804-4,921 ft) in depth (Hooker and Baird, 1999a). Blainsville's beaked whales (*M. densirostris*) were found in water depths of 136-1,319 m (446-4,327 ft) in the Bahamas, and were found most often in areas with a high bathymetric slope (MacLeod and Zuur, 2005). *Mesoplodons* were found in waters from 700 to >1,800 m (2,297 to >5,906 ft) off Scotland and the Faroe Islands (Weir, 2000) and between 680 and 1,933 m (2,231 and 6,342 ft) in the Gulf of Mexico (Davis et al., 1998).

Baird et al. (2006) reported that Blainsville's beaked whales off Hawaii were found in waters from 633-2,050 m (2,077-6,726 ft) deep (mean=1,119 m [3,671 ft]) while Cuvier's beaked whales were found in waters from 1,381-3,655 m (4,531-11,992 ft) deep (mean=2,131 m [6,991 ft]).

Group Size

Pod sizes of *Mesoplodon stejnegeri* in Alaska ranged between 5 and 15 animals (Loughlin, 1982). Sowerby's beaked whale in the Gully in Canada had group sizes ranging between 3 and 10 (Hooker and Baird, 1999a). Group sizes for dense-beaked whale off the Canary Islands ranged between 2 and 9, with a mean size of 3.44 whales (Ritter and Brederlau, 1999). Group size for Longman's beaked whale in the western Indian Ocean group ranged between 1 and 40, with a mean size of 7.2 whales (Anderson et al., 2006).

7.3.4.18. 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," with the exception of dive depth, were used to model killer whales. The different feeding ecology of these species makes very deep dives apparently unnecessary. When additional data allow, separate animats need to be developed for "resident" and "transient" killer whales.

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Killer Whale	1/1	75°	10/180	1/10	30	3/12	Norm.	25/reflect

Dive Depth

Killer whales feeding on herring were observed to dive to 180 m (591 ft) (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 (173 m [568 ft]) (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. Individual resident killer whales in the Pacific northwest had maximum dive depths ranging between 24 and 264 m (79 and 866 ft,) with a group mean maximum depth of 140.8 m (462 ft) (SD=61.8, n=34) (Baird et al., 1995). The distribution of dive depths reported by Baird et al. (2005) was strongly skewed toward shallow values.

Dive Time

Daytime dive times for males were 2.79 min, significantly longer than the 2.09 min dive times for females (Baird et al., 2005).

Speed

Uncalibrated swim speed data were presented by Baird et al. (2005). Killer whales chasing minke whales had prolonged speeds of 15-30 km/hr (9-19 mi/hr) (Ford et al., 2005) although these speeds are probably obtained only during predation. A shore-based study of southern resident killer whales in Washington State had a mean speed of 9.5 km/hr (5.9 mi/hr) with a mean range of 4.7-16.1 km/hr (2.9-10 mi/hr) (Kriete, 2002). The mean speed of control animals was approximately 5.3 km/hr (3.3 mi/hr), measured during a study of the response of killer whales to vessels (Williams et al., 2002). A similar study reported a mean speed of 6.64 km/hr (4.13 mi/hr) without vessels and 6.478 km/hr

(4.03 mi/hr) in the presence of vessels (Bain et al., 2006). Taken together, these three studies produced a speed range of 3-12 km/hr (1.9-7.5 mi/hr) for use in AIM.

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.

Killer whales in the Gulf of California were seen in groups of 2-15 whales with a mean of 8.5 and a SD of 9.19 (n=2) (Silber et al., 1994). Off the Pacific Coast of Costa Rica, the mean group size was 3.51 (SD=2.99, n=7) (May-Collado et al., 2005).

7.3.4.19. Harbor Porpoise

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Harbor Porpoise	1/1	17/31	1/10 (35) 10/40 (45) 40/100 (15) 100/230 (5)	1/4	30	2/7	Norm.	100-1,000/ reflect

Surface Time

Mean surface time was reported as 3.9 s (Otani, 2000).

Dive Depth

Maximum observed dive depth for a free-ranging harbor porpoise was 64.7 m (212 ft) (Otani, 2000). However, the same study reported that >90 percent of dives were less than 10 m (33 ft). Another TDR study with seven animals tagged had dive depths that ranged from a mean of 14 ±16 m (46 ±52 ft) to 41 ±32 m (135 ±105 ft) while the mean for all animals tagged was 25 ± 30 m (82 ±98 ft) (Westgate et al., 1995). One large female made a very deep dive to 226 m (741 ft) although dives this deep were infrequent.

Dive Time

Maximum observed dive time for a free-ranging harbor porpoise was 193 s (Otani, 2000) although most dives were less than one min in length. The mean dive duration of seven animals in the Bay of Fundy was 65 ±33 s (Westgate et al., 1995).

Speed

Mean descent speed was 2.9 km/hr (1.8 mi/hr) with a maximum descent speed of 15.5 km/hr (9.6 mi/hr). Ascent speeds were similar, with a mean of 3.24 km/hr (2 mi/hr) and a maximum of 14.5 km/hr (9 mi/hr) (Otani, 2000). TDR tagged animals moved at least 51 km (32 mi) in a 24 hr period (2.125 km/hr [1.3 mi/hr]) (Westgate et al., 1995). A captive harbor porpoise swam between 3.6-7.2 km/hr (2.2-4.5 mi/hr) (Curren et al., 1994). A speed range of 2-7 km/hr (1.2-4.3 mi/hr) was used in AIM to represent the harbor porpoise speed.

Group Size

The mean group size of harbor porpoise off California was 5.0 individuals (n=31) (Barlow, 1995).

7.3.4.20. Sperm Whale

There are indications of diurnal differences in diving behavior (Aoki et al., 2007). There is also evidence of large-scale variability between environments. Therefore, these parameters should be considered generalized and warrant location specific refinement.

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Sperm Whale	8/11	90/75º	600/1,400 (90) 200/600 (10)	18/65	20	1/10	Norm.	200/reflect
Atlantic Ocean Model Parameters								
Atlantic Sperm Whale	5/9	90/75º	600/1,000	35/65	30/300 (50) 90/300 (50)	1/8	Norm.	200/reflect

Surface Time

Male sperm whales in New Zealand had a mean duration on the surface of 9.1 min, with a range of 2-19 min (Jaquet et al., 2000). The distribution of surface times was non-normal, with 68 percent of the surface times falling in between 8 and 11 min. These values were used for AIM modeling.

Surfacing and Dive Angles

Surfacing angles of 90° and diving angles between 60° and 90° have been reported (Miller et al., 2004).

Dive Depth

The maximum accurately measured sperm whale dive depth was 1,330 m (4,364 ft) (Watkins et al., 2002). Foraging dives typically begin at depths of 300 m (984 ft) (Papastavrou et al., 1989). Digital acoustic recording tag (DTAG) data from the Gulf of Mexico show that most foraging dives were between the depths of 400-800 m (1,312-2,625 ft), with occasional dives between 900 and 1,000 m (2,953 and 3,281 ft) (Jochens et al., 2008, Figure 5.2.2).

Sperm whale diving is not uniform. As an example, data from a paper on sperm whale diving reported different dive types (Amano and Yoshioka, 2003). The AIM can now accommodate these different dive types at different frequencies of use.

		Depth		Time	
Type of Dive	N	AIM min	AIM max	AIM min	AIM max
Dives w/ active bottom period	65	606	1082	33.17	41.63
Dives w/o active bottom period	4	417	567	31.29	33.71
V shaped dives	3	213	353	12.77	20.83
Total	72				

Dive depths have also been shown to have diel variation in some areas while others do not show this variation (Aoki et al., 2007). These differences have been attributed to the behavior of the prey species. Tagged whales off California changed their dive patterns in response to changes in the depth of tagged squid (Davis et al., 2007).

Male sperm whales foraging in high latitude waters dove to a maximum depth of 1,860 m (6,102 ft), but the median dive depth was only 175 m (574 ft) (Teloni et al., 2008).

In the Atlantic, maximum dive depths ranged from 639-934 m (2,096-3,064 ft) (Palka and Johnson, 2007).

<table>
<tr><th rowspan="3">Area</th><th colspan="5">Average Duration (min)</th></tr>
<tr><th colspan="3">Foraging Dive</th><th rowspan="2">Inter-Dive Interval</th><th rowspan="2">Surface Interval</th></tr>
<tr><th>Total</th><th>Descent</th><th>Ascent</th></tr>
<tr><td>North Atlantic</td><td>44.6</td><td>24.4</td><td>20.2</td><td>7.1</td><td>70.0</td></tr>
<tr><td>Gulf of Mexico</td><td>44.7</td><td>22.2</td><td>22.4</td><td>8.2</td><td>63.7</td></tr>
<tr><td>Mediterranean</td><td>40.3</td><td>24.4</td><td>19.3</td><td>9.7</td><td>57.5</td></tr>
<tr><th rowspan="2">Area</th><th colspan="5">Average Depth (m)</th></tr>
<tr><th colspan="3">Maximum Depth of Foraging Dives</th><th>Inter-Dive Interval</th><th>Surface Interval</th></tr>
<tr><td>North Atlantic</td><td colspan="3">933.9</td><td>1.15</td><td>5.6</td></tr>
<tr><td>Gulf of Mexico</td><td colspan="3">638.7</td><td>0.45</td><td>4.6</td></tr>
<tr><td>Mediterranean</td><td colspan="3">797.3</td><td>0.34</td><td>4.9</td></tr>
</table>

Sperm whales showed diel variability off Ogasawara, Japan, where the whales dove deeper during the day (mean=853 ±130 m [2,799 ±427 ft]) than at night (mean=469 ±122 m [1,539 ±400 ft]) (Aoki et al., 2007). However, off the Kumano Coast, there was not a large difference in depths (561 versus 646 m [1,841 versus 2,119 ft]).

Dive Time

Sperm whale dive times average 44.4 min in duration and range from 18.2-65.3 min (Watkins et al., 2002). In the Gulf of Mexico, the modal dive time is about 55 min (Jochens et al., 2008, Figure 4.4.3). Dive times in the Atlantic averaged 40-45 min (Palka and Johnson, 2007).

Dive times off Ogasawara, Japan had an average of 40.1 min (SD=4.5) during the day and a mean of 32.3 min (SD=5.3) at night (Aoki et al., 2007). Off the Kumano Coast of Japan, they had intermediate values of 36.1 min (SD=3.7) during the day and 34.1 (SD=7) min at night.

Heading Variance

Whales in the Gulf of Mexico tend to follow bathymetric contours (Jochens et al., 2008). Relative angles between direction of movements and direction of contours have been calculated and transformed so that 0 shows alignment with the orientation of the contour, -90 would be moving directly offshore, and +90 would indicate a movement directly inshore (Jochens et al., 2008, Figure 4.4.5).

Speed

Sperm whales are typically slow or motionless on the surface. Mean surface speeds of 1.25 km/hr (0.78 mi/hr) were reported by Jaquet et al. (2000) and 3.42 km/hr (2.13 mi/hr) (Whitehead et al., 1989). Their mean dive rate ranges from 5.22 to 10.08 km/hr (3.24 to 6.26 mi/hr) with a mean of 7.32 km/hr (4.55 mi/hr) (Lockyer, 1997). In Norway, horizontal swimming speeds varied between 0.72 and 9.36 km/hr (0.45 and 5.8 mi/hr) (Wahlberg, 2002). Sperm whales in the Atlantic Ocean swam at speeds between 2.6 and 3.5 km/hr (1.6 and 2.2 mi/hr) (Jaquet and Whitehead, 1999; Watkins et al., 1999). Mean speeds in the Gulf of Mexico were 3.3 km/hr (2.1 mi/hr) (Jochens et al., 2008). Based on these data, a minimum speed of 1 km/hr (0.6 mi/hr) and a maximum speed of 8 km/hr (5 mi/hr) was set for sperm whales specified with a normal distribution so that mean speeds would be about 4 km/hr (2.5 mi/hr).

Off Ogasawara Japan, sperm whales swam faster during the day (mean=2.0 m/s [6.6 ft/s], SD=0.3) than during the night (mean=1.5 m/s [5 ft/s], SD=0.3).

Habitat

Sperm whales are found almost everywhere, but they are usually in water deeper than 480 m (1,575 ft) (Davis et al., 1998). However, there have been sightings of animals in shallow water (40-100 m [131-328 ft]) (Whitehead et al., 1992; Scott and Sadove, 1997). In the Gulf of California there was no relationship between depth or bathymetric slope and abundance and animals were seen in water as shallow as 100 m (328 ft) (Jaquet and Gendron, 2002). Based on these reports, a compromise value of 200 m (656 ft) was used as the shallow water limit for sperm whales.

Group Size

Social, female-centered groups of sperm whales in the Pacific have “typical” group sizes of 25-30 animals, based on the more precise measurements in (Coakes and Whitehead, 2004), although less precise estimates are as high as 53 whales in a group.

7.3.4.21. Stenella*: Spinner, Spotted, and Striped Dolphins*

Most *Stenella* species have strong diurnal variation in their behavior. Separate daytime and nighttime animats was built for this species by programming two dive behaviors. The relative proportion of these dive types can be scaled by the local photoperiod with the AIM weighting parameter.

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Stenella	1/1	75^{o}	Day: 5/25 (50) Night: 10/400 (10) Night: 10/100 (40)	1/4	30	2/9	Norm.	10/reflect

Dive Depth

Spinner dolphins feed during the night and rest inshore during the daytime. At night they dive to about 400 m (1,312 ft) to feed (Dolar et al., 2003).

Pantropical spotted dolphins off Hawaii also dive deeper at night than during the day. The daytime depth had a mean of 12.8 m (42 ft), with a maximum of 122 m (400 ft), whereas the night-time mean was 57 m (187 ft), with a maximum of 213 m (699 ft) (Baird et al., 2001).

Spinner dolphins off Hawaii typically track and forage upon the mesopelagic boundary layer as it migrates both vertically and horizontally at night. It appears that dolphins have to dive deeply only at the very beginning and end of the migration (Benoit-Bird and Au, 2003) foraging mostly at moderate depths.

Therefore, 10 percent of the dives were set to be deep, 40 percent of the dives were “typical” foraging depths, with a maximum of 150 m (492 ft), and 50 percent of the dives were set to represent the daytime resting behavior ranging between 5 and 25 m (16 and 82 ft).

Dive Time

A single spotted dolphin has dive times ranging between 1 and 204 s (Leatherwood and Ljungblad, 1979). Pantropical spotted dolphins off Hawaii had a mean dive duration of 1.95 min (SD=0.92) (Baird et al., 2001). An Atlantic spotted dolphin tagged with a satellite linked TDR had a maximum dive time of 3.5 min (Davis et al., 1996). A four min dive time maximum was used for modeling purposes in AIM.

Speed

The mean speed of striped dolphins in the Mediterranean was estimated at 6.1 kn (11 km/hr [6.8 mi/hr]) and burst to 32 kn were observed (Archer and Perrin, 1999). A maximum speed of 20 km/hr (12 mi/hr) was chosen as a typical (non-burst) maximum speed. A tagged spotted dolphin was tracked at estimated average speeds of 2.3-10.7 kn with bursts exceeding 12 kn (Leatherwood and Ljungblad, 1979). The estimated burst speed of spotted dolphins in the Eastern Tropical Pacific was 21.6 km/hr (13.4 mi/hr) for adults and 10.8 km/hr (6.7 mi/hr) for neonates. The estimated long-term top speed is 9 km/hr (5.6 mi/hr) for adults and 3.6 km/hr (2.2 mi/hr) for neonates (Edwards, 2006). The Edwards (2006) paper also summarized speed estimates and duration for a number of species. Therefore their estimate of 9 km/hr (5.6 mi/h) was used for long-term movements, as modeled in AIM.

Habitat

In the Gulf of Mexico, spinner dolphins were seen in water deeper than 526 m (1,726 ft), striped dolphins were seen in water deeper than 570 m (1,870 ft), and spotted dolphins were seen in water deeper than 102 m (335 ft) (Davis et al., 1998). Spinner dolphins in Hawaii are known to move into shallow bays during the day (Norris and Dohl, 1980).

Group Size

Group size estimates were summarized, and the majority of striped dolphin groups were less than 500 animals. The mean of the smaller groups was 101 animals (Archer and Perrin, 1999). Spotted dolphins off Costa Rica had group sizes between 1 and 50 (mean=10.16, SD=9.61) (May-Collado and Ramirez, 2005).

Summary of Gulf of Mexico Data (Source: Mullin et al., 2004)

Species	Min Group Size	Max Group Size	Mean	SE	N
Pantropical spotted dolphin	5	210	49.0	4.5	47
Atlantic spotted dolphin	5	48	22.4	3.9	12
Striped dolphin	7	150	46.3	16.0	8
Spinner dolphin	48	200	91.3	36.4	4
Clymene dolphin	9	168	59	19.5	7

Clymene dolphins off Costa Rica had a mean group size of 76.1 (SE=11, n=109) (Fertl et al., 2003).

Summary of Pacific Costa Rica Data (May-Collado et al., 2005)

Species	Mean	SD
Pantropical spotted dolphin	29.38	58.28
Striped dolphin	48.9	43.05
Spinner dolphin	100.59	107.7

7.3.4.22. 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 U.S., 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 are split into two animat categories.

Model Parameters

	Min/Max Surface Time (min)	Surface/Dive Angle	Dive Depth (m) Min/Max (Percentage)	Min/Max Dive Time (min)	Heading Variance (angle/time)	Min/Max Speed (km/hr)	Speed Distribution (α,β)	Depth Limit/Reaction Angle
Bottlenose (Coastal)	1/1	75^{o}	15/98	1/3	30	2/16	Norm.	10/reflect
Bottlenose (Pelagic)	1/1	75^{o}	6/50 (80) 50/100 (5) 100/250 (5) 250/450 (10)	1/2 2/3 3/4 5/6	30/300 (45) 90/90 (45) 90/90 (10)	2/16	Norm.	101/1,226 reflect

Dive Depth

An early maximum recorded dive depth for wild bottlenose dolphins is 200 m (656 ft) (Kooyman and Andersen, 1969). More recently, offshore bottlenose dolphins were reported to dive to depths greater than 450 m (1,476 ft) (Klatsky et al., 2007).

A satellite tagged dolphin in Tampa Bay, Florida had a maximum dive depth of 98 m (322 ft) (Mate et al., 1995). This value was used as the maximum dive depth for the coastal form of bottlenose.

Dive Time

Measured surface times for bottlenose dolphins ranged from 38 s to 1.2 min (Lockyer and Morris, 1986, 1987; Mate et al., 1995). Dive depths for a juvenile bottlenose had a mean value of 55.3 s although the distribution was skewed toward shorter dives (Lockyer and Morris, 1987). However, pelagic bottlenose dolphins were observed to dive for periods longer than five min (Klatsky et al., 2007).

Speed

Bottlenose dolphins were observed to swim for extended periods at speeds of 4-20 km/hr (2.5-12.4 mi/hr), although they could burst (for about 20 s) at up to 54 km/hr (34 mi/hr) (Lockyer and Morris, 1987). Dolphins in the Sado Estuary, Portugal had a mean speed of 4.3 km/hr (2.7 mi/hr) and maximum speed of 11.2 km/hr (7 mi/hr) (Harzen, 2002). A more recent analysis found that maximum speed of wild dolphins was 20.5 km/hr (12.7 mi/hr), although trained animals could double this speed when preparing to leap (Rohr et al., 2002). Maximum speeds of wild dolphins in France was 4.8 m/s (15.7 ft/s), with an average speed (relative to water) of 7.9 km/hr (4.9 mi/hr) (Ridoux et al., 1997). Bottlenose dolphins off Argentina swam much faster (14 km/hr [9.7 mi/hr]) when in water >10 m (>33 ft) than while in shallow water (5.8 km/hr [3.6 mi/hr]) (Würsig and Würsig, 1979).

Habitat

In the Gulf of Mexico, bottlenose dolphins where observed in water depths between 101 and 1,226 m (331 and 4,022 ft) (Davis et al., 1998). However tagged animals have been observed to swim into water 5,000 m (16,404 ft) deep (Wells et al., 1999).

Group Size

Bottlenose dolphins in the Gulf of California were seen in groups of 1-60 dolphins, with a mean group size of 10.1 (Silber et al., 1994). In the Gulf of Mexico they were seen in groups of 1-68 individuals (mean=14.5, SE=1.5, n=83) (Mullin et al., 2004). Off the Pacific Coast of Costa Rica, mean group size was 21.5 (SD=33.73, n=176) (May-Collado et al., 2005).

7.4. Estimations of Source Level of Effort

The final information needed to calculate the overall impact from the proposed action and the alternatives is the number and timing of the various surveys to be performed. The two major components of the estimates of the survey Level of Effort (LOE) are (1) the annual estimations of the total number of each survey type to be conducted; and (2) the spatial distribution of these surveys in the 35 modeling regions (regions 1-21 for seismic airgun surveys for oil and gas exploration, plus regions 22-35 for renewable energy and marine minerals HRG surveys). A brief discussion of these components follows.

There are several assumptions embedded in the modeling which are necessary because this analysis is being performed far in advance of the actual surveys efforts. These embedded assumptions include

- the estimation that surveys would have an even temporal distribution throughout the year. This allows all seasons to be examined in the analysis and enables to analysts to observe particularly time periods which could cause higher impacts than others. The reality of Western Atlantic Ocean operations is that winter operations could possibly encounter the worst conditions in general, aside from operations during a hurricane;

- the marine mammal densities are averaged for each area and this value is used in the analysis. This is reasonable because the exact location of each survey is unknown and on average, much or most of these regions would eventually be surveyed;
- nominal values used to describe the survey geometries are subject to change and most likely would be based on previous surveys conducted and their results; and
- nominal source levels and configurations were modeled.

7.4.1. Annual Survey Levels of Effort (LOE)

The BOEM has provided the annual LOE for each of the survey types out to the year 2020. The tables showing these LOE are included in the Programmatic EIS (**Chapter 3**), and a condensed version is presented in **Table E-11**.

Table E-11

Projected Levels of Seismic Airgun Surveys for Oil and Gas Exploration in the Mid- and South Atlantic Planning Areas, 2012-2020

Year	Mid-Atlantic Planning Area					South Atlantic Planning Area				
	2D (km)	3D (blocks)[a]	WAZ (blocks)[b]	HRG (line km)	VSP (line km)	2D (km)	3D (blocks)[a]	WAZ (blocks)[b]	HRG (line km)	VSP (line km)
2012	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0
2014	83,400	0	0	0	0	28,450	0	0	0	0
2015	160,950	0	0	0	0	56,900	0	0	0	0
2016	12,875	400	0	0	0	8,050	300	0	0	0
2017	64,375	200	0	0	0	48,300	200	0	3,220	0
2018	41,800	200	100	3,220	0	38,624	200	100	32,200	0
2019	16,100	200	100	16,100	160	32,200	200	200	16,100	320
2020	16,100	300	200	64,375	320	8,050	300	200	40,250	480
TOTAL	**395,600**	**1,300**	**400**	**83,695**	**480**	**220,574**	**1,200**	**500**	**91,770**	**800**

Abbreviations: 2D = two-dimensional; 3D = three-dimensional; HRG = high-resolution geophysical; VSP = vertical seismic profile; WAZ = wide azimuth.
[a] 3D surveys include ocean bottom cable and nodal surveys, vertical cable surveys, and 4D (time-lapse) surveys. Typically, one OCS block is 9 mi^2 (23.3 km^2, 2,331 ha or 5,760 ac).
[b] WAZ estimates include coil shooting (exclusive to WesternGeco).

7.4.2. Spatial Distribution of the 2D Survey Effort

BOEM provided the 13 seismic, 5 additional gravity, and 5 additional magnetic G&G survey applications from nine geophysical companies wishing to conduct seismic 2D surveys for oil and gas exploration in the AOI. Included in these applications were the descriptions of the areas to be surveyed and the planned survey geometries.

An analysis using geographic information system (GIS) programming was conducted on these applications and the resulting graphic was a density plot of the entire survey effort for the Mid- and South Atlantic Planning Areas (**Figure E-19**). In the analysis, this plot was handled in a manner similar to that used to determine the average marine mammal densities in each modeled region. Essentially, the number of survey miles for each modeled region was summed and then converted into the number of standard blocks in each region that would be surveyed. The description included in each of the nine applications changed the overall geometry employed to conduct the 2D survey. This necessitated an analysis of the variation in these surveys, and a nominal or average 2D survey for these applications had a linear miles per standard block surveyed conversion of 1.54 nmi per block (2.85 km/block). This average value is less than that typically used in the Gulf of Mexico for 2D surveys (e.g., approximately 6.24 nmi/block), but it conforms to the applications and it was used in all subsequent 2D survey calculations. Similarly, an average 2D HRG survey conversion of 200 nmi/block (370.40 km/block) is used for this analysis. This value is a compromise between the 70 nmi/block value typically used in the Gulf of Mexico and the 360 nmi/block calculated by BOEM from the applications. By using these conversion factors and the applications, the spatial distribution of the various seismic airgun surveys throughout the 21 modeling regions was estimated. For the non-airgun HRG surveys the conversion factor used was 666.3 nmi per block (1,234.0 km/block).

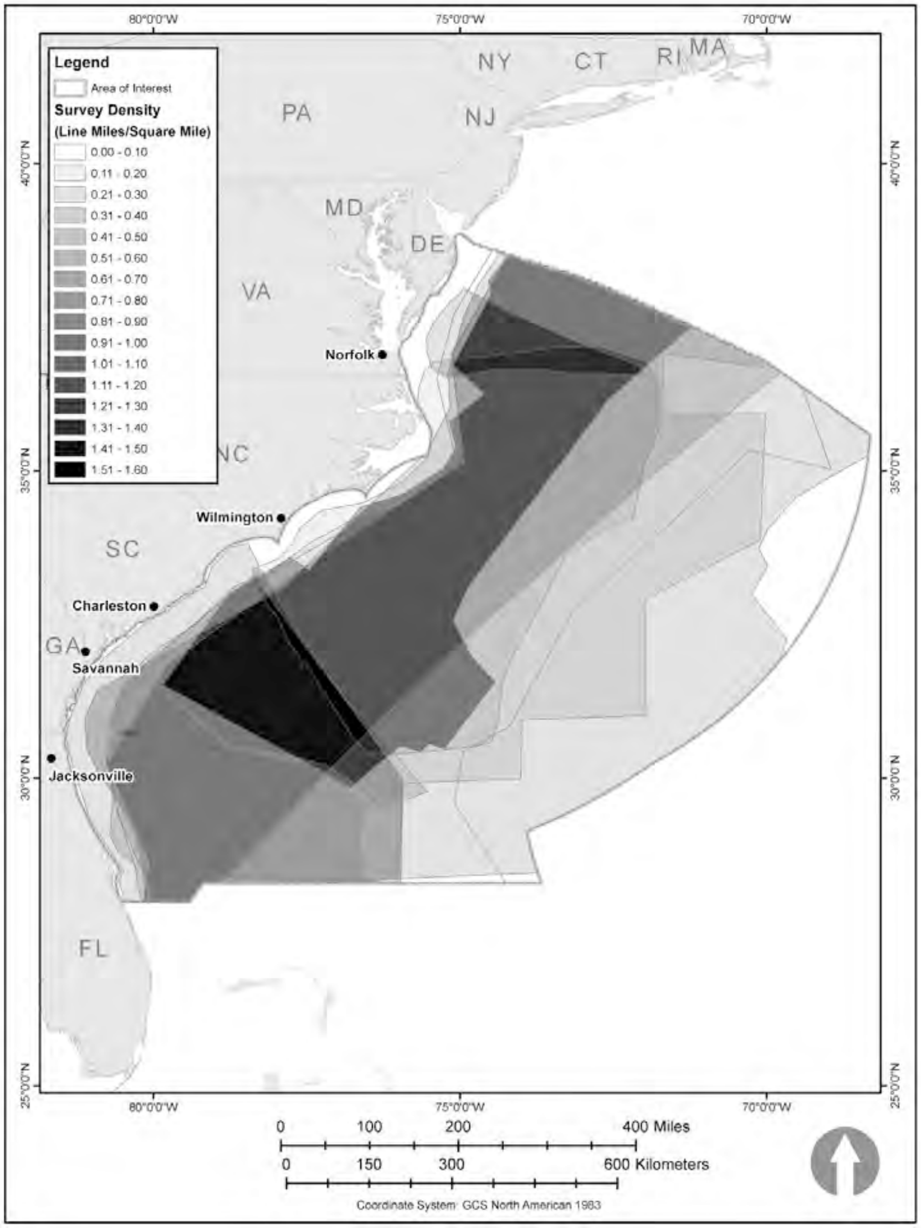


Figure E-19. Level of Effort Density Plot for Future 2D Seismic Airgun Surveys Based on Overlay of Seismic Survey Applications Submitted to BOEM. Areas with darker shading would be expected to have higher levels of survey effort due to overlapping survey areas.

The final adjustment to each regions 2D survey effort was to distribute temporally as per the distribution discussed in **Section 7.4.1**. The result is a distribution of the entire 2D survey effort over the years and modeling regions addressed in this Programmatic EIS.

Finally, the same spatial distribution of the 2D surveys over the 21 modeling regions was also used to distribute the 3D, WAZ, HRG, and VSP surveys, since it follows that the 2D surveys would essentially act as the gateway to the follow-up surveys by showing where they would be most productive.

7.4.3. Correction to Level of Effort (LOE) Tables to Account for Time-Area Closures

The proposed action includes a suite of existing regulations as well as mitigation measures that were developed specifically for this Programmatic EIS (**Chapter 2.1.2**). Specifically, all survey activity which was planned to occur in North Atlantic right whale critical habitat, the Southeast U.S. Seasonal Management Area (SMA), or the Mid-Atlantic U.S. SMA was assumed to be rescheduled for a period other than the time periods when those areas are established (November 15 through April 15 for the critical habitat and Southeast SMA; November 1 to April 30 for the Mid-Atlantic SMA). In order to incorporate this prohibition into the modeling the following steps were followed:

- all surveys which would have occurred in these closure areas and occur in modeled areas 4 and 5 (winter), 9 and 10 (2 months of spring) or 20 and 21 (the last month of fall) where rescheduled to the open and available time periods at the same sites for periods when the North Atlantic right whales are absent;
- since these closure areas constitute a large portion of some modeling regions (in some cases up to roughly 50 percent), each of the species densities were examined to ensure that the density being used was correct or at least conservative; and
- the LOE for these cancelled surveys was then evenly distributed over the remaining months when these surveys could be performed. This was reflected in the final LOE tables, **Tables E-12** through **E-15** for 2D, 3D, WAZ, and VSP surveys respectively. The LOE tables for HRG surveys of oil and gas sites using the 90 cubic airgun are shown in **Table E-16**. The LOE estimates for non-airgun HRG surveys for marine minerals and renewable energy sites are shown in **Tables E-17** and **E-18**, respectively.

Similarly, the number of potential impacts also is scaled to derive a “per block survey” level of potential impacts. The predicted potential impacts can then be calculated by multiplying this value by the number of surveys of that type to be performed in that year, and summing the potential impacts to that species from all survey types combined.

Although the effect of time-area closures on incidental take was not specifically studied, it is estimated that about two-thirds (67 percent) of the incidental takes of North Atlantic right whales would be avoided under Alternative A (the proposed action), based on comparison of the initial model runs (without closures) with the final model runs (with closures). Incidental take was not modeled for Alternative B. However, sightings data reviewed by NMFS in developing the ship strike rule indicate that approximately 83 percent of right whale sightings occur within 37 km (20 nmi) of the coast. Since Alternative B includes a time-area closure extending 37 km (20 nmi) from shore along the entire AOI, it is estimated that approximately 80 percent of the incidental takes of North Atlantic right whales would be avoided (as compared with no closures). These percentages are based solely on seismic airgun surveys, which account for nearly all of the incidental takes.

Table E-12

Adjusted Level of Effort in Blocks for 2D Seismic Airgun Surveys

	Year								
Modeled Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.0	0.0	1795.4	3465.8	278.9	1398.2	911.3	539.1	347.8
2	0.0	0.0	4461.0	8626.8	721.2	3677.6	2452.6	1098.7	883.9
3	0.0	0.0	2398.8	4738.9	571.1	3297.3	2539.6	1929.0	603.5
4	0.0	0.0	166.5	333.0	47.1	282.6	226.0	188.4	47.1
5	0.0	0.0	571.2	1118.8	118.2	656.7	285.9	329.1	131.2
6	0.0	0.0	2233.8	4310.9	344.8	1724.2	1119.6	431.2	431.2
7	0.0	0.0	4110.7	7949.8	665.4	3394.9	2256.6	1018.6	815.1
8	0.0	0.0	1802.5	3569.4	444.7	2590.1	2012.3	1563.5	464.4
9	0.0	0.0	842.1	1665.4	204.0	1182.8	914.9	702.8	214.3
10	0.0	0.0	253.8	489.9	39.2	195.9	127.2	49.0	49.0
11	0.0	0.0	1181.1	2279.3	182.3	011.7	592.0	228.0	228.0
12	0.0	0.0	4826.6	9321.0	756.8	3809.7	2496.9	1017.0	939.9
13	0.0	0.0	2509.1	4947.9	580.9	3330.4	2546.8	1897.5	619.7
14	0.0	0.0	1618.1	3201.2	393.6	2284.7	1769.0	1362.5	412.9
15	0.0	0.0	963.0	1858.5	148.7	743.4	482.7	185.9	185.9
16	0.0	0.0	1294.3	2497.9	199.8	999.1	648.7	249.9	249.9
17	0.0	0.0	1134.8	2191.8	178.6	900.7	591.7	244.2	221.5
18	0.0	0.0	2733.2	5305.3	477.8	2512.1	1742.1	935.6	566.7
19	0.0	0.0	2592.8	5106.4	588.5	3356.9	2553.4	1875.0	632.2
20	0.0	0.0	497.0	974.2	104.3	582.3	432.8	297.3	115.2
21	0.0	0.0	1231.0	2403.6	290.7	1675.0	1287.4	972.5	308.0

Table E-13

Adjusted Level of Effort in Blocks for 3D Seismic Airgun Surveys

	Year								
Modeled Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.0	0.0	0.0	0.0	24.8	12.5	12.5	12.5	18.7
2	0.0	0.0	0.0	0.0	65.2	33.9	33.9	33.9	50.8
3	0.0	0.0	0.0	0.0	58.4	37.0	37.0	37.0	55.6
4	0.0	0.0	0.0	0.0	5.0	3.3	3.3	3.3	5.0
5	0.0	0.0	0.0	0.0	11.6	7.0	7.0	7.0	10.5
6	0.0	0.0	0.0	0.0	30.6	15.3	15.3	15.3	22.9
7	0.0	0.0	0.0	0.0	60.2	31.3	31.3	31.3	46.9
8	0.0	0.0	0.0	0.0	45.9	29.4	29.4	29.4	44.1
9	0.0	0.0	0.0	0.0	21.0	13.4	13.4	13.4	20.0
10	0.0	0.0	0.0	0.0	3.5	1.7	1.7	1.7	2.6
11	0.0	0.0	0.0	0.0	16.2	8.1	8.1	8.1	12.1
12	0.0	0.0	0.0	0.0	67.5	34.2	34.2	34.2	51.3
13	0.0	0.0	0.0	0.0	59.0	37.0	37.0	37.0	55.6
14	0.0	0.0	0.0	0.0	40.5	25.8	25.8	25.8	38.8
15	0.0	0.0	0.0	0.0	13.2	6.6	6.6	6.6	9.9
16	0.0	0.0	0.0	0.0	17.7	8.9	8.9	8.9	13.3
17	0.0	0.0	0.0	0.0	16.0	8.1	8.1	8.1	12.2
18	0.0	0.0	0.0	0.0	44.5	24.4	24.4	24.4	36.7
19	0.0	0.0	0.0	0.0	59.5	37.1	37.1	37.1	55.6
20	0.0	0.0	0.0	0.0	10.3	6.2	6.2	6.2	9.3
21	0.0	0.0	0.0	0.0	29.7	18.8	18.8	18.8	28.1

Table E-14

Adjusted Level of Effort in Blocks for WAZ Seismic Airgun Surveys

	Year								
Modeled Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.0	0.0	0.0	0.0	0.0	0.0	6.2	6.4	12.5
2	0.0	0.0	0.0	0.0	0.0	0.0	16.9	19.5	33.9
3	0.0	0.0	0.0	0.0	0.0	0.0	18.5	34.2	37.0
4	0.0	0.0	0.0	0.0	0.0	0.0	1.7	3.3	3.3
5	0.0	0.0	0.0	0.0	0.0	0.0	3.5	5.8	7.0
6	0.0	0.0	0.0	0.0	0.0	0.0	7.6	7.6	15.3
7	0.0	0.0	0.0	0.0	0.0	0.0	15.6	18.0	31.3
8	0.0	0.0	0.0	0.0	0.0	0.0	14.7	27.7	29.4
9	0.0	0.0	0.0	0.0	0.0	0.0	6.7	12.5	13.4
10	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	1.7
11	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	8.1
12	0.0	0.0	0.0	0.0	0.0	0.0	17.1	18.0	34.2
13	0.0	0.0	0.0	0.0	0.0	0.0	18.5	33.6	37.0
14	0.0	0.0	0.0	0.0	0.0	0.0	12.9	24.1	25.8
15	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.3	6.6
16	0.0	0.0	0.0	0.0	0.0	0.0	4.4	4.4	8.9
17	0.0	0.0	0.0	0.0	0.0	0.0	4.1	4.3	8.1
18	0.0	0.0	0.0	0.0	0.0	0.0	12.2	16.6	24.4
19	0.0	0.0	0.0	0.0	0.0	0.0	18.5	33.2	37.1
20	0.0	0.0	0.0	0.0	0.0	0.0	3.1	5.3	6.2
21	0.0	0.0	0.0	0.0	0.0	0.0	9.4	17.2	18.8

Table E-15

Adjusted Level of Effort in Blocks for VSP Seismic Airgun Surveys

	Year								
Modeled Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.7
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4

Table E-16

Adjusted Level of Effort in Blocks for 90 Cubic Inch Airgun HRG Surveys for Oil and Gas Sites

	Year								
Modeled Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.7
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4

Table E-17

Adjusted Level of Effort in Blocks for Non-Airgun HRG Surveys for Marine Minerals Sites

	Year								
Modeled Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
22	0.004	0.004	0.030	0.030	0.030	0.015	0.015	0.015	0.015
23	0.083	0.083	0.355	0.355	0.355	0.243	0.243	0.243	0.243
24	0.087	0.087	0.340	0.340	0.340	0.135	0.135	0.135	0.135
25	0.000	0.000	0.046	0.046	0.046	0.123	0.123	0.123	0.123
26	0.087	0.087	0.386	0.386	0.386	0.258	0.258	0.258	0.258
27	0.083	0.083	0.279	0.279	0.279	0.016	0.016	0.016	0.016
28	0.004	0.004	0.107	0.107	0.107	0.241	0.241	0.241	0.241
29	0.004	0.004	0.030	0.030	0.030	0.015	0.015	0.015	0.015
30	0.083	0.083	0.355	0.355	0.355	0.243	0.243	0.243	0.243
31	0.087	0.087	0.340	0.340	0.340	0.135	0.135	0.135	0.135
32	0.000	0.000	0.046	0.046	0.046	0.123	0.123	0.123	0.123
33	0.087	0.087	0.386	0.386	0.386	0.258	0.258	0.258	0.258
34	0.083	0.083	0.279	0.279	0.279	0.016	0.016	0.016	0.016
35	0.004	0.004	0.107	0.107	0.107	0.241	0.241	0.241	0.241

Table E-18

Adjusted Level of Effort in Blocks for Non-Airgun HRG Surveys for Renewable Energy Sites

	Year								
Modeled Area	2012	2013	2014	2015	2016	2017	2018	2019	2020
22	0.000	2.000	2.000	2.000	2.000	2.000	2.000	0.000	0.000
23	6.708	7.208	7.208	7.208	7.208	7.208	0.500	0.000	0.000
24	4.833	7.333	7.333	7.333	7.333	7.333	2.500	0.000	0.000
25	1.875	1.875	1.875	1.875	1.875	1.875	0.000	0.000	0.000
26	6.708	9.208	9.208	9.208	9.208	9.208	2.500	0.000	0.000
27	4.208	4.208	4.208	4.208	4.208	4.208	0.000	0.000	0.000
28	2.500	5.000	5.000	5.000	5.000	5.000	2.500	0.000	0.000
29	0.000	2.000	2.000	2.000	2.000	2.000	2.000	0.000	0.000
30	6.708	7.208	7.208	7.208	7.208	7.208	0.500	0.000	0.000
31	4.833	7.333	7.333	7.333	7.333	7.333	2.500	0.000	0.000
32	1.875	1.875	1.875	1.875	1.875	1.875	0.000	0.000	0.000
33	6.708	9.208	9.208	9.208	9.208	9.208	2.500	0.000	0.000
34	4.208	4.208	4.208	4.208	4.208	4.208	0.000	0.000	0.000
35	2.500	5.000	5.000	5.000	5.000	5.000	2.500	0.000	0.000

7.5. AIM Results and Adjustments

Calculations of incidental take to marine mammals from both seismic and non-seismic sound sources associated with the proposed action (Alternative A) scenario are presented below. Incidental take calculations were made using the AIM© model, described above in **Section 7.1**. The modeling used both the current NMFS criteria for Level A and Level B harassment, as well as the Southall et al. (2007) criterion for Level A harassment.

The acoustic and impact modeling conducted to support this Programmatic EIS is by its very nature complex and requires numerous assumptions to predict results in scenarios where:

- the period modeled is in the future and spans 5 years, during which the knowledge of the source locations and movement, animal locations and movement, oceanographic/acoustic conditions, equipment descriptions and specification, and even the time of the year for each survey are not precisely known;
- the details of marine mammal abundances, distributions, and behavior patterns are not precisely known and are subject to change as animal populations vary from year to year and location to location; and
- the development of new or re-designed survey equipment, survey techniques, survey geometries or even signal processing approaches could change.

The acoustic and impact modeling conducted to support this Programmatic EIS is by its very nature conservative and complex. It requires numerous assumptions to predict results in scenarios. Each of the inputs into the models is purposely developed to be conservative, and this conservativeness accumulates throughout the analysis. Further, the models do not take into account all of the extensive mitigation measures summarized in **Table S-1** or other caveats discussed below. They should not be considered as expected levels of actual take.

These take estimates do not alone reflect BOEM's determination of the impact to marine mammals. The impact assessment approach used by BOEM is described in detail in **Chapter 4**. It considers the modeled take estimates, the best available information on marine mammal distribution, current science assessing the potential effects of G&G surveys on marine mammals, and an evaluation of how employed mitigation can reduce these effects. Although all mitigations cannot be effective 100 percent of the time, these measures undoubtedly will contribute to species protection, and they will be refined as environmental impacts are evaluated in environmental review for site-specific authorizations, including ESA and MMPA consultation. This assessment is then compared against the significance criteria (described in **Chapter 4.2.2.2.1**) to identify an anticipated level of impact. Future site-specific actions proposed by operators will, as necessary, follow the MMPA procedures for issuance of an Incidental Take Authorization (ITA), which will again evaluate potential impacts.

In order to better understand how these conservative results differ from actual *in situ* impacts, several of the most prominent conservative assumptions are discussed below.

- **Acoustic Source Specifications:** There is a large variation in the size, configuration, and ultimately the source level of the airgun arrays potentially employed during surveys. The modeling selected one source that was representative of those used (i.e., it was more powerful than most [about 95 percent] of the sources listed) that would be used in the various survey types. However, this selection necessitated that the representative source conservatively represented sources that were often 10 or more decibels lower in power. In addition, it was assumed that the modeled array was always at maximum power and that all airguns where fully operational for fully completed survey scenarios. Similarly, for the mineral resources survey, the most conservative parameters for source level, signal repetition rate, pulse length, etc. were assumed. This is not always the case for either type of source in the field.
- **Acoustic Source Modeling:** For simplicity, the acoustic modeling replaces the actual predicted airgun array sound field with one produced by a point source (i.e., one that has a single larger airgun versus the distributed actual airgun array) and a beam pattern. This is fairly accurate in the far-field, which is typically 100-300 m (328-984 ft) from the array center and outward, but within this range (i.e., in the near-field) this can greatly overestimate the apparent source level and the subsequent impacts calculated. Simply replacing this conservative near-field approximation is feasible from a mathematical modeling point of view. However, since it is highly dependent on the actual source parameters, it would be difficult to justify it in the PEIS and it would greatly enlarge the modeling effort, while not necessarily remaining conservative.
- **Acoustic Propagation Modeling:** Typically, the acoustic parameters used in acoustic modeling (including sound velocity profile, bottom sediment types/distributions/ thicknesses/coefficients, and surface wind and wave values) are averaged seasonal values over reasonably sampled areas and time periods. These averaging processes remove most local variability while capturing the general effect of the sound speed on acoustic propagation. This generally tends to underestimate the transmission loss and therefore overestimate the received levels at all ranges to some degree. Actual *in situ* propagation therefore typically displays much more fading and disruption of the signal, especially for signals shorter than 1 s (i.e., airguns).
- **Acoustic Modeling of the Multi-Path:** When a signal propagates through the ocean, it typically follows many pathways between the source and a receiver (e.g., an animal). For example, one path may be directly between the source and receiver, while others may reflect off of the ocean surface or bottom before arriving at the receiver. For most of the models used in acoustic propagation analyses, the model assumes that the signals continue until all of the significant paths have arrived at the receiver, then the energy from these different pathways is summed to derive a final received value. This is a conservative approach for short signals, like airgun pulses, and this spreading of a signal (and its energy) generally increases as range increases. This is not a simple or easy correction to make since it can also be highly dependent on the receiver's position in range and depth. Therefore, the conservative assumption is used. Additionally, real-world localized effects, such as bubble plumes from breaking waves and the scattering of sound from plants and air present near the ocean's surface, also greatly reduce received levels for animals within 3-6 m (10-20 ft) of the ocean's surface.
- **Marine Mammal Density Values:** Marine mammal density values are typically very conservative. As a simple check of their conservatism, a calculation consisting of multiplying each density value by the area that it covers and then summing these

values results in total population values that greatly exceed those identified in the Marine Mammal Stock Assessment reports.

- **Marine Mammal Congregations:** Marine mammals, especially dolphins, often occur in pods or groups of animals. When this occurs, the actual density near that pod can be greater than those used in these calculations, but the corresponding reduction of density for much of the surrounding areas has been decreased. Statistically, this averages out for multiple model runs that are not accounting for this. However, when this occurs during actual operations, sources may be turned off, especially since large pods of dolphins, which often can consist of hundreds of animals, are much easier to observe and mitigate for.
- **Mitigation:** The calculations included here do not include most mitigation effects that would reduce the potential for take. The mitigation measures are focused on reducing take and represent a best practices approach. However, there are limitations to mitigation measures' effectiveness. For example, visual monitoring and PAM are not 100 percent effective due to a variety of factors, including the physical conditions; presence of animals at the surface; difficulty in species identification; vocalization of animals; lack of knowledge regarding sound produced by some species; and the regular masking of lower frequency vocalizations, such as those produced by baleen whales, by vessel noise. There would be one exception to this statement in that the take estimates did take into account the effect of the NARW airgun time-area closure outlined in Alternative A and described in **Section 7.4.3**.

So, although the take estimates provide quantifiable numbers to consider in the impact analysis (**Chapter 4.2.2.2** of the Programmatic EIS), it is important to understand that these numbers represent highly conservative estimates of mostly unmitigated potential take. They should not be considered as expected levels of actual take. This is largely given the many minor conservative assumptions that ultimately result in an overestimation of potential impacts.

7.5.1. Modeling Results

The output results from AIM provide the number of Level A and Level B harassment takes for each species, by season, modeled region, and survey type that exceeded the specific threshold considered. Following the AIM runs, typically the resulting "ping-histories" or the individual received level values (in pressure or SPL units) for each of the modeled animats are available to be examined and summed into energy (SEL) units as needed. For this analysis, the TL modeling provided to the AIM model included both SPL and SEL values, so the received levels in the correct units are readily available without additional calculations. The individual animat's SEL ping histories are then examined and summed for each animat to determine its total received energy, which is what is required to be compared to the threshold criteria. Note that nowhere in these calculations are any mitigation (e.g., ramp-ups or stopping transmissions) assumed or applied to the calculation. Finally, these results were then corrected to adjust for two parameters which were programmed into the modeling: (1) the density of animats/animals in the modeled area; and (2) the actual number of blocks that the model examined in each modeled region. As discussed previously, the animal densities used in the AIM modeling were deliberately kept high to ensure that a statistically valid result was obtained. Typically, these "modeled" densities are at least an order of magnitude greater than the actual marine mammal density present in the region. Therefore, the modeling result is corrected or scaled by the ratio of the actual density divided by the modeled density. The result of applying these two corrections to the AIM modeling is a set of three tables for each type of survey. **Tables E-19** through **E-21** are a representative example of these tables for the 2D seismic airgun surveys. Each of these three tables captures the seasonal and spatial variability of the results in the 21 columns representing the 21 modeling regions, while providing the estimated impacts or takes for a specific threshold. The three tables, therefore, each represent one of the thresholds of interest. They are: (1) potential Level A impacts (takes) based on the Southall et al. (2007) criteria for one block of 2D survey effort; (2) potential Level A impacts (takes) based on the historic 180 dB (SPL) criterion for one block of 2D survey effort; and (3) the potential Level B impacts (takes) based on the historic 160 dB (SPL) criterion for one block of 2D survey effort.

Table E-19

Potential Level A Takes (number of individuals) for One Block of 2D Seismic Airgun Survey Effort, Based on the Southall et al. (2007) Injury Criteria

Common Name	Modeled Site																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ORDER CETACEA																					
Suborder Mysticeti (Baleen Whales)																					
Common minke whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sei whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bryde's whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blue whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fin whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
North Atlantic right whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Humpback whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)																					
Short-beaked common dolphin	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pygmy killer whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Short-finned pilot whale	0.003	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001
Long-finned pilot whale	0.001	0.000	0.008	0.000	0.000	0.000	0.000	0.009	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
Risso's dolphin	0.000	0.000	0.036	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.000	0.000	0.044	0.000	0.000	0.000	0.000	0.000	0.036	0.000	0.000
Northern bottlenose whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pygmy sperm whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dwarf sperm whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Atlantic white-sided dolphin	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fraser's dolphin	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sowerby's beaked whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blainville's beaked whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Gervais' beaked whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
True's beaked whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
Killer whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Melon-headed whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor porpoise	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sperm whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
False killer whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pantropical spotted dolphin	0.000	0.000	0.000	0.009	0.000	0.000	0.009	0.000	0.009	0.000	0.000	0.009	0.000	0.000	0.009	0.000	0.009	0.009	0.000	0.009	0.000
Clymene dolphin	0.000	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.004	0.000	0.000	0.004	0.000	0.000	0.004	0.000	0.004	0.004	0.000	0.004	0.000
Striped dolphin	0.000	0.000	0.000	0.011	0.000	0.000	0.084	0.000	0.011	0.000	0.000	0.022	0.000	0.000	0.020	0.000	0.011	0.011	0.000	0.011	0.000
Atlantic spotted dolphin	0.000	0.000	0.000	0.117	0.000	0.000	0.063	0.000	0.081	0.000	0.000	0.075	0.000	0.000	0.009	0.000	0.001	0.001	0.000	0.107	0.000
Spinner dolphin:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rough-toothed dolphin	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bottlenose dolphin	0.000	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cuvier's beaked whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000
ORDER SIRENIA																					
West Indian manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA																					
Suborder Pinnipedia																					
Hooded seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table E-20

Potential Level A Takes (number of individuals) for One Block of 2D Seismic Airgun Survey Effort, Based on the Historic NMFS Criterion (180 dB)

Common Name	Modeled Site																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ORDER CETACEA																					
Suborder Mysticeti (Baleen Whales)																					
Common minke whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sei whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bryde's whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blue whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fin whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
North Atlantic right whale	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Humpback whale	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)																					
Short-beaked common dolphin	0.012	0.019	0.245	0.036	0.142	0.011	0.016	0.243	0.300	0.049	0.008	0.012	0.250	0.215	0.010	0.033	0.010	0.018	0.073	0.293	0.046
Pygmy killer whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Short-finned pilot whale	0.002	0.037	0.247	0.003	0.001	0.001	0.020	0.244	0.033	0.002	0.000	0.017	0.150	0.034	0.019	0.005	0.001	0.029	0.160	0.000	0.001
Long-finned pilot whale	0.001	0.009	0.022	0.000	0.000	0.000	0.006	0.024	0.007	0.001	0.000	0.005	0.015	0.004	0.007	0.001	0.000	0.007	0.011	0.000	0.000
Risso's dolphin	0.010	0.017	0.103	0.014	0.049	0.001	0.019	0.126	0.025	0.000	0.000	0.033	0.127	0.035	0.000	0.035	0.000	0.008	0.103	0.014	0.035
Northern bottlenose whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pygmy sperm whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dwarf sperm whale	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Atlantic white-sided dolphin	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fraser's dolphin	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sowerby's beaked whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blainville's beaked whale	0.000	0.001	0.003	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.002	0.000	0.000
Gervais' beaked whale	0.000	0.001	0.003	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.002	0.000	0.000
True's beaked whale	0.000	0.001	0.003	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.002	0.000	0.000
Killer whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Melon-headed whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor porpoise	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sperm whale	0.000	0.005	0.014	0.000	0.000	0.000	0.006	0.007	0.000	0.000	0.000	0.007	0.007	0.000	0.003	0.007	0.000	0.000	0.000	0.000	0.000
False killer whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pantropical spotted dolphin	0.005	0.007	0.021	0.020	0.015	0.004	0.006	0.021	0.022	0.021	0.004	0.005	0.022	0.026	0.006	0.006	0.006	0.006	0.021	0.022	0.020
Clymene dolphin	0.002	0.003	0.010	0.009	0.007	0.002	0.003	0.010	0.011	0.010	0.002	0.002	0.010	0.008	0.003	0.003	0.003	0.003	0.010	0.011	0.010
Striped dolphin	0.006	0.072	0.221	0.024	0.022	0.005	0.052	0.025	0.027	0.025	0.004	0.012	0.203	0.026	0.013	0.075	0.008	0.007	0.025	0.027	0.025
Atlantic spotted dolphin	0.000	0.064	0.179	0.260	0.211	0.000	0.039	0.082	0.203	0.232	0.000	0.040	0.191	0.252	0.006	0.070	0.001	0.001	0.011	0.266	0.176
Spinner dolphin:	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rough-toothed dolphin	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
Bottlenose dolphin	0.005	0.017	0.350	0.353	0.049	0.005	0.083	0.356	0.035	0.033	0.004	0.074	0.464	0.274	0.010	0.107	0.007	0.110	0.417	0.217	0.261
Cuvier's beaked whale	0.000	0.010	0.019	0.000	0.000	0.000	0.007	0.017	0.000	0.000	0.000	0.006	0.008	0.000	0.007	0.009	0.000	0.006	0.017	0.000	0.000
ORDER SIRENIA																					
West Indian manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA																					
Suborder Pinnipedia																					
Hooded seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table E-21

Potential Level B Takes (number of individuals) for One Block of 2D Seismic Airgun Survey Effort, Based on the Historic NMFS Criterion (160 dB)

Common Name	Modeled Site																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ORDER CETACEA																					
Suborder Mysticeti (Baleen Whales)																					
Common minke whale	0.001	0.001	0.000	0.000	0.003	0.001	0.001	0.000	0.000	0.004	0.001	0.001	0.000	0.004	0.000	0.000	0.000	0.001	0.000	0.000	0.003
Sei whale	0.002	0.003	0.010	0.009	0.007	0.002	0.002	0.010	0.010	0.010	0.002	0.001	0.010	0.007	0.003	0.003	0.002	0.003	0.010	0.010	0.009
Bryde’s whale	0.002	0.003	0.009	0.010	0.007	0.002	0.002	0.009	0.010	0.010	0.002	0.001	0.010	0.008	0.003	0.003	0.003	0.003	0.009	0.010	0.009
Blue whale	0.003	0.004	0.009	0.010	0.008	0.003	0.003	0.009	0.010	0.010	0.002	0.003	0.010	0.008	0.003	0.003	0.003	0.004	0.009	0.010	0.010
Fin whale	0.004	0.004	0.040	0.011	0.010	0.003	0.004	0.008	0.051	0.009	0.003	0.003	0.040	0.010	0.003	0.020	0.004	0.004	0.008	0.016	0.010
North Atlantic right whale	0.000	0.000	0.000	0.142	0.039	0.000	0.000	0.003	0.016	0.014	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.059	0.012
Humpback whale	0.015	0.024	0.058	0.033	0.059	0.012	0.016	0.059	0.052	0.088	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)																					
Short-beaked common dolphin	1.182	1.882	24.008	3.566	13.956	1.050	1.568	23.791	29.431	4.814	0.810	1.138	24.514	21.043	0.941	3.216	1.028	1.794	7.199	28.708	4.464
Pygmy killer whale	0.003	0.005	0.010	0.009	0.010	0.003	0.003	0.010	0.010	0.012	0.002	0.003	0.009	0.008	0.002	0.004	0.003	0.003	0.010	0.011	0.009
Short-finned pilot whale	0.240	3.668	24.254	0.324	0.125	0.062	1.962	23.899	3.197	0.156	0.025	1.666	14.658	3.365	1.875	0.482	0.076	2.886	15.713	0.047	0.138
Long-finned pilot whale	0.080	0.917	2.144	0.000	0.029	0.021	0.611	2.384	0.677	0.052	0.008	0.519	1.467	0.406	0.716	0.129	0.024	0.666	1.055	0.026	0.009
Risso’s dolphin	0.968	1.678	10.082	1.398	4.778	0.061	1.856	12.365	2.456	0.043	0.023	3.203	12.472	3.470	0.047	3.421	0.028	0.818	10.099	1.343	3.452
Northern bottlenose whale	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000
Pygmy sperm whale	0.008	0.010	0.000	0.000	0.014	0.008	0.011	0.000	0.000	0.015	0.008	0.010	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.014
Dwarf sperm whale	0.025	0.030	0.061	0.025	0.042	0.025	0.034	0.061	0.017	0.045	0.023	0.029	0.061	0.049	0.027	0.027	0.020	0.025	0.061	0.018	0.041
Atlantic white-sided dolphin	0.035	0.000	0.062	0.000	0.000	0.008	0.000	0.020	0.006	0.000	0.007	0.000	0.020	0.019	0.018	0.018	0.013	0.000	0.014	0.012	0.000
Fraser's dolphin	0.003	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.000
Sowerby’s beaked whale	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
Blainville’s beaked whale	0.001	0.138	0.260	0.000	0.001	0.001	0.100	0.231	0.000	0.001	0.001	0.084	0.115	0.001	0.097	0.124	0.000	0.090	0.237	0.000	0.001
Gervais’ beaked whale	0.001	0.138	0.260	0.000	0.001	0.001	0.100	0.231	0.000	0.001	0.001	0.084	0.115	0.001	0.097	0.124	0.000	0.090	0.237	0.000	0.001
True’s beaked whale	0.001	0.138	0.260	0.000	0.001	0.001	0.100	0.231	0.000	0.001	0.001	0.084	0.115	0.001	0.097	0.124	0.000	0.090	0.237	0.000	0.001
Killer whale	0.003	0.004	0.008	0.003	0.008	0.003	0.003	0.008	0.003	0.011	0.002	0.003	0.008	0.005	0.005	0.004	0.004	0.003	0.008	0.002	0.012
Melon-headed whale	0.003	0.005	0.012	0.012	0.010	0.003	0.003	0.012	0.012	0.012	0.002	0.003	0.011	0.010	0.004	0.004	0.003	0.003	0.012	0.013	0.009
Harbor porpoise	0.022	0.021	0.073	0.000	0.016	0.009	0.010	0.040	0.009	0.053	0.002	0.002	0.008	0.007	0.018	0.024	0.016	0.007	0.028	0.017	0.011
Sperm whale	0.008	0.502	1.384	0.003	0.005	0.006	0.553	0.708	0.002	0.005	0.005	0.696	0.696	0.003	0.340	0.700	0.008	0.009	0.014	0.002	0.005
False killer whale	0.003	0.005	0.016	0.018	0.010	0.003	0.003	0.016	0.004	0.012	0.002	0.003	0.016	0.006	0.004	0.005	0.003	0.003	0.016	0.003	0.009
Pantropical spotted dolphin	0.498	0.676	2.083	1.940	1.451	0.383	0.543	2.038	2.198	2.011	0.347	0.472	2.118	2.528	0.587	0.614	0.632	0.587	2.038	2.172	2.003
Clymene dolphin	0.238	0.323	0.995	0.927	0.693	0.183	0.259	0.974	1.050	0.961	0.166	0.225	1.012	0.829	0.281	0.293	0.302	0.281	0.974	1.037	0.957
Striped dolphin	0.603	7.028	21.640	2.346	2.164	0.463	5.105	2.464	2.658	2.432	0.420	1.170	19.917	2.589	1.307	7.335	0.764	0.710	2.464	2.625	2.421
Atlantic spotted dolphin	0.047	6.291	17.501	25.444	20.654	0.036	3.830	8.064	19.944	22.762	0.033	3.964	18.751	24.709	0.583	6.814	0.060	0.055	1.107	26.046	17.263
Spinner dolphin:	0.002	0.003	0.009	0.009	0.007	0.002	0.002	0.009	0.010	0.009	0.002	0.002	0.010	0.008	0.003	0.003	0.003	0.003	0.009	0.010	0.009
Rough-toothed dolphin	0.021	0.029	0.049	0.054	0.067	0.021	0.026	0.049	0.086	0.056	0.019	0.024	0.047	0.037	0.022	0.026	0.027	0.020	0.049	0.088	0.047
Bottlenose dolphin	0.501	1.684	34.290	34.629	4.811	0.473	8.098	34.882	3.385	3.267	0.394	7.267	45.474	26.882	0.982	10.488	0.680	10.751	40.828	21.279	25.572
Cuvier’s beaked whale	0.005	0.965	1.818	0.002	0.004	0.005	0.698	1.620	0.002	0.004	0.005	0.588	0.804	0.004	0.677	0.868	0.003	0.629	1.657	0.002	0.004
ORDER SIRENIA																					
West Indian manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA																					
Suborder Pinnipedia																					
Hooded seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Based on comments received to the Draft Programmatic EIS, harp seals were added to the marine mammals list but were not modeled. However, based on the densities in the NODE database, the number of Level A and Level B harassment takes for the harp seal would be zero.

Similar tables were produced for each of the seismic airgun surveys and non-airgun HRG surveys to be conducted, including the following:

Seismic Airgun Surveys

- 2D seismic surveys;
- 3D seismic surveys;
- WAZ seismic surveys;
- VSP seismic surveys; and
- HRG surveys (90 in^3 airgun).

Non-Airgun HRG Surveys

- boomer HRG marine mineral surveys;
- boomer HRG renewable energy surveys;
- side-scan sonar HRG marine mineral surveys;
- side-scan sonar HRG renewable energy surveys;
- chirp subbottom profiler HRG marine mineral surveys;
- chirp subbottom profiler HRG renewable energy surveys;
- multibeam HRG marine mineral surveys; and
- multibeam HRG renewable energy surveys.

For the non-airgun HRG surveys, even though the individual surveys are typically conducted in roughly square nautical mile areas, all of the above tables were presented in a “per block” format to be consistent with the airgun surveys. Also, the LOE tables for these non-airgun surveys have been kept in that format.

Each of these “per block” survey results were multiplied by the appropriate LOE to estimate the number of incidental takes by species by modeled area for each year. Total annual takes are summarized in the following tables in the **Attachment** to this appendix:

All Surveys (seismic airgun and non-airgun HRG)

- Table Attachment E-1: Level A incidental take using Southall criteria
- Table Attachment E-2: Level A incidental take using historic NMFS criterion (180 dB SPL)
- Table Attachment E-3: Level B incidental take using historic NMFS criterion (160 dB SPL)

All Seismic Airgun Surveys

- Table Attachment E-4: Level A incidental take using Southall criteria
- Table Attachment E-5: Level A incidental take using historic NMFS criterion (180 dB SPL)
- Table Attachment E-6: Level B incidental take using historic NMFS criterion (160 dB SPL)

All Non-Airgun HRG Surveys

- Table Attachment E-7: Level A incidental take using Southall criteria
- Table Attachment E-8: Level A incidental take using historic NMFS criterion (180 dB SPL)

- Table Attachment E-9: Level B incidental take using historic NMFS criterion (160 dB SPL)

Supporting tables for each year and survey type are available on BOEM's website at http://www.boem.gov/Oil-and-Gas-Energy-Program/GOMR/GandG.aspx.

In general, due to their significant LOE and strong transmission signal, for any given year the combination of 2D and 3D surveys, account for about 90-95 percent of all takes, while all of the non-airgun survey efforts result in less than about 5 percent of takes for any given year. This is due to their lower source levels, beam patterns, and significantly lower LOE.

7.5.2. Discussion of the Uncertainty of the Modeling Effort

The task for this modeling effort was to use the best available science to estimate the potential impacts of the proposed action on marine mammals. There are several steps in the modeling effort and a degree of uncertainty associated with each step. The first step was outlining the proposed action, including defining the variety of sources and where and how they might be utilized. It is important to recognize that this is a Programmatic EIS to help BOEM develop a comprehensive understanding of the potential for multiple possible activities within three program areas (oil and gas, renewable energy, and marine minerals) to impact the marine environment over a 10-year period from 2012-2020. It is a framework under which future NEPA and MMPA evaluations of site-specific actions will occur, including requests for incidental take authorizations (ITAs), if necessary. Within those site-specific documents, much more refined actions will be outlined and evaluated.

To begin to outline the possible actions that may occur across three program areas for 10 years, representative conditions needed to be developed. In **Chapter 3**, projected activity levels for each of the three program areas were outlined. These activity levels are based on historic use of the area of interest (AOI) and interviews with industry representatives on anticipated survey interest. A variety of G&G techniques are used to characterize the shallow and deep structure of the shelf, slope, and deepwater ocean environments. The G&G surveys are conducted to (1) obtain data for hydrocarbon exploration and production; (2) aid in siting renewable energy structures; (3) locate potential sand and gravel resources; (4) identify possible seafloor or shallow depth geologic hazards; and (5) locate potential archaeological resources and potential hard bottom habitats for avoidance. The selection of a specific technique or suite of techniques is driven by data needs and the target of interest. With input of industry on data needs and interests, and the historical background of activity previously authorized by BOEM within the region, projected activity levels were developed. Because these are projected activity levels, there is uncertainty in the level and location of effort, but the best available data were used to determine the best estimates of activity and location.

Once the activities and locations were outlined, the characteristics of the active acoustic sources and the propagation conditions of the environment were defined. The active acoustic sources vary in their implementation based on the objective of the survey. **Appendix D** describes the acoustic characteristics of representative sources selected for analysis in the Programmatic EIS; other sources were not modeled as they either produce an acoustic field similar to another modeled source, or the sound field levels are negligible compared to other equipment. Depending on the objective and location of a particular survey, the acoustic sources may have a different configuration, which would influence the way that acoustic energy propagates away from it. The analyses described in this appendix and **Appendix D** used the best available, state-of-the-art acoustic models and databases for determining acoustic propagation and source characteristics. As described in detail in **Appendix D**, there are several major factors that affect sound propagation, including the sound source and characteristics of the location (water depth, bottom composition, sound velocity profile, etc.). In order to capture the full range of potential actions, 105 acoustic field estimates were conducted, which included various permutations of six acoustic sources, 35 modeling sites, two types of bottom composition, and 12 sound velocity profiles. These acoustic field estimates span the range of propagation conditions and G&G activities that may occur during the proposed action and bound the range of potential impacts.

The next step in the modeling effort was to define the marine mammals that may occur in the AOI during the proposed action. The best available data at the time of this analysis was the U.S. Navy's NODE database (U.S. Dept. of the Navy, 2007b), described in Section 6 of this appendix. The database consolidates cetacean density estimates from shipboard line-transect surveys conducted by the NOAA

Fisheries Southeast Fisheries Science Center between 1994 and 2006. There are advantages and disadvantages to using this database to estimate potential impacts. One advantage is that the database consolidated multiple surveys across several years. By spanning multiple years and oceanographic conditions, any bias associated with density estimates from single surveys that might not represent average oceanographic conditions is reduced. Furthermore, when sufficient data were available, spatially explicit, species-specific density surface models were derived that incorporated environmental covariates. These surface models utilized the environmental covariates to predict species density in regions where little survey effort had occurred, thereby reducing biases associated with broad-scale surveys that could not sample the entire AOI. One disadvantage of the database is that the surveys included in the database occurred in 1994-2006. NOAA Fisheries maintains guidelines recommending that no data older than eight years be used to calculate potential biological removal in its stock assessment reports (Wade and Angliss, 1997). Some of the data included in the database are older than 8 years and might not reliably represent current conditions. In addition, the NODE database does not include confidence limits for density estimates.

The most significant drawback to the Southeast NODE database is that it assumes all animals located directly on the trackline were observed during the surveys. This assumption of line-transect theory is defined by the equation $g(0)=1$ (i.e., at a distance of 0, the probability of detecting a group is 1; Buckland et al., 1993, 2001). However, because of availability bias (i.e., animals are diving and not available to be seen at the ocean surface) and perception bias (i.e., animals at the surface are not detected by the survey team because of other factors, such as sun glare, sea state, or cryptic behaviors), this assumption is not met during cetacean line-transect surveys. In some surveys, attempts were made to estimate the fraction of groups missed on the transect line, to quantify the amount of bias associated with that survey. For the surveys incorporated into the Southeast NODE database, it was assumed that $g(0)=1$ because $g(0)$ could not be calculated during the surveys and there were no $g(0)$ estimates available for species in the southeast study area. Therefore, the density estimates in the NODE database are underestimates.

BOEM recognizes the limitations in the existing NODE database but used it for this Programmatic EIS as the best available data for a programmatic analysis of the entire AOI. BOEM expects that better density data will become available in the near future and is committed to using the best available new information as it becomes available. In 2011, NOAA convened a working group to map cetacean density and distribution (CetMap) within U.S. waters including the Atlantic and concurrently an underwater sound field working group (SoundMap) to characterize ocean noise. BOEM expects that the CetMap density data will be superior to the NODE database used for the calculations in this Programmatic EIS. However, the CetMap density data for the Atlantic were not available prior to the release of the Draft Programmatic EIS and have not become available during the 12-month period following the close of the public comment period. Even though the data were not available for incorporation into either the Draft or the Final Programmatic EIS, BOEM will use the CetMap data for future G&G exploration reviews when the new data and and maps become available.

The final step in the modeling effort in this Programmatic EIS was to integrate the acoustic field estimates with the marine mammals to determine their acoustic exposure during a particular activity. Time-based integration models, such as the AIM used in this modeling effort and described in detail in Section 7 of this appendix, are necessary to fully evaluate the potential exposure. Under the oversight and sponsorship of NOAA/NMFS, the Center for Independent Experts (CIE) conducted a thorough review of AIM in 2006. The main findings were as follows:

- AIM can correctly implement the models and data upon which it is based;
- animal movement appears to be appropriately modeled within AIM;
- the principles of credible science had been addressed during the development of AIM;
- AIM is a useful and credible tool for developing application models; and
- the use of AIM can lead to models which will meet the Council for Regulatory Monitoring (CREM) guidelines for model development and evaluation.

Because the exact positions of sound sources and animals (sound receivers for the purpose of this analysis) cannot be known, multiple runs of realistic simulations are used to provide statistical validity of the predicted potential effects. The range of documented animal movement and diving behaviors are captured in probabilistic definitions of simulated behavior. Many more animals than could realistically be encountered during an activity are modeled. Both of these conservative measures help to fully bound the range of potential impacts.

The above discussion provides insight into the multiple steps in the modeling effort and the degree of certainty associated with the process. For each step, the best estimate for each data parameter was used to derive the best estimate of the potential impacts of the proposed action on the marine environment. BOEM does not believe it is realistic to develop confidence limits for incidental take estimates at this time for several reasons. First, incidental take applications and authorizations generally do not contain this information. Second, we do not believe it is appropriate to calculate confidence limits for Level A takes because we expect them to be avoided to the extent practicable through mitigation. The modeling in this appendix estimates Level A takes without mitigation (other than time-area closures), which is the typical method used in ITAs. Finally, with respect to Level B harassment takes, we note that the current NMFS criterion for pulsed sources (160 dB re 1 µPa) is widely recognized as a very simplistic predictor of behavioral responses, and there is much ongoing research and discussion to develop refined behavioral criteria. Therefore, we believe that calculating confidence limits for numbers of Level B harassment takes would imply a level of quantification and statistical certainty that does not currently exist.

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ATTACHMENT: SUMMARY TABLES OF TOTAL ANNUAL TAKE ESTIMATES

Table Attachment E-1

All Surveys (airgun and non-airgun) – Total Annual Level A Takes (number of individuals) Using Southall Criteria

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.000	0.000	0.084	0.161	0.018	0.067	0.047	0.022	0.024
Sei Whale	0.002	0.002	0.211	0.405	0.049	0.172	0.121	0.061	0.068
Bryde's Whale	0.002	0.003	0.635	1.240	0.147	0.716	0.536	0.364	0.173
Blue Whale	0.000	0.000	0.831	1.623	0.181	0.908	0.672	0.443	0.215
Fin Whale	0.015	0.021	0.021	0.021	0.021	0.018	0.005	0.000	0.000
North Atlantic Right Whale	0.002	0.003	0.039	0.074	0.011	0.047	0.034	0.024	0.009
Humpback Whale	0.000	0.000	3.046	5.931	0.674	3.102	2.279	1.415	0.848
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	4.094	5.223	121.807	230.677	24.072	100.657	65.225	28.714	23.101
Pygmy Killer Whale	0.000	0.001	0.162	0.313	0.062	0.159	0.130	0.082	0.091
Short-Finned Pilot Whale	0.005	0.011	11.627	22.508	74.427	55.171	93.699	123.153	153.571
Long-Finned Pilot Whale	0.000	0.000	59.577	117.528	13.886	79.691	61.042	45.685	14.791
Risso’s Dolphin	1.863	2.229	372.779	733.668	89.369	503.600	385.481	290.103	92.466
Northern Bottlenose Whale	0.000	0.000	0.004	0.007	0.001	0.003	0.002	0.001	0.001
Pygmy Sperm Whale	0.005	0.006	0.006	0.006	0.087	0.047	0.081	0.083	0.138
Dwarf Sperm Whale	0.014	0.019	2.838	5.583	1.345	4.218	3.681	3.169	2.010
Atlantic White-sided Dolphin	0.000	0.000	1.347	2.659	0.522	1.965	1.659	1.415	0.768
Fraser's Dolphin	0.000	0.000	0.209	0.403	0.033	0.162	0.105	0.041	0.040
Sowerby's Beaked Whale	0.000	0.000	0.000	0.000	0.006	0.004	0.007	0.009	0.012
Blainville's Beaked Whale	0.000	0.000	1.459	2.816	0.225	1.126	0.731	0.282	0.282
Gervais' Beaked Whale	0.000	0.000	1.459	2.816	0.225	1.126	0.731	0.282	0.282
True's Beaked Whale	0.000	0.000	1.459	2.816	0.225	1.126	0.731	0.282	0.282
Killer Whale	0.003	0.006	0.058	0.106	0.039	0.059	0.056	0.040	0.056
Melon-Headed Whale	0.000	0.000	0.161	0.313	0.062	0.158	0.129	0.082	0.091
Harbor Porpoise	0.001	0.001	2.065	3.995	0.656	1.914	1.510	0.963	1.012
Sperm Whale	0.001	0.001	0.096	0.185	0.016	0.076	0.050	0.021	0.019
False Killer Whale	0.000	0.000	0.155	0.300	0.126	0.194	0.204	0.186	0.224
Pantropical Spotted Dolphin	0.448	0.587	136.558	264.052	35.998	127.698	96.680	61.943	53.868
Clymene Dolphin	0.214	0.280	65.241	126.151	17.198	61.008	46.189	29.593	25.736
Striped Dolphin	0.595	0.767	528.228	1021.267	158.742	487.628	383.634	258.793	256.816
Atlantic Spotted Dolphin	5.399	6.957	778.669	1503.662	208.965	747.752	566.636	369.930	303.780
Spinner Dolphin	0.002	0.003	0.614	1.187	0.162	0.574	0.435	0.278	0.242
Rough-Toothed Dolphin	0.010	0.015	0.015	0.015	0.050	0.036	0.048	26.189	0.075
Bottlenose Dolphin	1.298	2.142	17.135	31.297	24.044	30.537	35.859	39.268	42.313
Cuvier's Beaked Whale	0.001	0.002	10.214	19.711	1.578	7.884	5.119	1.972	1.972
ORDER SIRENIA									
West Indian Manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table Attachment E-2

All Surveys (airgun and non-airgun) – Total Annual Level A Takes (number of individuals) Using Historic NMFS Criterion (180 dB)

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.000	0.000	0.342	0.666	0.101	0.365	0.285	0.197	0.144
Sei Whale	0.000	0.000	1.966	3.855	0.648	2.474	2.010	1.568	0.928
Bryde's Whale	0.000	0.000	1.948	3.820	0.642	2.445	1.987	1.549	0.920
Blue Whale	0.001	0.001	2.183	4.275	0.701	2.654	2.140	1.633	1.003
Fin Whale	0.001	0.002	4.401	8.639	1.509	5.681	4.661	3.707	2.185
North Atlantic Right Whale	0.002	0.003	1.164	2.293	0.613	1.760	1.600	1.467	0.866
Humpback Whale	0.003	0.003	5.901	11.546	1.857	7.074	5.674	4.277	2.638
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	1.219	1.459	3122.878	6148.048	1115.753	4284.442	3553.253	2921.201	1615.095
Pygmy Killer Whale	0.000	0.001	2.253	4.410	0.706	2.709	2.171	1.636	0.999
Short-Finned Pilot Whale	0.013	0.017	2354.317	4631.150	840.273	3170.293	2628.399	2146.148	1226.868
Long-Finned Pilot Whale	0.003	0.003	297.403	582.364	96.848	362.033	293.016	224.532	140.102
Risso’s Dolphin	0.091	0.112	1619.783	3180.578	551.281	2096.002	1718.057	1368.235	798.633
Northern Bottlenose Whale	0.000	0.000	0.127	0.250	0.043	0.174	0.143	0.116	0.061
Pygmy Sperm Whale	0.001	0.002	2.372	4.594	0.561	2.142	1.563	0.872	0.772
Dwarf Sperm Whale	0.003	0.005	14.849	29.009	4.269	16.957	13.306	9.596	5.951
Atlantic White-sided Dolphin	0.000	0.000	4.668	9.152	1.468	5.795	4.659	3.574	2.067
Fraser's Dolphin	0.000	0.001	0.243	0.469	0.056	0.211	0.152	0.080	0.076
Sowerby's Beaked Whale	0.000	0.000	0.203	0.397	0.060	0.233	0.184	0.134	0.085
Blainville's Beaked Whale	0.000	0.000	39.568	77.313	11.835	45.465	35.992	26.242	16.771
Gervais' Beaked Whale	0.000	0.000	39.568	77.313	11.835	45.465	35.992	26.242	16.771
True's Beaked Whale	0.000	0.000	39.568	77.313	11.835	45.465	35.992	26.242	16.771
Killer Whale	0.001	0.001	1.966	3.844	0.603	2.310	1.840	1.363	0.854
Melon-Headed Whale	0.000	0.001	2.523	4.943	0.818	3.099	2.506	1.925	1.171
Harbor Porpoise	0.002	0.002	7.056	13.800	2.246	8.378	6.736	5.074	3.242
Sperm Whale	0.000	0.000	158.828	309.724	44.502	173.128	134.561	93.598	62.379
False Killer Whale	0.000	0.001	2.802	5.492	0.930	3.501	2.849	2.219	1.337
Pantropical Spotted Dolphin	0.304	0.445	447.192	876.533	146.418	560.370	454.376	353.146	208.593
Clymene Dolphin	0.145	0.213	207.399	406.406	67.598	258.364	209.218	161.992	96.255
Striped Dolphin	0.396	0.575	2039.432	3993.807	651.474	2484.216	2001.592	1526.857	930.479
Atlantic Spotted Dolphin	3.461	4.927	2983.959	5852.577	993.875	3818.018	3108.774	2447.448	1409.673
Spinner Dolphin	0.001	0.002	1.951	3.823	0.636	2.430	1.968	1.524	0.906
Rough-Toothed Dolphin	0.006	0.007	13.762	26.895	4.286	16.056	12.829	9.515	6.129
Bottlenose Dolphin	0.938	1.406	5978.504	11749.675	2092.311	7910.110	6525.719	5268.738	3028.705
Cuvier's Beaked Whale	0.000	0.000	276.973	541.189	82.842	318.256	251.943	183.694	117.398
ORDER SIRENIA									
West Indian Manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table Attachment E-3

All Surveys (airgun and non-airgun) – Total Annual Level B Takes (number of individuals) Using Historic NMFS Criterion (160 dB)

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.022	0.029	33.552	65.312	9.887	35.746	27.976	19.270	14.158
Sei Whale	0.036	0.048	192.676	377.852	63.517	242.451	197.032	153.667	90.922
Bryde's Whale	0.036	0.047	190.946	374.409	62.955	239.663	194.766	151.772	90.214
Blue Whale	0.066	0.098	214.005	418.979	68.725	260.084	209.774	160.036	98.302
Fin Whale	0.115	0.160	431.371	846.749	147.899	556.747	456.786	363.296	214.176
North Atlantic Right Whale	0.194	0.246	114.095	224.739	60.098	172.494	156.800	143.799	84.922
Humpback Whale	0.245	0.328	578.309	1131.575	181.990	693.318	556.149	419.221	258.568
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	119.444	142.983	306073.239	602570.182	109354.910	419918.182	348254.315	286306.930	158295.425
Pygmy Killer Whale	0.034	0.049	220.825	432.243	69.155	265.498	212.809	160.343	97.950
Short-Finned Pilot Whale	1.292	1.629	230746.601	453899.015	82355.144	310720.375	257609.343	210343.995	120245.361
Long-Finned Pilot Whale	0.262	0.320	29148.479	57077.465	9492.066	35482.820	28718.497	22006.375	13731.407
Risso’s Dolphin	8.944	10.958	158754.967	311728.435	54031.021	205429.110	168386.746	134100.755	78273.997
Northern Bottlenose Whale	0.000	0.000	12.462	24.544	4.259	17.031	14.000	11.400	6.015
Pygmy Sperm Whale	0.112	0.150	232.504	450.223	54.935	209.923	153.146	85.507	75.617
Dwarf Sperm Whale	0.336	0.451	1455.336	2843.191	418.399	1661.964	1304.137	940.513	583.263
Atlantic White-sided Dolphin	0.003	0.005	457.486	896.992	143.832	567.940	456.642	350.280	202.615
Fraser's Dolphin	0.035	0.057	23.781	45.946	5.491	20.650	14.849	7.792	7.488
Sowerby's Beaked Whale	0.002	0.003	19.913	38.908	5.905	22.877	18.076	13.154	8.304
Blainville's Beaked Whale	0.002	0.003	3878.018	7577.417	1159.905	4456.041	3527.568	2571.983	1643.742
Gervais' Beaked Whale	0.002	0.003	3878.018	7577.417	1159.905	4456.041	3527.568	2571.983	1643.742
True's Beaked Whale	0.003	0.003	3878.019	7577.418	1159.905	4456.041	3527.568	2571.983	1643.742
Killer Whale	0.051	0.064	192.657	376.717	59.070	226.357	180.328	133.634	83.748
Melon-Headed Whale	0.036	0.053	247.292	484.433	80.188	303.734	245.652	188.696	114.732
Harbor Porpoise	0.154	0.172	691.548	1352.566	220.178	821.083	660.231	497.283	317.753
Sperm Whale	0.018	0.021	15566.727	30356.018	4361.685	16968.298	13188.312	9173.569	6113.787
False Killer Whale	0.039	0.058	274.585	538.272	91.171	343.171	279.236	217.454	131.030
Pantropical Spotted Dolphin	29.753	43.645	43829.255	85909.037	14350.425	54921.838	44533.415	34611.829	20444.174
Clymene Dolphin	14.215	20.851	20327.206	39831.854	6625.244	25322.211	20505.465	15876.869	9433.977
Striped Dolphin	38.853	56.401	199884.688	391433.034	63850.968	243477.994	196176.044	149647.258	91196.244
Atlantic Spotted Dolphin	339.182	482.888	292457.860	573611.088	97409.708	374203.969	304690.978	239874.373	138162.050
Spinner Dolphin	0.131	0.190	191.219	374.705	62.320	238.208	192.899	149.359	88.749
Rough-Toothed Dolphin	0.555	0.728	1348.839	2636.003	420.112	1573.606	1257.388	932.571	600.688
Bottlenose Dolphin	91.950	137.760	585953.172	1151585.614	205067.371	775269.861	639585.714	516389.050	296843.403
Cuvier's Beaked Whale	0.016	0.018	27146.128	53041.920	8119.334	31192.284	24692.973	18003.881	11506.197
ORDER SIRENIA									
West Indian Manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table Attachment E-4

All Seismic Airgun Surveys – Total Annual Level A Takes (number of individuals) Using Southall Criteria

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.000	0.000	0.083	0.161	0.017	0.067	0.047	0.022	0.024
Sei Whale	0.000	0.000	0.208	0.402	0.047	0.170	0.121	0.061	0.068
Bryde's Whale	0.000	0.000	0.632	1.237	0.144	0.714	0.535	0.364	0.173
Blue Whale	0.000	0.000	0.831	1.622	0.180	0.908	0.672	0.443	0.215
Fin Whale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
North Atlantic Right Whale	0.000	0.000	0.036	0.071	0.008	0.045	0.034	0.024	0.009
Humpback Whale	0.000	0.000	3.046	5.931	0.674	3.102	2.279	1.415	0.848
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	0.000	0.000	116.584	225.454	18.848	96.111	64.095	28.714	23.101
Pygmy Killer Whale	0.000	0.000	0.161	0.312	0.061	0.158	0.129	0.082	0.091
Short-Finned Pilot Whale	0.000	0.000	11.616	22.498	74.416	55.161	93.694	123.153	153.571
Long-Finned Pilot Whale	0.000	0.000	59.577	117.528	13.886	79.691	61.042	45.685	14.791
Risso's Dolphin	0.000	0.000	370.550	731.439	87.140	501.580	385.115	290.103	92.466
Northern Bottlenose Whale	0.000	0.000	0.004	0.007	0.001	0.003	0.002	0.001	0.001
Pygmy Sperm Whale	0.000	0.000	0.000	0.000	0.081	0.041	0.080	0.083	0.138
Dwarf Sperm Whale	0.000	0.000	2.819	5.564	1.326	4.200	3.676	3.169	2.010
Atlantic White-sided Dolphin	0.000	0.000	1.347	2.659	0.522	1.965	1.659	1.415	0.768
Fraser's Dolphin	0.000	0.000	0.208	0.402	0.032	0.161	0.105	0.041	0.040
Sowerby's Beaked Whale	0.000	0.000	0.000	0.000	0.006	0.004	0.007	0.009	0.012
Blainville's Beaked Whale	0.000	0.000	1.459	2.816	0.225	1.126	0.731	0.282	0.282
Gervais' Beaked Whale	0.000	0.000	1.459	2.816	0.225	1.126	0.731	0.282	0.282
True's Beaked Whale	0.000	0.000	1.459	2.816	0.225	1.126	0.731	0.282	0.282
Killer Whale	0.000	0.000	0.052	0.100	0.033	0.054	0.052	0.040	0.056
Melon-Headed Whale	0.000	0.000	0.161	0.312	0.061	0.158	0.129	0.082	0.091
Harbor Porpoise	0.000	0.000	2.064	3.995	0.655	1.913	1.509	0.963	1.012
Sperm Whale	0.000	0.000	0.095	0.184	0.015	0.076	0.050	0.021	0.019
False Killer Whale	0.000	0.000	0.155	0.300	0.126	0.194	0.204	0.186	0.224
Pantropical Spotted Dolphin	0.000	0.000	135.938	263.432	35.378	127.155	96.513	61.914	53.839
Clymene Dolphin	0.000	0.000	64.945	125.855	16.902	60.749	46.109	29.580	25.722
Striped Dolphin	0.000	0.000	527.416	1020.455	157.930	486.916	383.424	258.754	256.777
Atlantic Spotted Dolphin	0.000	0.000	771.308	1496.301	201.604	741.310	564.738	369.590	303.440
Spinner Dolphin	0.000	0.000	0.611	1.184	0.159	0.571	0.434	0.278	0.242
Rough-Toothed Dolphin	0.000	0.000	0.000	0.000	0.036	0.023	0.043	0.061	0.075
Bottlenose Dolphin	0.000	0.000	14.775	28.936	21.683	28.545	34.819	39.072	42.117
Cuvier's Beaked Whale	0.000	0.000	10.213	19.709	1.577	7.883	5.119	1.972	1.972
ORDER SIRENIA									
West Indian Manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table Attachment E-5

All Seismic Airgun Surveys – Total Annual Level A Takes (number of individuals) Using Historic NMFS Criterion (180 dB)

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.000	0.000	0.342	0.666	0.101	0.364	0.285	0.196	0.144
Sei Whale	0.000	0.000	1.965	3.855	0.648	2.473	2.009	1.567	0.925
Bryde's Whale	0.000	0.000	1.948	3.820	0.642	2.445	1.986	1.548	0.918
Blue Whale	0.000	0.000	2.182	4.274	0.700	2.653	2.139	1.632	1.000
Fin Whale	0.000	0.000	4.400	8.638	1.507	5.679	4.657	3.705	2.180
North Atlantic Right Whale	0.000	0.000	1.162	2.290	0.611	1.757	1.595	1.464	0.858
Humpback Whale	0.000	0.000	5.897	11.542	1.853	7.071	5.671	4.275	2.632
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	0.000	0.000	3121.383	6146.553	1114.258	4282.933	3551.165	2919.887	1611.226
Pygmy Killer Whale	0.000	0.000	2.253	4.410	0.705	2.708	2.170	1.635	0.997
Short-Finned Pilot Whale	0.000	0.000	2354.300	4631.133	840.256	3170.157	2627.151	2145.343	1224.552
Long-Finned Pilot Whale	0.000	0.000	297.400	582.360	96.845	362.017	292.887	224.439	139.821
Risso’s Dolphin	0.000	0.000	1619.672	3180.466	551.169	2095.819	1717.190	1367.649	796.896
Northern Bottlenose Whale	0.000	0.000	0.127	0.250	0.043	0.174	0.143	0.116	0.061
Pygmy Sperm Whale	0.000	0.000	2.371	4.592	0.559	2.140	1.562	0.872	0.770
Dwarf Sperm Whale	0.000	0.000	14.844	29.005	4.264	16.952	13.300	9.592	5.939
Atlantic White-sided Dolphin	0.000	0.000	4.668	9.152	1.467	5.795	4.657	3.573	2.063
Fraser's Dolphin	0.000	0.000	0.242	0.468	0.055	0.210	0.151	0.079	0.076
Sowerby's Beaked Whale	0.000	0.000	0.203	0.397	0.060	0.233	0.184	0.134	0.085
Blainville's Beaked Whale	0.000	0.000	39.568	77.313	11.835	45.464	35.978	26.232	16.739
Gervais' Beaked Whale	0.000	0.000	39.568	77.313	11.835	45.464	35.978	26.232	16.739
True's Beaked Whale	0.000	0.000	39.568	77.313	11.835	45.464	35.978	26.232	16.739
Killer Whale	0.000	0.000	1.965	3.843	0.602	2.309	1.839	1.363	0.852
Melon-Headed Whale	0.000	0.000	2.523	4.942	0.818	3.098	2.505	1.924	1.168
Harbor Porpoise	0.000	0.000	7.054	13.798	2.245	8.376	6.733	5.072	3.235
Sperm Whale	0.000	0.000	158.828	309.723	44.502	173.124	134.518	93.561	62.258
False Killer Whale	0.000	0.000	2.801	5.491	0.930	3.501	2.848	2.218	1.334
Pantropical Spotted Dolphin	0.000	0.000	446.741	876.082	145.967	559.932	454.020	352.985	208.113
Clymene Dolphin	0.000	0.000	207.184	406.191	67.382	258.155	209.054	161.919	96.038
Striped Dolphin	0.000	0.000	2038.848	3993.224	650.891	2483.607	2000.683	1526.327	928.896
Atlantic Spotted Dolphin	0.000	0.000	2978.964	5847.582	988.880	3813.267	3105.692	2446.233	1406.107
Spinner Dolphin	0.000	0.000	1.949	3.821	0.634	2.429	1.967	1.523	0.903
Rough-Toothed Dolphin	0.000	0.000	13.755	26.888	4.279	16.048	12.821	9.510	6.112
Bottlenose Dolphin	0.000	0.000	5977.039	11748.210	2090.846	7908.443	6521.887	5266.486	3022.262
Cuvier's Beaked Whale	0.000	0.000	276.973	541.189	82.842	318.247	251.849	183.622	117.174
ORDER SIRENIA									
West Indian Manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table Attachment E-6

All Seismic Airgun Surveys – Total Annual Level B Takes (number of individuals) Using Historic NMFS Criterion (160 dB)

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.000	0.000	33.522	65.282	9.857	35.718	27.956	19.257	14.116
Sei Whale	0.000	0.000	192.625	377.801	63.466	242.395	196.917	153.588	90.689
Bryde's Whale	0.000	0.000	190.896	374.359	62.904	239.608	194.649	151.692	89.980
Blue Whale	0.000	0.000	213.901	418.875	68.622	259.980	209.629	159.949	98.045
Fin Whale	0.000	0.000	431.204	846.583	147.732	556.574	456.478	363.111	213.637
North Atlantic Right Whale	0.000	0.000	113.846	224.490	59.848	172.225	156.298	143.499	84.052
Humpback Whale	0.000	0.000	577.964	1131.230	181.646	692.987	555.789	419.002	257.919
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	0.000	0.000	305926.755	602423.698	109208.426	419770.312	348049.714	286178.116	157916.298
Pygmy Killer Whale	0.000	0.000	220.776	432.193	69.105	265.443	212.700	160.267	97.713
Short-Finned Pilot Whale	0.000	0.000	230744.930	453897.344	82353.473	310707.070	257487.079	210265.101	120018.336
Long-Finned Pilot Whale	0.000	0.000	29148.152	57077.138	9491.739	35481.323	28705.807	21997.239	13703.882
Risso's Dolphin	0.000	0.000	158744.009	311717.478	54020.063	205411.212	168301.811	134043.314	78103.785
Northern Bottlenose Whale	0.000	0.000	12.462	24.544	4.259	17.031	13.994	11.395	6.003
Pygmy Sperm Whale	0.000	0.000	232.353	450.073	54.784	209.782	153.072	85.460	75.450
Dwarf Sperm Whale	0.000	0.000	1454.885	2842.740	417.949	1661.508	1303.577	940.144	582.097
Atlantic White-sided Dolphin	0.000	0.000	457.481	896.987	143.826	567.919	456.474	350.144	202.187
Fraser's Dolphin	0.000	0.000	23.717	45.882	5.427	20.593	14.819	7.782	7.470
Sowerby's Beaked Whale	0.000	0.000	19.910	38.905	5.903	22.874	18.068	13.148	8.286
Blainville's Beaked Whale	0.000	0.000	3878.016	7577.415	1159.902	4455.915	3526.252	2570.966	1640.602
Gervais' Beaked Whale	0.000	0.000	3878.016	7577.415	1159.902	4455.915	3526.252	2570.966	1640.602
True's Beaked Whale	0.000	0.000	3878.016	7577.415	1159.902	4455.915	3526.252	2570.966	1640.602
Killer Whale	0.000	0.000	192.589	376.649	59.002	226.289	180.233	133.567	83.546
Melon-Headed Whale	0.000	0.000	247.240	484.381	80.135	303.674	245.516	188.604	114.448
Harbor Porpoise	0.000	0.000	691.367	1352.385	219.996	820.894	659.933	497.063	317.088
Sperm Whale	0.000	0.000	15566.706	30355.996	4361.663	16967.893	13184.100	9169.873	6101.896
False Killer Whale	0.000	0.000	274.527	538.213	91.113	343.104	279.084	217.358	130.741
Pantropical Spotted Dolphin	0.000	0.000	43785.058	85864.840	14306.228	54878.902	44498.535	34596.047	20397.152
Clymene Dolphin	0.000	0.000	20306.091	39810.739	6604.129	25301.751	20489.358	15869.727	9412.707
Striped Dolphin	0.000	0.000	199827.536	391375.882	63793.815	243418.330	196086.989	149595.327	91041.146
Atlantic Spotted Dolphin	0.000	0.000	291968.246	573121.475	96920.094	373738.318	304388.840	239755.284	137812.574
Spinner Dolphin	0.000	0.000	191.026	374.513	62.127	238.022	192.750	149.292	88.549
Rough-Toothed Dolphin	0.000	0.000	1348.103	2635.268	419.376	1572.892	1256.603	932.059	599.076
Bottlenose Dolphin	0.000	0.000	585809.587	1151442.029	204923.786	775106.463	639210.107	516168.326	296211.886
Cuvier's Beaked Whale	0.000	0.000	27146.110	53041.902	8119.316	31191.403	24683.766	17996.764	11484.217
ORDER SIRENIA									
West Indian Manatee	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gray Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Harbor Seal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table Attachment E-7

All Non-Airgun HRG Surveys – Total Annual Level A Takes (number of individuals) Using Southall Criteria

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.0003	0.0004	0.0004	0.0004	0.0004	0.0003	0.0000	0.0000	0.0000
Sei Whale	0.0020	0.0024	0.0024	0.0024	0.0024	0.0021	0.0004	0.0000	0.0000
Bryde's Whale	0.0023	0.0030	0.0030	0.0030	0.0030	0.0027	0.0007	0.0000	0.0000
Blue Whale	0.0002	0.0005	0.0005	0.0005	0.0005	0.0005	0.0003	0.0000	0.0000
Fin Whale	0.0155	0.0208	0.0208	0.0208	0.0208	0.0185	0.0053	0.0000	0.0000
North Atlantic Right Whale	0.0021	0.0026	0.0026	0.0026	0.0026	0.0022	0.0005	0.0000	0.0000
Humpback Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	4.0936	5.2235	5.2235	5.2235	5.2235	4.5460	1.1299	0.0000	0.0000
Pygmy Killer Whale	0.0004	0.0010	0.0010	0.0010	0.0010	0.0009	0.0006	0.0000	0.0000
Short-Finned Pilot Whale	0.0053	0.0106	0.0106	0.0106	0.0106	0.0106	0.0053	0.0000	0.0000
Long-Finned Pilot Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Risso’s Dolphin	1.8630	2.2287	2.2287	2.2287	2.2287	2.0205	0.3658	0.0000	0.0000
Northern Bottlenose Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pygmy Sperm Whale	0.0048	0.0064	0.0064	0.0064	0.0064	0.0059	0.0016	0.0000	0.0000
Dwarf Sperm Whale	0.0145	0.0192	0.0192	0.0192	0.0192	0.0178	0.0047	0.0000	0.0000
Atlantic White-sided Dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fraser's Dolphin	0.0001	0.0003	0.0004	0.0004	0.0004	0.0003	0.0003	0.0000	0.0000
Sowerby's Beaked Whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000
Blainville's Beaked Whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000
Gervais' Beaked Whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000
True's Beaked Whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0000	0.0000	0.0000
Killer Whale	0.0025	0.0061	0.0061	0.0061	0.0061	0.0058	0.0036	0.0000	0.0000
Melon-Headed Whale	0.0001	0.0004	0.0004	0.0004	0.0004	0.0003	0.0003	0.0000	0.0000
Harbor Porpoise	0.0005	0.0007	0.0007	0.0007	0.0007	0.0006	0.0002	0.0000	0.0000
Sperm Whale	0.0008	0.0009	0.0009	0.0009	0.0009	0.0008	0.0001	0.0000	0.0000
False Killer Whale	0.0001	0.0004	0.0004	0.0004	0.0004	0.0003	0.0003	0.0000	0.0000
Pantropical Spotted Dolphin	0.4477	0.5868	0.6200	0.6200	0.6200	0.5432	0.1677	0.0287	0.0287
Clymene Dolphin	0.2139	0.2803	0.2962	0.2962	0.2962	0.2595	0.0801	0.0137	0.0137
Striped Dolphin	0.5954	0.7674	0.8121	0.8121	0.8121	0.7114	0.2107	0.0386	0.0386
Atlantic Spotted Dolphin	5.3991	6.9574	7.3614	7.3614	7.3614	6.4414	1.8980	0.3397	0.3397
Spinner Dolphin	0.0020	0.0026	0.0028	0.0028	0.0028	0.0024	0.0008	0.0001	0.0001
Rough-Toothed Dolphin	0.0099	0.0145	0.0145	0.0145	0.0145	0.0134	0.0047	0.0000	0.0000
Bottlenose Dolphin	1.2977	2.1422	2.3608	2.3608	2.3608	1.9922	1.0400	0.1955	0.1955
Cuvier's Beaked Whale	0.0013	0.0015	0.0015	0.0015	0.0015	0.0013	0.0003	0.0000	0.0000
ORDER SIRENIA									
West Indian Manatee	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gray Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Harbor Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table Attachment E-8

All Non-Airgun HRG Surveys – Total Annual Level A Takes (number of individuals) Using Historic NMFS Criterion (180 dB)

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0001	0.0004
Sei Whale	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0012	0.0008	0.0024
Bryde's Whale	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0012	0.0008	0.0024
Blue Whale	0.0007	0.0010	0.0011	0.0011	0.0011	0.0011	0.0015	0.0009	0.0026
Fin Whale	0.0012	0.0016	0.0017	0.0017	0.0017	0.0018	0.0031	0.0019	0.0055
North Atlantic Right Whale	0.0020	0.0025	0.0025	0.0025	0.0025	0.0027	0.0051	0.0031	0.0089
Humpback Whale	0.0025	0.0034	0.0035	0.0035	0.0035	0.0034	0.0037	0.0022	0.0066
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	1.2187	1.4589	1.4946	1.4946	1.4946	1.5087	2.0876	1.3143	3.8682
Pygmy Killer Whale	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0011	0.0008	0.0024
Short-Finned Pilot Whale	0.0132	0.0166	0.0171	0.0171	0.0171	0.1358	1.2475	0.8050	2.3163
Long-Finned Pilot Whale	0.0027	0.0033	0.0033	0.0033	0.0033	0.0153	0.1295	0.0932	0.2808
Risso’s Dolphin	0.0913	0.1118	0.1118	0.1118	0.1118	0.1826	0.8666	0.5861	1.7367
Northern Bottlenose Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
Pygmy Sperm Whale	0.0011	0.0015	0.0015	0.0015	0.0015	0.0014	0.0007	0.0005	0.0017
Dwarf Sperm Whale	0.0034	0.0046	0.0046	0.0046	0.0046	0.0046	0.0057	0.0038	0.0119
Atlantic White-sided Dolphin	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002	0.0017	0.0014	0.0044
Fraser's Dolphin	0.0004	0.0006	0.0007	0.0007	0.0007	0.0006	0.0003	0.0001	0.0002
Sowerby's Beaked Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002
Blainville's Beaked Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0134	0.0104	0.0320
Gervais' Beaked Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0134	0.0104	0.0320
True's Beaked Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013	0.0134	0.0104	0.0320
Killer Whale	0.0005	0.0007	0.0007	0.0007	0.0007	0.0007	0.0010	0.0007	0.0021
Melon-Headed Whale	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006	0.0014	0.0009	0.0029
Harbor Porpoise	0.0016	0.0018	0.0018	0.0018	0.0018	0.0019	0.0031	0.0023	0.0068
Sperm Whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0041	0.0430	0.0377	0.1213
False Killer Whale	0.0004	0.0006	0.0006	0.0006	0.0006	0.0007	0.0016	0.0010	0.0029
Pantropical Spotted Dolphin	0.3036	0.4453	0.4509	0.4509	0.4509	0.4381	0.3559	0.1610	0.4798
Clymene Dolphin	0.1450	0.2127	0.2154	0.2154	0.2154	0.2088	0.1643	0.0729	0.2170
Striped Dolphin	0.3964	0.5755	0.5831	0.5831	0.5831	0.6088	0.9086	0.5299	1.5825
Atlantic Spotted Dolphin	3.4607	4.9269	4.9955	4.9955	4.9955	4.7511	3.0827	1.2151	3.5657
Spinner Dolphin	0.0013	0.0019	0.0020	0.0020	0.0020	0.0019	0.0015	0.0007	0.0020
Rough-Toothed Dolphin	0.0057	0.0074	0.0075	0.0075	0.0075	0.0073	0.0080	0.0052	0.0164
Bottlenose Dolphin	0.9382	1.4056	1.4650	1.4650	1.4650	1.6672	3.8323	2.2521	6.4434
Cuvier's Beaked Whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0090	0.0939	0.0726	0.2243
ORDER SIRENIA									
West Indian Manatee	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gray Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Harbor Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table Attachment E-9

All Non-Airgun HRG Surveys – Total Annual Level B Takes (number of individuals) Using Historic NMFS Criterion (160 dB)

Marine Mammal	Year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
ORDER CETACEA									
Suborder Mysticeti (Baleen Whales)									
Common Minke Whale	0.0225	0.0287	0.0300	0.0300	0.0300	0.0282	0.0200	0.0135	0.0419
Sei Whale	0.0358	0.0476	0.0511	0.0511	0.0511	0.0557	0.1152	0.0784	0.2328
Bryde's Whale	0.0355	0.0470	0.0505	0.0505	0.0505	0.0553	0.1169	0.0790	0.2338
Blue Whale	0.0659	0.0980	0.1037	0.1037	0.1037	0.1048	0.1448	0.0871	0.2568
Fin Whale	0.1153	0.1598	0.1665	0.1665	0.1665	0.1722	0.3083	0.1847	0.5384
North Atlantic Right Whale	0.1945	0.2461	0.2491	0.2491	0.2491	0.2690	0.5016	0.3002	0.8702
Humpback Whale	0.2454	0.3285	0.3444	0.3444	0.3444	0.3313	0.3597	0.2189	0.6492
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)									
Short-beaked Common Dolphin	119.4440	142.9833	146.4839	146.4839	146.4839	147.8699	204.6009	128.8144	379.1270
Pygmy Killer Whale	0.0345	0.0494	0.0494	0.0494	0.0494	0.0549	0.1097	0.0759	0.2370
Short-Finned Pilot Whale	1.2920	1.6287	1.6711	1.6711	1.6711	13.3054	122.2637	78.8942	227.0254
Long-Finned Pilot Whale	0.2621	0.3201	0.3267	0.3267	0.3267	1.4975	12.6893	9.1359	27.5252
Risso’s Dolphin	8.9444	10.9577	10.9577	10.9577	10.9577	17.8981	84.9354	57.4417	170.2112
Northern Bottlenose Whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0063	0.0041	0.0118
Pygmy Sperm Whale	0.1119	0.1503	0.1503	0.1503	0.1503	0.1410	0.0732	0.0472	0.1675
Dwarf Sperm Whale	0.3358	0.4508	0.4508	0.4508	0.4508	0.4557	0.5592	0.3686	1.1655
Atlantic White-sided Dolphin	0.0027	0.0055	0.0055	0.0055	0.0055	0.0208	0.1680	0.1357	0.4275
Fraser's Dolphin	0.0345	0.0568	0.0637	0.0637	0.0637	0.0575	0.0304	0.0098	0.0183
Sowerby's Beaked Whale	0.0023	0.0026	0.0026	0.0026	0.0026	0.0030	0.0073	0.0056	0.0175
Blainville's Beaked Whale	0.0023	0.0026	0.0026	0.0026	0.0026	0.1259	1.3153	1.0167	3.1400
Gervais' Beaked Whale	0.0023	0.0026	0.0026	0.0026	0.0026	0.1259	1.3153	1.0167	3.1400
True's Beaked Whale	0.0026	0.0032	0.0032	0.0032	0.0032	0.1265	1.3156	1.0167	3.1400
Killer Whale	0.0509	0.0642	0.0678	0.0678	0.0678	0.0680	0.0952	0.0667	0.2021
Melon-Headed Whale	0.0361	0.0525	0.0525	0.0525	0.0525	0.0604	0.1362	0.0921	0.2839
Harbor Porpoise	0.1543	0.1717	0.1812	0.1812	0.1812	0.1894	0.2990	0.2206	0.6643
Sperm Whale	0.0182	0.0215	0.0215	0.0215	0.0215	0.4051	4.2127	3.6965	11.8913
False Killer Whale	0.0389	0.0582	0.0582	0.0582	0.0582	0.0674	0.1524	0.0959	0.2885
Pantropical Spotted Dolphin	29.7529	43.6445	44.1968	44.1968	44.1968	42.9366	34.8805	15.7818	47.0220
Clymene Dolphin	14.2145	20.8513	21.1152	21.1152	21.1152	20.4600	16.1068	7.1416	21.2706
Striped Dolphin	38.8529	56.4013	57.1529	57.1529	57.1529	59.6638	89.0555	51.9312	155.0979
Atlantic Spotted Dolphin	339.1818	482.8880	489.6133	489.6133	489.6133	465.6510	302.1377	119.0890	349.4761
Spinner Dolphin	0.1306	0.1899	0.1924	0.1924	0.1924	0.1862	0.1484	0.0672	0.2001
Rough-Toothed Dolphin	0.5554	0.7281	0.7355	0.7355	0.7355	0.7138	0.7853	0.5128	1.6114
Bottlenose Dolphin	91.9501	137.7600	143.5851	143.5851	143.5851	163.3981	375.6071	220.7238	631.5169
Cuvier's Beaked Whale	0.0158	0.0181	0.0181	0.0181	0.0181	0.8810	9.2072	7.1172	21.9798
ORDER SIRENIA									
West Indian Manatee	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ORDER CARNIVORA									
Suborder Pinnipedia									
Hooded Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gray Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Harbor Seal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

APPENDIX F

PHYSICAL AND ENVIRONMENTAL SETTINGS

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LIST OF ACRONYMS AND ABBREVIATIONS

AOI	Area of Interest
AQI	Air Quality Index
BOEM	Bureau of Ocean Energy Management
CAA	Clean Air Act
CO	carbon monoxide
CBSA	core based statistical area
ECA	Emission Control Area
G&G	geological and geophysical
GRT	gross registered tons
HRG	high-resolution geophysical
IMO	International Maritime Organization
JAXPORT	Port of Jacksonville
MAB	Mid-Atlantic Bight
MARPOL	International Convention for the Prevention of Pollution from Ships
MMS	Minerals Management Service
NAAQS	National Ambient Air Quality Standards
NCDC	National Climatic Data Center
NDBC	National Data Buoy Center
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxide
O_3	ozone
OCS	Outer Continental Shelf
PM	particulate matter
ppb	parts per billion
ppm	parts per million
SAB	South Atlantic Bight
SCPA	South Carolina Ports Authority
SO_2	sulfur dioxide
SO_x	sulfur oxide
$\mu g/m^3$	micrograms per cubic meter
USDOC	U.S. Department of Commerce
USDOI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency

1. GEOGRAPHY AND GEOLOGY

This section provides a regional geologic description of the Area of Interest (AOI). Additional geological background information is provided in a literature synthesis by White (2013).

1.1. REGIONAL GEOLOGIC DESCRIPTION

The AOI encompasses Atlantic waters from the shoreline (excluding estuaries) to 350 nmi (648 km) offshore and from the mouth of Delaware Bay (38°51' N) to Cape Canaveral, Florida (28°N). The region has a mix of depositional and erosional environments and is greatly influenced by a prominent ocean current system, the Gulf Stream. Physiographically, the AOI includes the southern portion of the Mid-Atlantic Bight (MAB) from the mouth of Delaware Bay south to Cape Hatteras, North Carolina, plus all of the South Atlantic Bight (SAB) extending from Cape Hatteras to just south of Cape Canaveral, Florida (**Figure F-1**). The MAB and SAB differ physiographically; the MAB has a classic continental shelf-slope-rise sequence, while the SAB has a terrace-like sequence with several prominent features as discussed below and shown in **Figure F-1**.

The MAB has a broad continental shelf, with the 100-m (330-ft) water-depth contour generally coinciding with the shelf break. Offshore Norfolk, Virginia, the continental shelf is approximately 55-125 km (30-68 nmi) wide, with the change from gradual to steep topographic relief at the shelf break generally occurring at depths of 40-160 m (130-525 ft) (Tucholke, 1987). Bathymetry in the AOI is shown in **Figure F-2**. The continental slope, which has an average gradient between 4º and 11º, begins seaward of the shelf break (Heezen et al., 1959). The continental rise begins at a depth of approximately 2,000 m (6,560 ft). The MAB shelf is incised with deep canyons and valleys. Some canyons were eroded by rivers during lower stands of sea level, but most were formed via other erosional processes, such as slides, debris flows, and turbidity currents (Uchupi, 1968; Malahoff et al., 1980; Tucholke, 1987). There are three major canyons in the AOI (Baltimore, Washington, and Norfolk) and several minor canyons (Warr, Accomac, Hull, Keller, Hatteras, and Pamlico) (**Figure F-1**).

The seafloor in the SAB is divided into two distinct bathymetric areas: the Florida-Hatteras Shelf and the Blake Plateau (**Figure F-1**), which are connected by the gently dipping Florida-Hatteras Slope (Popenoe, 1981; Shor and McClennen, 1988). The Florida-Hatteras Shelf is a shallow, extremely flat inner shelf with water depths less than 100 m (330 ft) and a gradient less than 1:1,000 (Heezen et al., 1959; Shepard, 1973). Off Cape Hatteras, the shelf is narrow (~45 km [~24 nmi]), then broadens to over 105 km (57 nmi) offshore Cape Fear (**Figure F-1**) (Newton et al., 1971). Off the Georgia coast, the Florida-Hatteras Shelf extends nearly 150 km (81 nmi) at its greatest width before narrowing again to less than 60 km (32 nmi) off Cape Canaveral (**Figure F-1**). The shelf break generally occurs in water depths of approximately 40-80 m (130-260 ft) offshore northeastern Florida (Macintyre and Milliman, 1970).

From the edge of the shallow shelf, the Florida-Hatteras Slope gently transitions down about 60 m (200 ft) onto the Blake Plateau, a broad, flat sedimentary basin. The slope is smooth and uniform with a seaward slope of approximately 1º (Tucholke, 1987). Shelf-edge ridges, or reefs, occur near the top of the slope, and the upper slope is smooth and largely devoid of submarine canyons. Blake Plateau is an intermediate depth outer shelf where water depths range from approximately 700-1,100 m (2,300-3,600 ft). There are numerous terrace-like features and elongated depressions (some with deepwater coral mounds) along the base of the Florida-Hatteras Slope, although the Blake Plateau generally has a smooth surface (Stetson et al., 1962, 1969; Milliman et al., 1967). The western and northern portions of the Plateau have a series of deep elongated and flat-bottomed erosional depressions caused by scouring by the Gulf Stream and other currents. The Florida-Hatteras Slope and the terraces and depressions on the Blake Plateau are attributed to Gulf Stream erosion (Tucholke, 1987).

The Charleston Bump, located offshore Charleston, South Carolina (**Figure F-1**) and identified by the recurving 500-600 m (1,640-1,969 ft) isobaths (Bane and Brooks, 1979), is a distinctive feature of the SAB. It presents prominent bottom relief on a flat seafloor located in water depths of 400-700 m (1,312-2,297 ft), causing an offshore deflection of the Gulf Stream’s path and producing meanders, eddies, and upwelling over the continental shelf in this area (Bane, 1983; Sedberry et al., 2001).

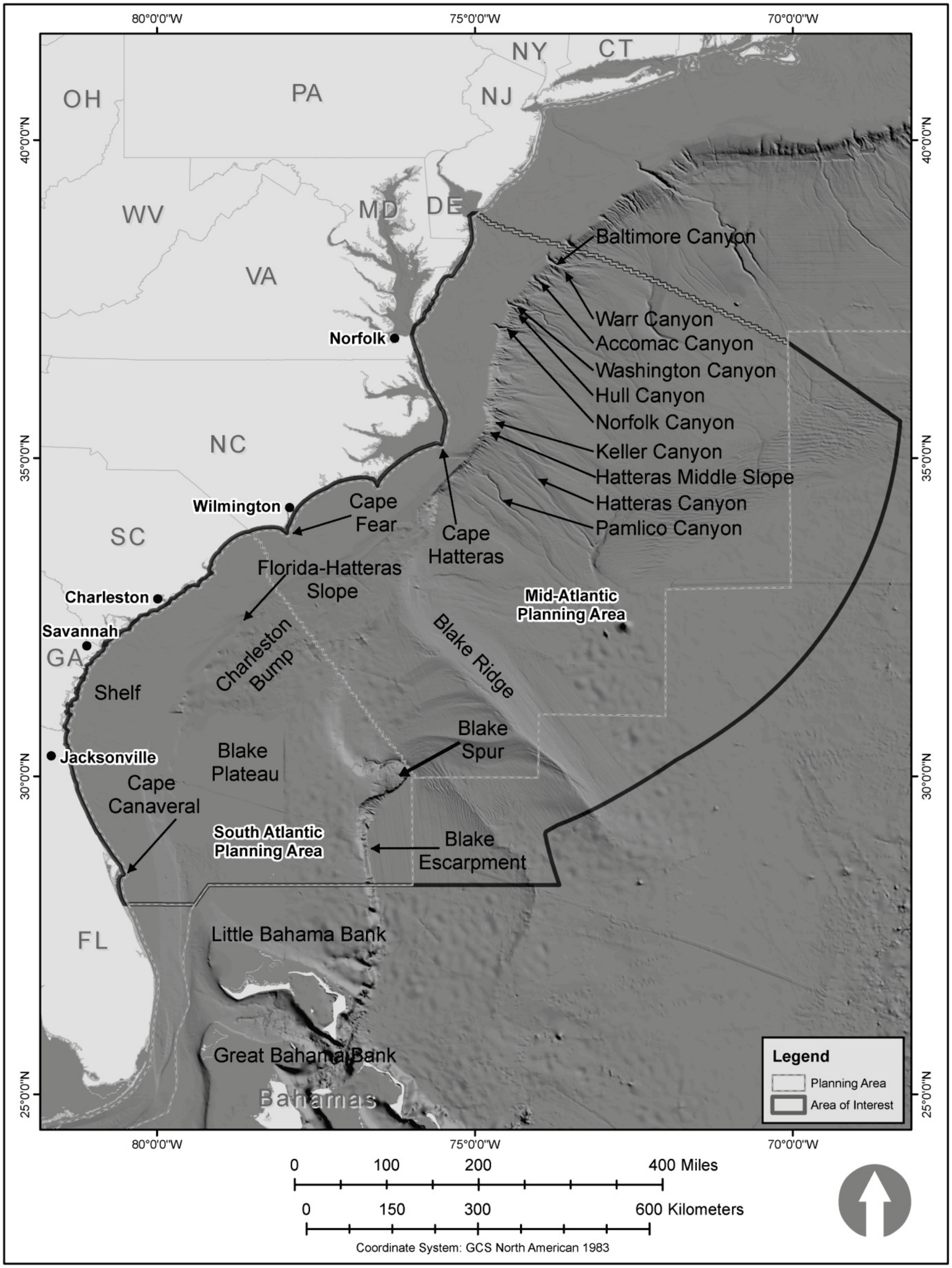

Figure F-1. Submarine Physiographic Features in the Area of Interest.

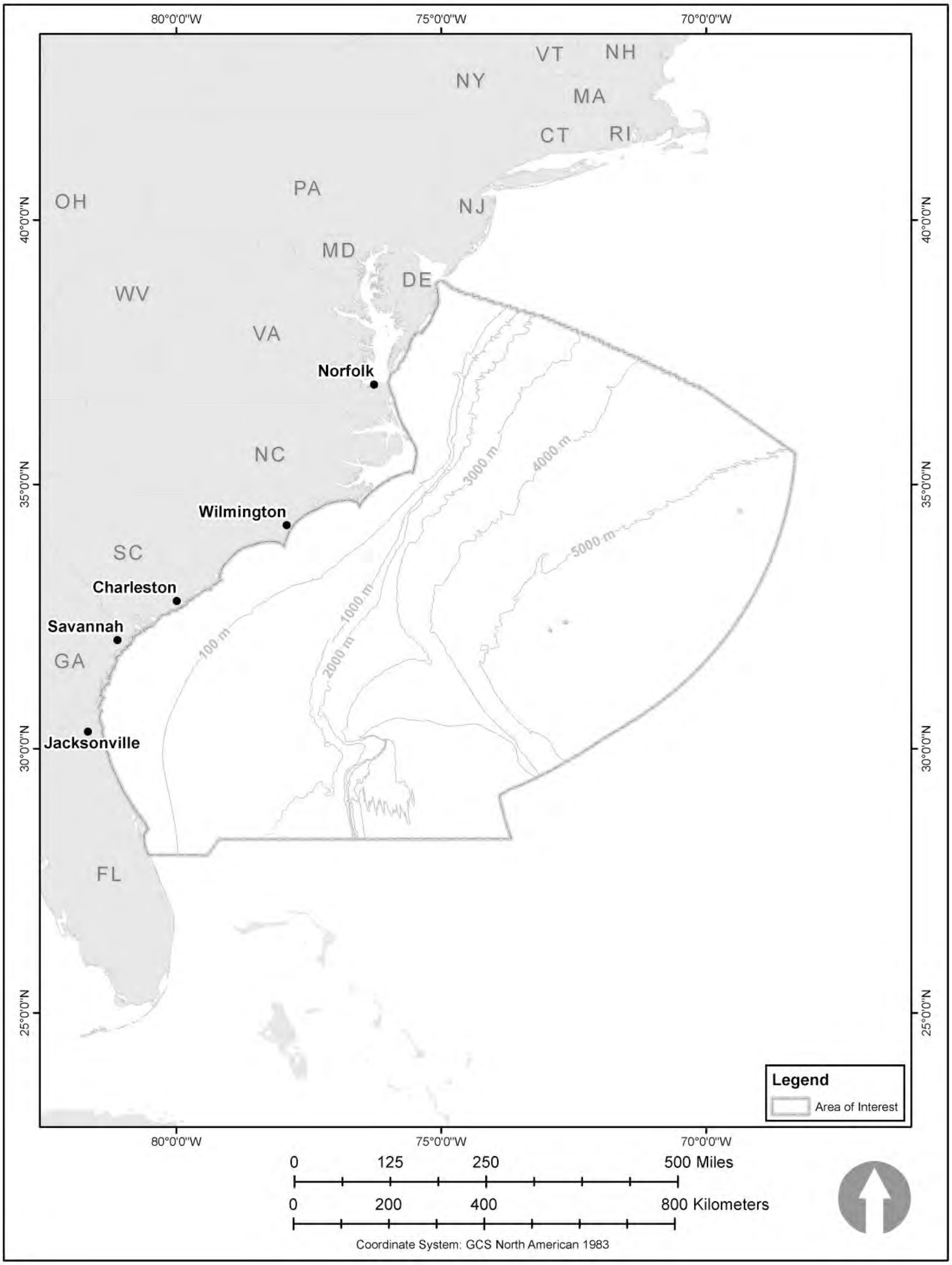

Figure F-2. Bathymetry in the Area of Interest.

1.2. GEOLOGIC HISTORY AND SEDIMENTARY BASINS

The Atlantic and Gulf coasts of North America are situated along a passive continental margin formed by the break up and pull-apart of the supercontinent Pangea during the Triassic-Jurassic periods during formation of the incipient Atlantic basin (**Figure F-3**). Continental rifting was accompanied by the deposition of red beds and volcanic rocks during the Triassic period followed by marine incursions into rift basins during the middle and late Jurassic period when deposition of evaporites took place along the Atlantic margin from Newfoundland to the SAB (**Figure F-4**).

A passive continental margin is one where the continent and adjacent ocean floor are on the same tectonic plate. Passive continental margins are characterized by subsidence, erosion, and thick sediment accumulations leading to the development of the characteristic continental margin sequence: continental shelf, continental slope, and continental rise (Kennett, 1982). This type of margin experiences little, if any, volcanic or earthquake activity after initial formation of the basin. Because these margins are found along the east coasts of North and South America and the west coasts of Europe and Africa, they are also known as "Atlantic-type" margins.

ERA	PERIOD	MILLION YEARS		EPOCH
		DURATION	BEFORE PRESENT	
CENOZOIC	QUATERNARY (Q)		0.01	HOLOCENE (Recent)
		1.99	2.5	PLEISTOCENE (Qp)
	TERTIARY (T)	5	7	PLIOCENE (Tpl)
		19	26	MIOCENE (Tm)
		12	38	OLIGOCENE (To)
		16	54	EOCENE (Te)
		11	65	PALEOCENE (Tp)
MESO-ZOIC	CRETACEOUS (K)	71	136	
	JURASSIC (J)	54	190	
	TRIASSIC (TR)	35	225	
PALEOZOIC	PERMIAN (P)	55	280	
	PENNSYLVANIAN (P)	30	310	
	MISSISSIPPIAN (M)	35	345	
	DEVONIAN (D)	50	395	
	SILURIAN (S)	35	430	
	ORDOVICIAN (O)	70	500	
	CAMBRIAN (C)	70	570	
	PROTEROZOIC	1930	2500	
	ARCHEAN	1900	4600	

Figure F-3. Geologic Time Scale (from Guccione and Zachary, 2000).

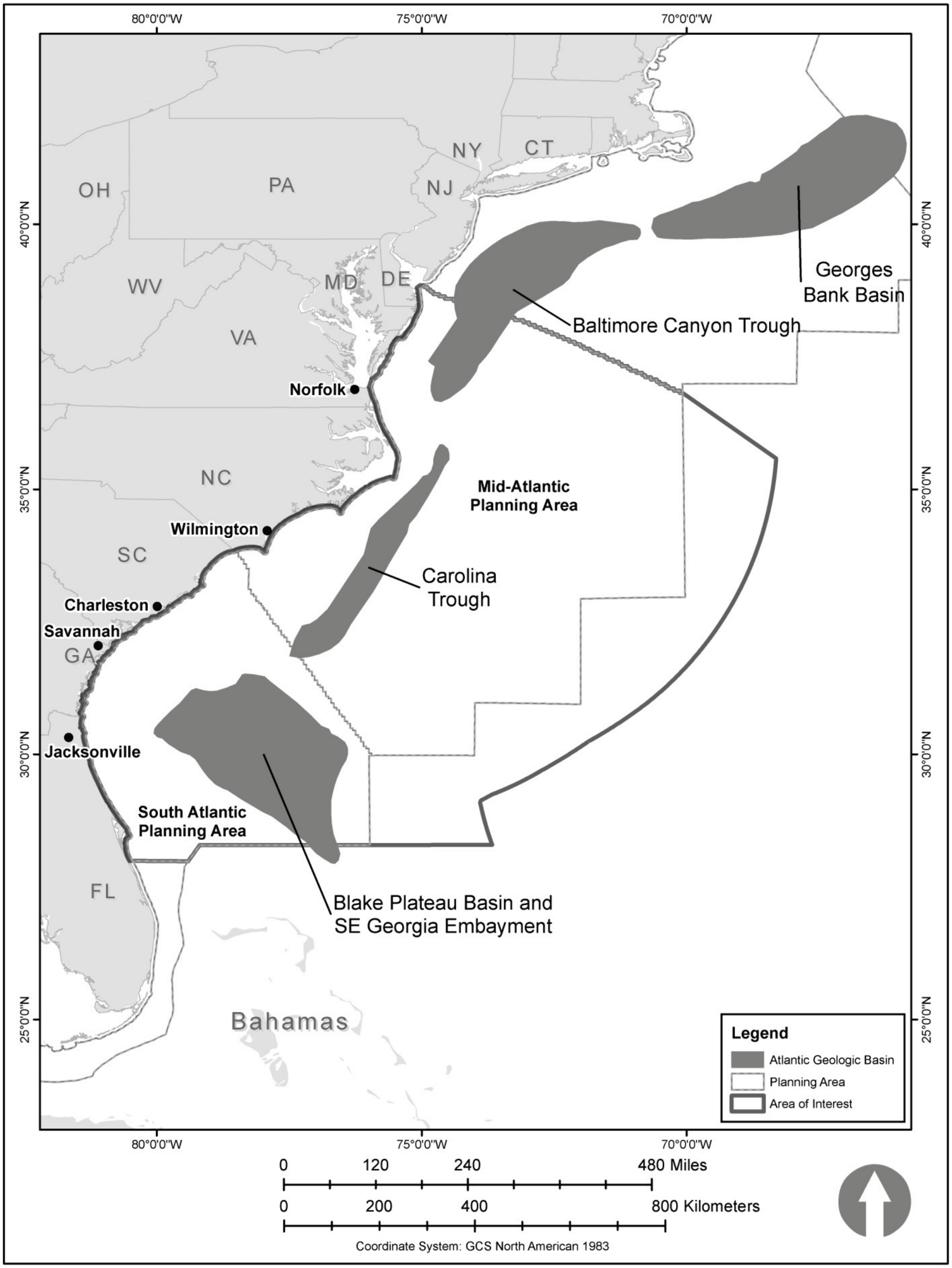

Figure F-4. Major Geologic Basins along the Atlantic Coast.

Sedimentary basins are areas of the Earth's crust with a history of subsidence and within which sediments accumulate forming stratigraphic successions. The stratigraphy of each basin is controlled primarily by large-scale events, such as tectonic activity, climate changes, and eustatic sea-level change. The mechanisms that produce sedimentary basins are lithospheric stretching, flexuring of the oceanic-continental lithosphere, and strike-slip faulting. Sedimentary basins develop within plates (intraplate basins) or at their edges (interplate basins). Intraplate basins can develop on both continental and oceanic crust; interplate basins can form at passive margins where new oceanic crust is being created, as well as destructive and conservative margins.

Figure F-4 illustrates major geologic basins along the Atlantic coast that are defined by seismic surveys. Underlying the Blake Plateau are two deep sedimentary basins with sediment accumulations up to 13 km (8 mi) thick that have no surface physiographic expression: the Carolina Trough and the Blake Plateau Basin (**Figure F-4**). The Carolina Trough exhibits salt diapirism and is located below the continental slope and upper rise off North and South Carolina. The Blake Plateau Basin is located below the southern portion of Blake Plateau to the east of Georgia and northern Florida. The Southeast Georgia Embayment is a deep sedimentary basin located beneath the Blake Plateau where sediment thickness can be as much as 3.4 km (2.1 mi); it also has no surface physiographic expression.

1.3. SEDIMENTS

Unconsolidated sediment, primarily sand, silt, clay, and some gravel, covers much of the continental shelf and slope of both the MAB and SAB (**Figure F-5**). The MAB shelf is overlain by a mantle of sand approximately 20 m (65 ft) thick, with some areas characterized by linear sand ridges and swales. Rivers draining into the MAB carry little sediment offshore because of sediment being trapped in estuaries or coastal marshes, resulting in coarse sediments on the shelf (Milliman and Meade, 1983). Tucholke (1987) attributes the coarse sediments on the shelf to the winnowing out of fine-grained materials and their transport either shoreward into estuaries or off the shelf via submarine canyons onto the continental slope. On the Mid-Atlantic continental slope, sediments tend to be silt and clay mixtures with interspersed, localized sandy areas (Milliman et al., 1972; Ray et al., 1980). Slope sediments are highly variable, consisting mainly of sandy silts on the upper slope and silts and clays on the lower slope (McGregor, 1983). Fine-grained biogenic calcareous sediments predominate seaward of the 3,000-m (9,843-ft) isobath (Amato, 1994).

Late Jurassic (approximately 190 million years ago) carbonate sediments and reefs of the Florida Platform form the shelf off the northern Florida coast and the Carolina Platform off the North Carolina coast (**Figure F-5**). Terrigenous clastic sediments of Tertiary age prograded across the Florida-Hatteras Shelf (**Figure F-4**) to form a thick sedimentary wedge over these platforms that are truncated by the Gulf Stream, which scours the inner part of the Blake Plateau nearly clean of sediments. The distribution of continental shelf and slope bottom sediments in the SAB are much more complex than those found in other areas (Amato, 1994). A thick layer of phosphoritic sediment, whose thickness varies widely, is covered by a thin layer of carbonate sand over much of the Blake Plateau. The thin layer of sand, generally less than 5 m (15 ft) thick, covers most of the shelf surface. Hard substrate, such as cemented sand, that can range from smooth outcrops to rough bottoms with relief up to 15 m (50 ft) occurs in places where the sand cover is absent. Accumulation of sediment on the Blake Plateau has not kept pace with the rate of subsidence because the Plateau lies beneath and east of the Gulf Stream along the east side on the inner shelf, so deposition of coastal sediments is precluded (Amato, 1994).

Sand and gravel layers in the SAB are much thinner than those found north of Cape Hatteras, and rock outcrops are common. The northern areas are characterized by quartz sands while the southern areas of the SAB have higher carbonate content. Continental shelf sands are remnants of delta and riverine sediments. Sediments on the outer shelf of the SAB tend to be medium to coarse-grained sand (Pilkey et al., 1979). Sediments on the continental slope are primarily composed of silt and clay (Tucholke, 1987).

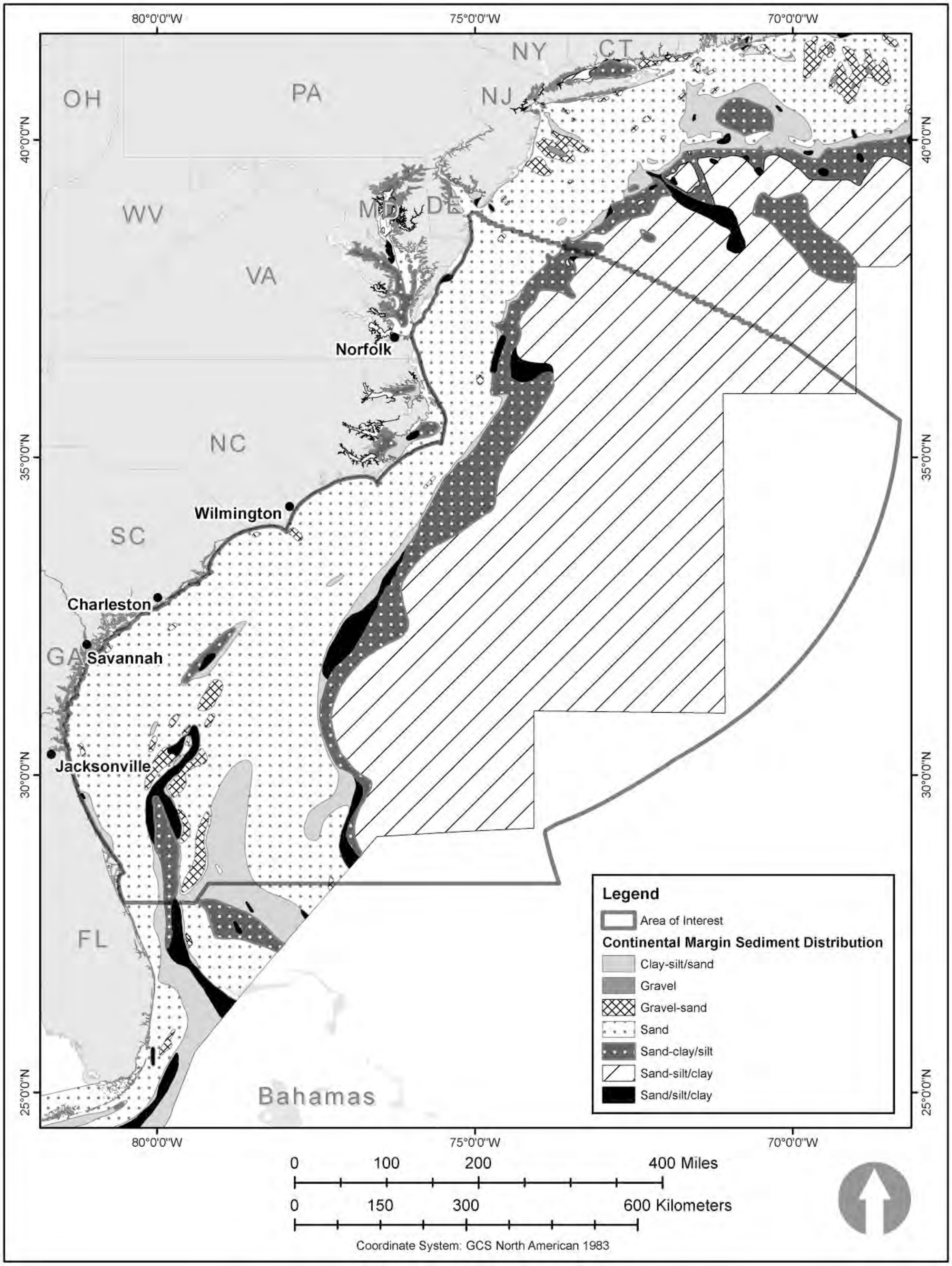

Figure F-5. Distribution of Surficial Sediment Types in the Area of Interest (Adapted from: Poppe et al., 2005).

2. PHYSICAL OCEANOGRAPHY

This section provides a regional description of the physical oceanography in the AOI. Additional background information is provided in a literature synthesis by Voulgaris (2013).

The major currents along the Atlantic coast are the Gulf Stream system flowing northward and the Labrador Current flowing southward. The Gulf Stream is the western boundary current of the North Atlantic Subtropical Gyre that strongly influences the physical oceanography of the MAB and SAB (Pickard and Emery, 1990; Verity et al., 1993). Offshore southeastern Florida, the Gulf Stream begins in the Florida Straits as the Florida Current, a continuation of the Loop Current from the Gulf of Mexico. The Florida Current is that section of the Gulf Stream that stretches from the Florida Straits north to Cape Hatteras, North Carolina. A composite of the Loop Current, Florida Current, and Gulf Stream positions from satellite imagery is shown in **Figure F-6**.

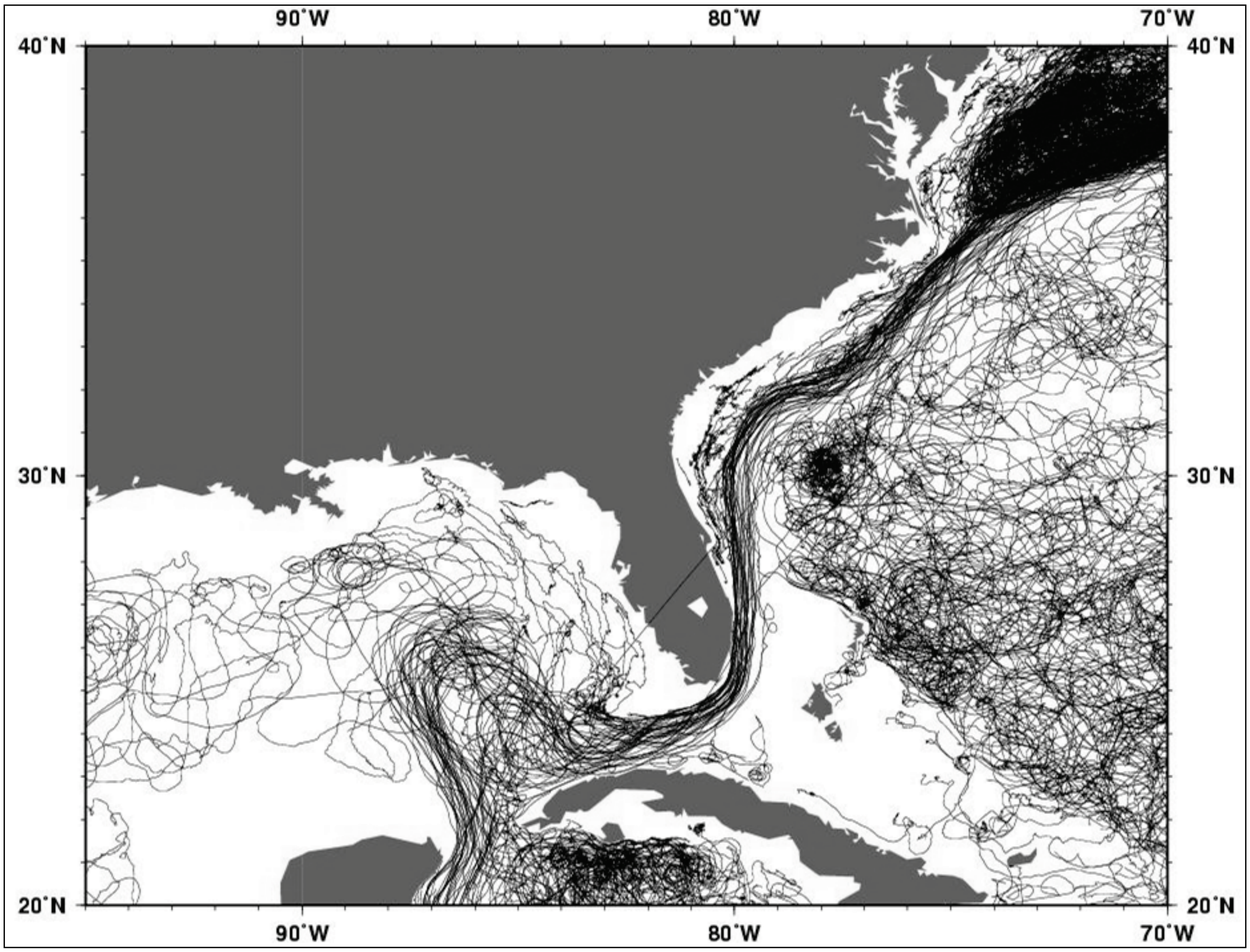

Figure F-6. Loop Current (Gulf of Mexico) and Gulf Stream (Atlantic Coast) Locations Based on Trajectories of Near-Surface Drifting Buoys from 1978-2003 (From: Cooperative Institute for Marine and Atmospheric Studies, 2008).

The Gulf Stream is a powerful, warm, and swiftly flowing current that flows northward, generally along the shelf edge, carrying warm equatorial waters into the cooler North Atlantic (Pickard and Emery, 1990; Verity et al., 1993). It generally follows the shelf edge up the southeast coast until it reaches Cape Hatteras, where it begins its northeastward flow across the Atlantic Ocean toward Europe (Pickard and Emery, 1990). The Antilles Current, which originates from the North Equatorial Current and flows northwestward along the eastern edge of the Bahamas, contributes to the Gulf Stream when it joins the Florida Current off the east coast of Florida.

About 30 million m^3/s (1,060 million ft^3/s) of water is transported through the Florida Straits by the Florida Current; transport volume increases progressively to the northeast to about 85 million m^3/s (3,000 million ft^3/s) near Cape Hatteras (Pickard and Emery 1990). Surface current speed is high, at times exceeding 2.5 m/s (8.2 ft/s) with a mean surface velocity of about 1.8 m/s (5.9 ft/s) (Von Arx et al., 1974; Tomczak and Godfrey, 2003). Current flow in the Florida Straits is greatest within about 200 m (656 ft) of the surface, with velocity decreasing with depth. Current speed is about 10 cm/s (0.3 ft/s) at depths greater than about 1,000 m (3,280 ft) (Tomczak and Godfrey, 2003). The Gulf Stream is typically 80-150 km (50-93 mi) wide and 800-1,200 m (2,600-4,000 ft) deep and has a slightly lower flow rate after passing Cape Hatteras (80 million m^3/s [2.8 billion ft^3/s]) where the velocity of the current also is fastest near the surface with a maximum speed of about 2.5 m/s (8 ft/s) (Pickard and Emery, 1990; Tomczak and Godfrey, 2003).

In addition to the Gulf Stream, features such as rings, meanders, and filaments can form and affect shelf waters in the SAB (Science Applications International Corporation, 1984; Florida Institute of Oceanography, 1986). South of Cape Hatteras, meanders diverging from the Gulf Stream typically form frontal eddies that remain attached to the Gulf Stream. North of Cape Hatteras, meanders pinch off to form small gyre features that become separated from the Gulf Stream as either warm or cold core rings (Mann and Lazier, 1996).

Off northeastern Florida, the Gulf Stream flows consistently northward. Although its position remains fairly stable off northeastern Florida, lateral meandering does occur (Bane et al., 1981; Lee et al., 1981; U.S. Dept. of the Navy, 1995). Frontal eddies, filaments, and warm and cold core rings may form during development of a meander and move across the shelf. Over the SAB shelf, there is a broad, slow, northerly flow with frequent intrusions of the Gulf Stream. Currents and water masses on the SAB shelf are mainly influenced by the Gulf Stream's deflections, meanders, and flow with mean current speeds on the shelf ranging from 1.8 m/sec (3.5 knots [kn]) near the surface to 0.40 m/sec (0.8 kn) near the bottom (Lee and Waddell, 1983). Surface velocities within the Gulf Stream offshore northeastern Florida are higher, ranging from 1.03 to 2.57 m/sec (2 to 5 kn) (Mann and Lazier, 1996) with a difference in current speeds reported for December (0.30 m/sec [0.6 kn]) and July (0.50 m/sec [1 kn]) (U.S. Dept. of the Navy, 1986).

Anticyclonic meanders that pinch off from the Gulf Stream form a separated deep pool of warm Sargasso Sea water rotating clockwise known as warm core rings (Brooks, 1996). Warm core rings span 100 km (~54 nmi) in diameter (García-Moliner and Yoder, 1994) with vertical dimensions of about 1 km (0.6 nmi) and may persist for several weeks to more than a year, drift in a south-to-southwesterly direction, and either dissipate or merge with the Gulf Stream (Pickard and Emery, 1990; García-Moliner and Yoder, 1994; Mann and Lazier, 1996); on average, 22 warm-core rings are formed per year, each measuring approximately 100 km (54 nmi) in diameter and 1,000 m (3,280 ft) in the vertical dimension (Gyory et al., 2005). When a cyclonic meander pinches off the Gulf Stream, cold core rings form, a counterclockwise rotating ring of cool continental slope water surrounded by the warmer waters of the Sargasso Sea (Pickard and Emery, 1990). Cold core rings form twice as frequently as warm core rings. On average, 35 cold-core rings are shed by the Gulf Stream per year (Gyory et al., 2005). Cold core rings are larger (100-300 km [54-162 nmi] in diameter) and last longer, persisting from months to years. Cold core rings form to the south of the Gulf Stream, drift in a south-to-southwest direction, and eventually dissipate or merge with the Gulf Stream in a similar fashion to their warm core ring counterparts (Pickard and Emery, 1990). Frontal eddies are distinct features from the larger cold and warm core rings that pinch off the Gulf Stream after it is deflected from the U.S. coastline. Frontal eddies often take the form of finger-like extensions and protrude onto the shelf, folding back to enclose a cold, nutrient-rich core of water upwelled from deep within the Gulf Stream (Mann and Lazier, 1996). The transient upwelling associated with frontal eddies results in more localized areas of high surface primary productivity. The formation of warm and cold core rings does not appear to be correlated with seasonality, but rather appears to be driven by localized flow dynamics of the Gulf Stream.

Upwelling along the Atlantic coast is both wind-driven and a result of dynamic uplift (Shen et al., 2000; Lentz et al., 2003). Upwelling can occur along the area of the MAB from New Jersey to Virginia during summer months when southwesterly winds prevail (Cook, 1988). In some areas of the upper

MAB, upwelling occurs in stratified waters (spring and summer) after the passing of storms (Cook, 1988).

In addition to the Gulf Stream, currents originating from the outflow of both Chesapeake and Delaware Bays influence the surface circulation in the MAB. The Chesapeake Bay plume flows seaward from the mouth of the Bay and then turns south to form a coastal jet that can extend as far as Cape Hatteras. Similarly, the Delaware Coastal Current begins in Delaware Bay and flows southward along the Delmarva Peninsula before being entrained into the Chesapeake Bay plume.

3. WATER QUALITY

This section provides a regional description of water quality in the AOI. Additional information on chemical oceanography and water quality is provided in a literature synthesis by Windom (2013).

Water quality is typically gauged by measuring a series of parameters such as dissolved oxygen, transparency (i.e., water clarity, turbidity, or suspended matter), chlorophyll content, nutrient concentrations, and contaminant concentrations (heavy metals and hydrocarbons). Offshore water quality in the AOI is expected to be generally good to excellent, with minimal water column stratification. Additionally, observations of high water clarity, dissolved oxygen concentrations at or near saturation, and low concentrations of suspended matter and trace metal and hydrocarbon contaminants indicate good water quality (U.S. Environmental Protection Agency [USEPA], 1998). Concentrations of suspended matter (turbidity) are typically low in Mid-Atlantic marine waters, generally <1 mg/L (Louis Berger Group, Inc., 1999). Suspended matter and turbidity vary locally between surface and bottom waters, vary seasonally (because of rainfall and riverine discharge), are located in different areas because of differing sources and grain sizes, and increase naturally during storm events. Turbidity may be temporarily affected by dredging activities; in offshore waters, this would be limited primarily to disposal at approved offshore disposal sites. These sites are located, designed, and operated under permit guidelines of the Clean Water Act and the Marine Protection, Research, and Sanctuaries Act to ensure any changes in turbidity would be localized and short-term (USEPA, 2011a).

The overall condition of the Nation's coastal waters is rated as fair. This assessment is based on an evaluation of five indices: water quality, sediment, benthic, coastal habitat, and fish tissue contaminants. The southeast coast is rated as fair with an index score of 3.6, and the northeast coast is rated fair to poor with a score of 2.6 (based on a scale from 1 to 5). A good rating for the benthic and fish tissue contaminant indices, a fair rating for the coastal habitat and water quality indices, and fair to poor rating for sediment quality comprise the index score of 3.6 for the southeast coast. The water quality index includes measurements of five component indicators: dissolved inorganic nitrogen, dissolved inorganic phosphorus, chlorophyll a, water clarity, and dissolved oxygen. The southeast coast had the highest proportion of coastal area in the U.S. rated poor for water quality (13%), the highest proportion of coastal area with poor water clarity (26%), and low dissolved oxygen (11%). However, 82 percent of the southeast coastal waters had a good rating for the benthic index, which is based on benthic community condition. The northeast coast score of 2.6 comprised a good to fair rating for the coast habitat index, a fair rating for water quality and sediment quality indices, a poor to fair rating for fish tissue contaminant index, and a poor rating for the benthic index. The northeast coast had the greatest proportion of coastal area in poor benthic condition (31%) (USEPA, 2012a).

Some areas of the Atlantic have heavy shipping traffic and may experience localized impacts from ships, especially from bilge water, domestic wastewater, and tank washings. Ship discharges are regulated under USEPA's National Pollutant Discharge Elimination System vessels program. The primary means of regulation is the Vessel General Permit, which applies to discharges incidental to the normal operation of all non-recreational, non-military vessels of 24 m (79 ft) or greater in length that discharge in U.S. waters (USEPA, 2011b).

Pelagic tar is probably the most common form of hydrocarbon contamination present in the offshore environment (Farrington, 1987). Higher tar concentrations tend to be associated with the Loop Current and the Gulf Stream, and only trace concentrations are found over the continental shelf. Van Vleet (1984) indicated that tanker operations may be the major source of pelagic tar.

Hydrocarbons and metals concentrations in MAB and SAB sediments vary with sediment texture but, with the exception of disposal sites (identified in **Chapter 4.2.12.1.5**), are not indicative of significant contamination (Lee, 1979; Smith et al., 1979; Windom and Betzer, 1979). Metals and hydrocarbons concentrations on the continental slope tend to be higher than on the shelf because of the greater proportions of silt and clay in slope sediments. Trace metals include elements that are generally present in minute amounts in the sediment. With the exception of dump sites, trace metal concentrations nearshore and offshore rarely approach toxicity limits defined by the USEPA. To assist in understanding applicable limits, the National Oceanic and Atmospheric Administration (NOAA) has recently upgraded its Screening Quick Reference Tables to include an expanded list of analytes for which benchmarks are presented (U.S. Dept. of Commerce [USDOC], NOAA, 2011). Elevated lead concentrations in sediments have been detected in the South Atlantic, decreasing with depth in the sediment column within both the South Atlantic and Mid-Atlantic, suggesting an anthropogenic source (U.S. Dept. of the Interior [USDOI], Minerals Management Service [MMS], 1992). On the Mid-Atlantic slope and rise, hydrocarbons found in sediment samples were either mainly biogenic in origin or were contaminants derived from the burning of fossil fuels. Biogenic gas is found in all marine sediments, but no evidence of petroleum contamination was reported in sediments from the South Atlantic slope and rise (USDOI, MMS, 1992). The first deepwater gas seeps were recently found at water depths greater than 1,000 m (3,300 ft) off the U.S. Atlantic Coast north of Cape Hatteras. Based on preliminary information, it is believed that the seeps are likely emitting methane gas. If these seeps are emitting methane, this could lead to changes in ocean chemistry, e.g., ocean acidification, since methane released into the water column is often oxidized to carbon dioxide (USDOC, NOAA, 2012c).

In coastal waters, water quality is controlled primarily by the anthropogenic inputs of land runoff, land point source discharges, and atmospheric deposition. With increasing distance from shore, oceanic circulation patterns play an increasingly larger role in dispersing and diluting anthropogenic contaminants and determining water quality. Due primarily to the influence of tidal plumes leaving estuaries, areas of the Atlantic closer to shore will show major local variations (USDOI, MMS, 1992). Most threats to marine water quality originate on land. Along the coastline, water quality is influenced by cities and other large nearby populations with associated non-point pollution sources: urban runoff containing oil, greases, and nutrients; domestic and sanitary wastes; and large expanses of agricultural land where fertilizers and biocides are applied. In less populated areas, networks of wetlands, estuaries, and bays can be subject to effluents from numerous septic systems. Plumes from the two prominent estuaries in the MAB, Chesapeake and Delaware Bays, affect coastal water quality. The area's extensive watersheds funnel nutrients, sediment, and organic material into secluded, poorly flushed estuaries that are much more susceptible to eutrophication, the pattern of which also closely reflects the distribution of population density (USEPA, 2008). Hypoxic environments, i.e., those with low dissolved oxygen concentrations, usually of 3 mg/L or less, occur when the water column becomes vertically stratified and mixing between oxygenated surface waters and bottom waters cannot occur. Such conditions often follow periods of eutrophication and intense bacterial or secondary production. Hypoxia is not a widespread phenomenon in the AOI. However, it does occur, most notably during summer thermal stratification affecting the deeper waters of Chesapeake Bay (Hagy et al., 2004).

Between 1980 and 2003, coastal counties of the southeast coast region showed the largest rate of population increase (58%) of any coastal region in the conterminous U.S. In 2003, the coastal population of the northeast coast region was the largest in the country, with 52.6 million people, representing 34 percent of the Nation's total coastal population. Although coastal counties along the northeast coast showed the slowest rate of population increase between 1980 and 2003, the region gained the second-largest number of people (almost 8 million) of all U.S. regions during this period (USEPA, 2008).

There is also documented evidence of a "garbage patch" in the North Atlantic within the AOI. The highest concentrations of plastics in this "garbage patch" were found between the approximate latitudes of Virginia to Cuba (http://www.wired.com/wiredscience/2010/08/atlantic-plastic/).

4. METEOROLOGY

Oceanographic and atmospheric phenomena combine to create the long-term climate and short-term weather patterns that characterize the AOI. The regional climate is influenced by several factors, including oscillating atmospheric pressure systems, prevailing winds, and warm Gulf Stream waters. Three atmospheric pressure systems govern the wind patterns and climate in this region: the Icelandic Low, the Bermuda-Azores High, and the Ohio Valley High (Blanton et al., 1985). The Bermuda-Azores High is a semi-permanent, high-pressure system centered over the island of Bermuda in summer and fall and over the Azores in the eastern North Atlantic in winter and spring. The anticyclonic (clockwise) circulation associated with the Bermuda-Azores High dominates the climate from approximately May through August, producing southeasterly winds (<6 m/s [<20 ft/s]) and hot, humid weather over much of the southeastern U.S. In winter (approximately November through March), the Icelandic Low and weak Ohio Valley High combine to generate west-northwesterly winds (8-10 m/s [26-33 ft/s]) and drier weather conditions in the region (Adams et al., 1993). Wind velocities offshore of Cape Canaveral exhibited similar trends, but with slightly lower average speeds at 4.6 m/s (15.1 ft/s) in summer and 6.7 m/s (22 ft/s) in winter (USDOC, NOAA, National Data Buoy Center [NDBC], 2011a). Weather systems pass rapidly through the southeastern U.S. (approximately every 2-5 days) throughout the year, and their effects are superimposed on the seasonal cycling of the Bermuda-Azores High (Joyce, 1987). While there is a large range of changes in air temperature, wind, and barometric pressure between seasons, fluctuations associated with the passage of weather systems may exceed seasonal changes.

A long-term record of atmospheric and oceanographic conditions is available from oceanographic buoys maintained by the USDOC, NOAA, NDBC (2011b). Air temperature measured over a 17-year period at an oceanographic buoy 48 km (26 nmi) southeast of Cape May, New Jersey, averaged 23.3°C (73.9°F) in August and 3.6°C (38.5°F) in February, the warmest and coldest months, respectively (USDOC, NOAA, NDBC, 2011c). In contrast, a buoy located 278 km (150 nmi) east of Cape Hatteras recorded mean monthly air temperatures of 26.1 °C (79.0°F) in August and 14.9°C (58.8°F) in January over a concurrent 25-year period (USDOC, NOAA, NDBC, 2011d), illustrating the warming influence of the Gulf Stream.

Prevailing westerly winds result in a tropical/subtropical climate south of Cape Hatteras (Joyce, 1987). Air temperature measured in southeast Onslow Bay averages 26°C (78.8°F) in summer (June through August) and 13°C (55.4°F) in winter (December through February), with annual extremes of 31°C (87.8°F) and -12°C (10.4°F) (Coastal Ocean Research and Monitoring Program, 2011). By contrast, air temperatures recorded from a NOAA oceanographic buoy located approximately 37 km (20 nmi) off Cape Canaveral averaged 27.1°C (80.8°F) in summer and 19.8°C (67.6°F) in winter between 1988 and 2001 (USDOC, NOAA, NDBC, 2011a). Warmer average temperatures and temperature extremes of 31.8°C (89.2°F) and 0°C (32.0°F) are almost certainly a result of the moderating influence of the warm Gulf Stream waters.

Over the past 50 years, total annual precipitation has averaged about 115 cm (45 in) in Lewes, Delaware and 145 cm (57 in) at Cape Hatteras, North Carolina (Southeast Regional Climate Center, 2011a,b). Precipitation in the form of snow or freezing rain occurs more frequently in the north. Average annual precipitation ranges between 109 and 142 cm (43 and 56 in) along the coastlines of the Carolinas, Georgia, and northern Florida (Boyles et al., 2004). Maximum rainfall occurs in late summer; however, maximum discharge of freshwater from local rivers into the SAB occurs in March or April as water drains from inland mountain and piedmont areas, which receive their maximum rainfall in the early spring (Blanton et al., 1985).

The proximity of the Gulf Stream to the southeast U.S. coast has a strong effect in the generation of cyclonic, extra-tropical storms in winter as cold, dry continental air meets the warm, moist air over Gulf Stream waters (Adams et al., 1993). Thunderstorms and major storm systems occur in the region most often during summer and fall as hot, humid air masses collide with passing fronts (Joyce, 1987).

Tropical and extra-tropical cyclones (northeasters) are significant influences on weather and sea state conditions in the AOI. Tropical cyclones, which occur during summer and fall, are severe but infrequent. Extra-tropical cyclones occur frequently during winter and may produce unfavorable conditions during winter and spring. Tropical and extra-tropical cyclones have the potential for high wind speeds, heavy rain (or snow in winter), flooding, tornadoes, and significant storm surges depending on the severity of the storm. Most major storms, including hurricanes, occur during the North Atlantic hurricane season, which occurs from June through November. Tropical cyclones form in warm, equatorial waters of the North Atlantic Ocean and Caribbean Sea and often move northward along the southeastern U.S. coast following the path of the Gulf Stream (Adams et al., 1993; Buchan, 2000). Since 1944, when reliable data on storm systems began being recorded, 761 named storms have occurred over the North Atlantic; 182 of these storms were major hurricanes (USDOC, NOAA, National Climatic Data Center [NCDC], 2013a). From 1950 through 2011, 29 hurricanes made first landfall between Cape Canaveral, Florida and Cape Hatteras, with just two hurricanes striking the coast between Cape Hatteras and Long Island, New York (USDOC, NOAA, NCDC, 2013b). Recent statistics for the 2012 season revealed 19 named storms in the Atlantic Basin, of which 10 were hurricanes and 1 was classified as a major hurricane (Hurricane Michael; Category 3) (USDOC, NOAA, NCDC, 2013c).

The 2012 season also included one post-tropical storm with hurricane force winds (Sandy). Sandy began in the southern Caribbean Sea and quickly developed first into a tropical storm, then into a hurricane that was downgraded to Post-Tropical Cyclone Sandy, meaning it still had hurricane-force winds but lost the characteristics of a tropical storm, prior to making landfall about 8 km (5 mi) southwest of Atlantic City, New Jersey, on October 29, 2012 (USDOC, NOAA, 2012b). The winds at landfall were estimated to be 80 kn, with a minimum pressure of 946 millibars. Hurricane-force winds gusts were reported across Long Island and the New York metropolitan area. In addition, there was a significant storm surge that occurred along the Mid-Atlantic and southern New England coast (USDOC, NOAA, 2012a). This storm caused significant damage to the coastal areas and infrastructure at the landfall location (Atlantic City, New Jersey) and the surrounding areas, which are north of the AOI. Within the AOI, a long portion of the Mid-Atlantic coastline experienced strong waves and storm surge. Barrier islands were breached in a number of places, and erosion of the beach and dunes occurred all along the Mid-Atlantic coast (U.S. Geological Survey, 2012).

5. AIR QUALITY

Air quality typically is defined by the concentration of criteria pollutants established by the USEPA under the National Ambient Air Quality Standards (NAAQS)—a listing that identifies those pollutants considered harmful to public health and the environment. The Clean Air Act (CAA) establishes two types of national air quality standards: (1) primary standards, which set limits to protect public health, including the health of "sensitive" populations (e.g., asthmatics, children, and the elderly); and (2) secondary standards, which set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. The NAAQS apply to sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$, particulate matter of less than or equal to 10 and 2.5 μm, respectively), and lead (40 CFR part 50). The primary NAAQS are set at levels to protect public health with an adequate margin of safety. The USEPA has designated secondary NAAQS to protect public welfare (USDOI, BOEM, 2012). The NAAQS standards are expressed as concentration in air and duration of exposure. Many standards address both short- and long-term exposures. Any individual State may adopt a more stringent set of standards. Current NAAQS are outlined in **Table F-1**. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (µg/m3). When the monitored pollutant levels in an area of a state exceed the NAAQS for any pollutant, the area is classified as “nonattainment” for that pollutant.

5.1. BASELINE

G&G surveys will occur under three different programs, with air emissions associated with vessel activity both offshore and during transit into and out of coastal ports, as required. For the oil and gas program, seismic survey vessels typically are 60-90 m (200-300 ft) long for 2D surveys and 80-90 m (262-300 ft) long for 3D surveys. The 3D surveys usually require larger vessels because there is more equipment to be towed. A typical towing speed is 4.5 kn (8.3 km/hr). These surveys could occur anywhere within the AOI, with 24-hr operations that may continue for weeks or months, depending upon the size of the survey. The proposed action scenario includes 616,174 line km of 2D streamer surveys, 2,500 blocks of 3D streamer surveys (or 120,000 line km, assuming 48 line km [30 line mi] per block), and 900 line km of 3D wide azimuth surveys. Assuming a vessel speed of 4.5 kn (8.3 km/hr), these surveys would represent about 90,000 hr (3,750 days) of vessel activity. Seismic survey vessels are likely to remain offshore for most of the survey duration. They may be supported by supply vessels operating from ports along the Atlantic Coast, but service vessel support is not a requirement.

Table F-1

National Ambient Air Quality Standards (NAAQS), as of October 2011

Pollutant	Primary/ Secondary	Averaging Time	Level	Form	Final Rule Cite
Carbon monoxide	Primary	8-hr	9 ppm	Not to be exceeded more than once per year	76 FR 54294, Aug. 31, 2011
		1-hr	35 ppm		
Lead	Primary and Secondary	Rolling 3 month average	0.15 µg/m^3 [a]	Not to be exceeded	73 FR 66964, Nov. 12, 2008
Nitrogen dioxide	Primary	1-hr	100 ppb	98th percentile, averaged over 3 years	75 FR 6474, Feb. 9, 2010; 61 FR 52852, Oct. 8, 1996
	Primary and Secondary	Annual	53 ppb [b]	Annual mean	
Ozone	Primary and Secondary	8-hr	0.075 ppm [c]	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years	73 FR 16436, Mar. 27, 2008
Particle pollution $PM_{2.5}$	Primary	Annual	12 µg/m^3	Annual mean, averaged over 3 years	Dec. 14, 2012
	Secondary	Annual	15 µg/m^3	Annual mean, averaged over 3 years	
	Primary and Secondary	24-hr	35 µg/m^3	98th percentile, averaged over 3 years	
Particle pollution PM_{10}	Primary and Secondary	24-hr	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years	
Sulfur dioxide	Primary	1-hr	75 ppb [d]	99th percentile of 1-hr daily maximum concentrations, averaged over 3 years	75 FR 35520, June 22, 2010; 38 FR 25678, Sept. 14, 1973
	Secondary	3-hr	0.5 ppm	Not to be exceeded more than once per year	

[a] Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m^3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

[b] The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hr standard.

[c] Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, USEPA revoked the 1-hr ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard (“anti-backsliding”). The 1-hr ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

[d] Final rule signed June 2, 2010. The 1971 annual and 24-hr SO_2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Vessels conducting G&G surveys or sampling under the renewable energy program would operate mainly at specific sites (consisting of one or more Outer Continental Shelf [OCS] blocks) in water depths less than 40 m (131 ft) and along potential cable routes to shore. The proposed action scenario includes a maximum of 464,250 km of high-resolution geophysical (HRG) surveys; this is the equivalent to approximately 75,000 hr of surveying within the Wind Energy Areas. Typically, a survey would be completed in 3-5 days, and depending on the location, the vessel may return to its shore base daily. Sites in deeper water may require larger vessels that operate 24 hr per day and can remain at sea for weeks.

For HRG surveys of sand source areas under the marine minerals program, geophysical survey equipment is typically deployed from a single vessel, <20-30 m (<65-98 ft) long, moving at about 4.5 kn (8.3 km/hr). Surveys are likely to focus on prospective borrow sites (3-10 km^2) or reconnaissance areas (on the order of 1-3 OCS blocks), and each survey is assumed to require 1-5 operational days for completion. Vessels are assumed to operate on site for 8 hr per day and return to the shore base at the end of each day. The marine minerals scenario includes approximately 100-3,200 km of HRG prospecting surveys, 850-4,300 km of HRG prelease/design surveys, and 900-4,600 km of on-lease HRG surveys. Across all geophysical survey activities, the maximum activity level is estimated at 12,100 km; this is the equivalent of approximately 1,450 hr of surveying across 180 8-hr operational survey days. The scenario would require 180 vessel round trips.

Five ports have been identified as likely shore bases for G&G activities. These are Norfolk, Virginia (Port of Virginia); Wilmington, North Carolina; Charleston, South Carolina; Savannah, Georgia; and Jacksonville, Florida. The ports were selected based on their geographic proximity to the AOI, locations named in permit applications for G&G activities, and the availability of adequate support facilities that could be used by G&G survey vessels. However, there are many smaller ports that exist along the coast from Delaware to Florida that could be used as support bases for G&G activities associated with individual renewable energy or marine minerals projects.

5.1.1. Air Quality and Vessel-Based Emissions

Air quality information for the five primary port locations is provided in **Tables F-2** through **F-5**. Air quality in the five primary port location areas is generally good (Air Quality Index [AQI] value of 50 or less). Based on 2012 air quality data, unhealthy air quality conditions for sensitive groups (AQI value between 101 and 150) at each locale ranged between 1 and 8 days; single unhealthy days (AQI values 151-200) were noted only for Norfolk and Jacksonville during 2012.

Criteria pollutants of concern in these areas include SO_2 and PM. NO_x, SO_x, and direct particulate matter are the primary pollutants of concern emitted from ships. These pollutants and the pollutants that are secondarily formed from these emissions can have atmospheric lifetimes of 5-10 days before being significantly dispersed, deposited, or converted to other species (USEPA, 2009).

On March 26, 2010, the International Maritime Organization (IMO) amended the International Convention for the Prevention of Pollution from Ships (MARPOL) designating specific portions of U.S., Canadian, and French waters, including the AOI, as an Emission Control Area (ECA). In October 2008, the member states of IMO agreed to amend MARPOL Annex VI, adopting new tiers of NO_x and fuel sulfur controls. Ships are significant contributors to the U.S. and Canadian mobile-source emission inventories, though most are flagged or registered elsewhere. Ships complying with ECA standards will reduce their emissions of nitrogen oxides (NO_x), sulfur oxides (SO_x), and fine particulate matter ($PM_{2.5}$) (USEPA, 2009, 2010).

5.1.2. AOI Port Activity

Most of the harbors and associated coastal areas in Virginia, North Carolina, South Carolina, Georgia, and northeastern Florida are heavily developed metropolitan and industrial areas and have historically been, and continue to be host to very large volumes of rail, road, vessel, and air traffic, all of which emit air pollutants (USDOI, BOEM, 2012).

5.1.2.1. Port of Virginia

There were 35,360 vessel trips to and from ports in Virginia in 2009 (approximately 17,680 round trips) (USACE, 2009). The Port of Virginia ranks ninth among all U.S. ports handling over 15,900,000 tons of cargo in 2005. In recent years, regulatory officials have increased their focus on air emissions generated from U.S. port operations. Diesel exhaust generated from cargo handling equipment is responsible for approximately 25 percent of emissions from port facilities. In 1999, the Port of Virginia voluntarily implemented emissions reduction program through a series of revisions to its equipment purchasing policies. The Port specifies to its suppliers that all new cargo handling equipment contain the lowest emission engine available on the market. From 1999 to 2005, air emissions from cargo handling activities at the Port of Virginia decreased by 30 percent despite a 55 percent increase in cargo volume. For 2005-2015, emissions are expected to decline by an additional 38 percent with a 49 percent projected increase in cargo volume (Port of Virginia, 2013).

Table F-2

Air Quality Statistics Report for the Five Port Areas of the Area of Interest (AOI) for 2012
for Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), and Ozone (O_3)
(Values shown are the highest reported during the year by all monitoring sites in the county or Core Based Statistical Area [CBSA] [from USEPA, 2013a].)

CBSA	CO 1-hr 2nd Max	CO 8-hr 2nd Max	NO_2 98th Percentile	O_3 1-hr 2nd Max	O_3 8-hr 4th Max
Norfolk, VA	1.5	1	41	0.1	0.074
Wilmington, NC	-	-	-	0.09	0.064
Charleston, SC	-	-	35	0.08	0.064
Savannah, GA	-	-	-	0.08	0.063
Jacksonville, FL	3.8	1.6	37	0.08	0.061

Notes: Norfolk, VA = Virginia Beach-Norfolk-Newport News, VA-NC CSBA; Charleston, SC = Charleston-North Charleston, SC CSBA.

Determinations: CO 1-hr 2nd Max = the second highest 1-hr measurement in the year for CO; CO 8-hr 2nd Max = the second highest non-overlapping 8-hr average in the year for CO; NO_2 98th Percentile = the 98th percentile of the daily maximum 1-hr measurements in the year for NO_2; O_3 1-hr 2nd Max = the second highest daily maximum 1-hr measurement in the year for O_3; O_3 8-hr 4th Max = the fourth highest daily maximum 8-hr average in the year for O_3.

Table F-3

Air Quality Statistics Report for the Five Port Areas of the Area of Interest (AOI) for 2012
for Sulfur Dioxide (SO_2), and Particulate Matter ($PM_{2.5}$, and PM_{10})
(Values shown are the highest reported during the year by all monitoring sites in the county or Core Based Statistical Area [CBSA] [from USEPA, 2013a].)

CBSA	SO_2 99th Percentile	SO_2 24-hr 2nd Max	$PM_{2.5}$ 98th Percentile	$PM_{2.5}$ Weighted Mean	PM_{10} 24-hr 2nd
Norfolk, VA	56	9	23	8.3	32
Wilmington, NC	47	8	16	8.7	-
Charleston, SC	17	5	34	9.6	41
Savannah, GA	78	35	24	10	27
Jacksonville, FL	54	19	22	8	55

Notes: Norfolk, VA = Virginia Beach-Norfolk-Newport News, VA-NC CSBA; Charleston, SC = Charleston-North Charleston, SC CSBA.

Determinations: SO_2 99th Percentile = the 99th percentile of the daily maximum 1-hr measurements in the year for SO_2; SO_2 24-hr 2nd Max = the second highest 24-hr average measurement in the year for SO_2; $PM_{2.5}$ 98th Percentile = the 98th percentile of the daily average measurements in the year for $PM_{2.5}$; $PM_{2.5}$ Weighted Mean = the weighted annual mean (mean weighted by calendar quarter) for the year for $PM_{2.5}$; PM_{10} 24-hr 2nd Max = the second highest 24-hr average measurement in the year for PM_{10}.

Table F-4

Air Quality Index (AQI) Annual Summary Information for the Five Port Areas of the Area of Interest (AOI) for 2012 showing Number of Days by Air Quality Category (The AQI is an indicator of overall air quality [from USEPA, 2013b].)

CBSA	No. Days with AQI	No. Good Days	No. Moderate Days	No. Days USG	No. Days Unhealthy	No. Days Very Unhealthy
Norfolk, VA	366	291	71	3	1	-
Wilmington, NC	366	322	43	1	-	-
Charleston, SC	366	239	126	1	-	-
Savannah, GA	366	236	122	8	-	-
Jacksonville, FL	366	290	71	4	1	-

Notes: Norfolk, VA = Virginia Beach-Norfolk-Newport News, VA-NC CSBA; CSBA; Charleston, SC = Charleston-North Charleston, SC CSBA; CSBA = core based statistical area.

Determinations: No. Days with AQI = Number of days in the year having an AQI value; this is the number of days on which measurements from any monitoring site in the county or Metropolitan Statistical Area were reported to the air quality standards database; No. Good Days = Number of days in the year having an AQI value 0 through 50; No. Moderation Days = Number of days in the year having and AQI value 51 through 100; No. Days USG (Unhealthy for Sensitive Groups) = Number of days in the year having an AQI value 101 through 150; No. Days Unhealthy = Number of days in the year having an AQI value 151 through 200; No. Days Very Unhealthy = Number of days in the year having an AQI value 201 or higher. This includes the AQI categories very unhealthy and hazardous. Very few locations (about 0.3% of counties) have any days in the very unhealthy or hazardous categories.

Table F-5

Air Quality Index (AQI) Annual Summary Information for the Five Port Areas of the Area of Interest (AOI) for 2012 showing AQI Statistics and Pollutants (The AQI is an indicator of overall air quality [from USEPA, 2013b].)

CBSA	AQI Max	AQI 98th Percentile	AQI Median	No. Days CO	No. Days NO_2	No. Days O_3	No. Days SO_2	No. Days $PM_{2.5}$	No. Days PM_{10}
Norfolk, VA	164	61	41	-	12	144	22	188	-
Wilmington, NC	104	52	34	-	-	147	33	186	-
Charleston, SC	134	62	43	-	5	55	-	306	-
Savannah, GA	124	67	43	-	-	61	78	227	-
Jacksonville, FL	165	56	39	-	1	163	36	163	3

Notes: Norfolk, VA = Virginia Beach-Norfolk-Newport News, VA-NC CSBA; CSBA; Charleston, SC = Charleston-North Charleston, SC CSBA; CSBA = core based statistical area.

Determinations: AQI Max = The highest daily AQI value in the year; AQI 90th Percentile = 90 percent of daily AQI values during the year were less than or equal to the 90th percentile value; AQI Median = Half of daily AQI values during the year were less than or equal to the median value, and half equaled or exceeded it; No. Days CO, No. Days NO_2, No. Days O_3, No. Days SO_2, No. Days $PM_{2.5}$, No. Days PM_{10} = A daily index value is calculated for each air pollutant measured. The highest of those index values is the AQI value, and the pollutant responsible for the highest index value is the "Main Pollutant." These columns give the number of days each pollutant measured was the main pollutant. A blank column ("-") indicates a pollutant not measured in the county or CBSA.

5.1.2.2. Port of Wilmington

The Port of Wilmington is owned and operated by the North Carolina State Ports Authority and offers terminal facilities serving container, bulk, and breakbulk operations. The Port of Wilmington handled 461 commercial vessel and one barge visit in 2012 (Port of Wilmington, 2013). The North Carolina Ports Authority adopted ultra-low sulfur diesel fuel as its primary off-road diesel fuel on July 1, 2007, over 3 years in advance of Federal requirements. Also in 2007, the Authority put into service four new environmentally friendly electrified container cranes, and is exploring additional grants that would replace other specialized cargo handling diesel equipment with all electric units. In December 2008, as part of its commitment to sustainable, environmentally friendly operations at the Ports of Wilmington and Morehead City, the Ports Authority offered a free workshop on diesel emissions reduction for truckers. The North Carolina State Ports Authority also has been awarded grants to install biodiesel fuel tanks at its facilities and to retrofit lighting in its warehouses.

5.1.2.3. Port of Charleston

In 2012, the Port of Charleston ranked as the eighth port in the United States by cargo value, with $63 billion in imports and exports traded across the docks. Newer, cleaner engines and cleaner fuels have helped reduce total pollutants from port equipment and trucks, according to an air emissions inventory report commissioned by the South Carolina Ports Authority (SCPA). That inventory, which measured all port-related emissions in the tri-county region during 2011, was a follow-up to the port's baseline study that quantified 2005 levels. The 2011 inventory report included analysis of emissions of six criteria pollutants from trucks, trains, cargo-handling equipment, ships, and tugs and spanned an approximately 6,475-square kilometer (2,500-square mile) area.

Key findings of the 2011 inventory report included that total port-related levels of nitrogen oxide (NO_x), carbon monoxide (CO), and hydrocarbons were reduced by 29, 51, and 26 percent, respectively from 2005 levels.

The region's air meets or exceeds all State and Federal air quality standards, and port-related emissions today are already lower than the report's findings. Additionally, the U.S. joined other nations in adopting new fuel standards for ocean-going vessels. The North American Emissions Control Area (ECA), a boundary extending 200 miles off the coast of North America, requires the use of low-sulfur content fuel and is providing further reductions to ship emissions than what was measured for 2011 operations. Although total vessel counts were down in 2011 versus 2005, the 2011 report indicates that the average engine size of ships calling Charleston has increased more than 45 percent since 2005, reflecting the trend toward larger vessels in global trade.

Using USEPA emissions factors for these larger vessels, the 2011 report concludes that 2013 will see approximately 60 percent less PM and SO_2 emissions from ships than occurred in 2011. By 2015 and the full implementation of ECA, PM and SO_2 from all ships will be reduced by more than 80 percent compared to 2011. Beginning in 2016, all new ships additionally must meet stringent NO_x emissions requirements.

The 2011 report projects similar improvement in total port-related air quality in the coming years. While the number varies by sector and by pollutant, the 2011 report calculates that by 2015 there will have been between an 80 to 90 percent reduction in the amount of criteria pollutants of most concern to public health and sensitive populations (PM and SO_2).

The SCPA completed a first-in-the-Southeast air emissions inventory in September 2008, which measured port-related air emissions across the Tri-County region in 2005. That emissions inventory provided a baseline of emissions sources and information for the evaluation of other possible reduction strategies.

A subsequent inventory to measure 2017 port-related air emissions will track the effect of the SCPA's truck replacement program that began in late 2011, additional repower projects for cargo-handling equipment and full implementation of new Federal fuel standards for ocean-going vessels calling North American ports (Port of Charleston, 2013).

5.1.2.4. Port of Savannah

The Port of Savannah, operated by the Georgia Ports Authority, specializes in the handling of container, reefer, breakbulk, and RoRo cargoes. Total vessel calls at the Port of Savannah increased 5 percent from 2,073 in Fiscal Year 2009 to 2,175 in Fiscal Year 13 (Port of Savannah, 2013).

5.1.2.5. Port of Jacksonville

In 2012, the Port of Jacksonville (JAXPORT) facilities handled 8.2 million tons of cargo, including nearly a million cargo containers, based on 2,083 cargo vessel calls. JAXPORT is the leading vehicle export port in the U.S and contributes $19 billion in annual economic impact to the region (Port of Jacksonville, 2013a).

Recently, JAXPORT became one of the first Florida ports to enter into a grant partnership with the State, allowing the port to voluntarily reduce terminal diesel emissions further. The grant, awarded by the Florida Department of Environmental Protection and funded by the USEPA, will pay for the port to install diesel oxidation catalysts on JAXPORT cranes and equipment, reducing emissions by 10 tons per year (Port of Jacksonville, 2013b).

5.1.3. Nonattainment, Maintenance, and Class I Areas

Outer Continental Shelf waters are not classified as to the presence of criteria pollutants under NAAQS and the CAA. Ambient air quality offshore is expected to range from good to excellent because of the distance from significant emission sources (e.g., large urban areas or concentrated offshore development). Most of the coastal counties adjacent to the AOI have all criteria pollutants present. However, Sussex County, Delaware, at the mouth of Delaware Bay is part of the Philadelphia-Wilmington-Atlantic City moderate nonattainment area for 8-hr ozone (USEPA, 2012b). The Norfolk-Virginia Beach-Newport News-Hampton Roads area in Virginia is a maintenance area for 8-hr ozone (USEPA, 2012b). A maintenance area is an area that has been redesignated to attainment for the 8-hr ozone standard. There are no other coastal nonattainment or maintenance areas adjacent to the AOI (USEPA, 2013c).

Class I Areas are defined in Sections 101(b)(1), 169A(a)(2), and 301(a) of the CAA, as amended (42 USC 7401(b), 7410, 7491(a)(2), and 7601(a)). Class I areas are federally owned lands where very little air quality degradation is allowed (USEPA, 2013d). In these areas, air quality-related values including visibility are protected. Class I Areas have stringent incremental limits for NO_2, SO_2, and PM_{10}. Three wilderness areas have been identified adjacent to the AOI (**Figure F-7**):

- Swanquarter Wilderness Area, North Carolina;
- Cape Romain FWS Cape Romain Wilderness, South Carolina; and
- Wolf Island FWS Wolf Island Wilderness Area, Georgia.

5.2. IMPACTS

A significant amount of vessel traffic is expected to occur within the AOI during the project period, including high levels of vessel activity associated with shipping and marine transportation around ports along the U.S. eastern seaboard. Military operations, research vessels, and commercial and recreational fishing activity would also contribute to overall vessel activity.

Six commercial deepwater ports are located along the coast adjacent to the AOI. Vessels using these ports include large commercial vessels, military vessels, commercial business craft, commercial recreational craft, research vessels, and personal craft. Current levels of shipping and marine transportation occurring along the entire U.S. Atlantic coast amount to nearly 30,000 arrivals for 2002-2004 (USDOC, NMFS, 2008) for vessels of 150 gross registered tons (GRT) or more.

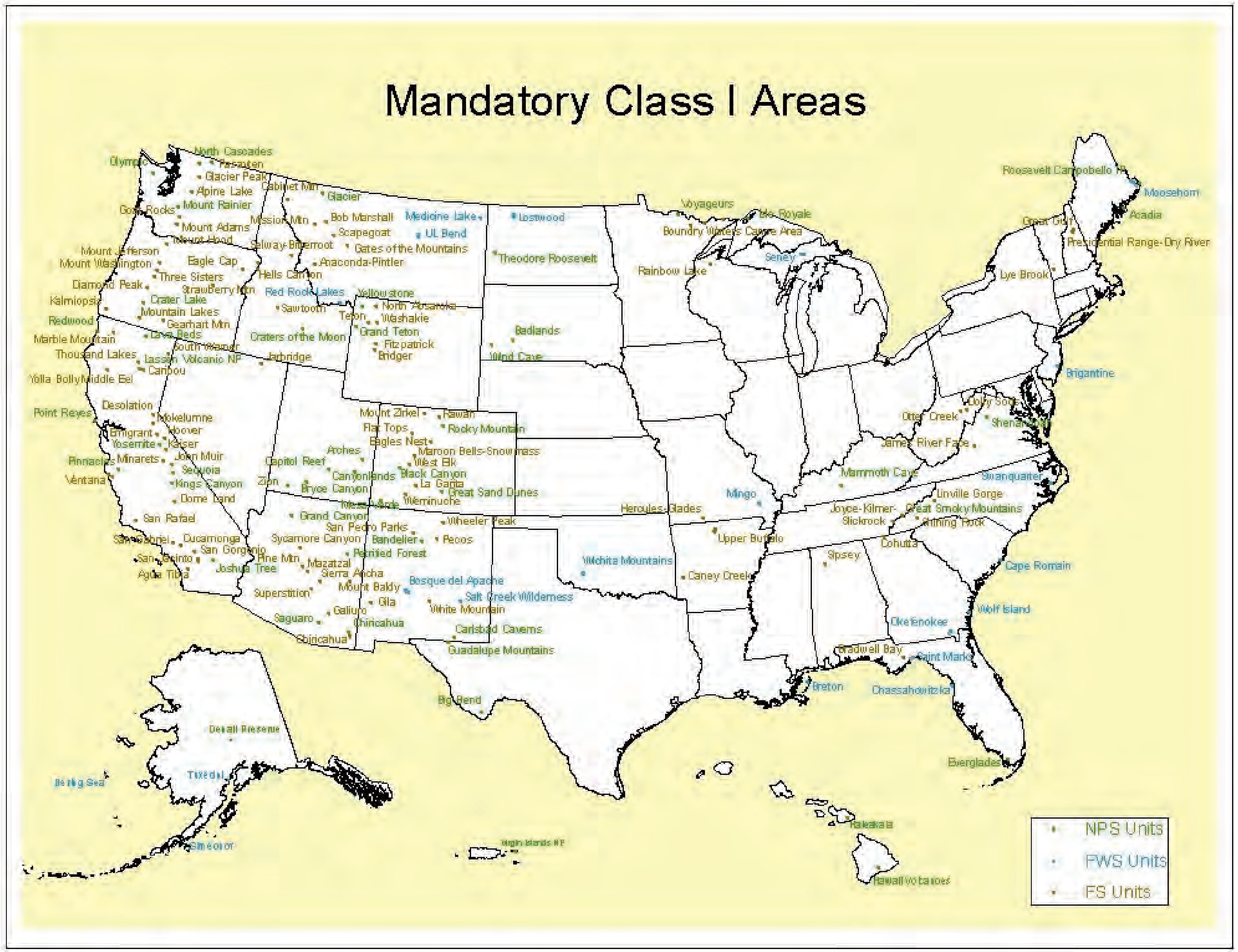

Figure F-7. Locations of Mandatory Class I Areas in the U.S. (from USEPA, 2009).

Shipping and maritime vessel activity in the five major commercial ports of the AOI is substantial, with several thousand vessel arrivals per port per year noted. Actual vessel movements consider both vessel approach/arrival and departure from a port facility, indicating that vessel transits levels through the region are approximately twice the vessel arrival levels. Based on 2004 U.S Coast Guard data, more than 54,000 vessel transits (involving commercial vessels of at least 150 GRT) occur at U.S. east coast ports per year, a significant proportion of which either use ports of the AOI or may traverse waters of the AOI during inbound or outbound transit.

Based on the vessel traffic expected under G&G activities, impacts to shipping and marine transport are expected to be negligible since the number of G&G-related vessel trips involved (approximately 4,250) and the duration of these surveys is small in relation to the existing vessel traffic throughout the AOI. There would not be a sufficient increase in vessel traffic to impact shipping and marine transportation; similarly, G&G vessel activities do not represent an appreciable source of combustion emissions.

Vessel traffic associated with geological and geophysical (G&G) operations would involve relatively small numbers of survey-related vessels operating within offshore waters on a transient and intermittent basis over the period of interest (**Table F-6**).

Table F-6

Summary of Vessel Activity, by Type, for Ports Adjacent to the Area of Interest (AOI) and Vessel Activity within and Adjacent to the AOI

Vessel Activity Type	Total (2012-2020 Period)	Average Per Year
G&G Activity		
Seismic airgun – port visits	125	14
Renewal Energy – HRG	3,106-9,969	345-1,108
Renewable Energy – geotechnical	4,255	473
Marine minerals – HRG	180	20
Marine minerals – geotechnical	93-615	10-68
Total G&G-related	7,759-15,144	862-1,683
Commercial Vessels		
Shipping and maritime transport	>486,000	>54,000
U.S. Navy Exercises, Training, Testing		
Independent Unit Level Training	--	764-1,216
Coordinated Unit Level Training	--	118-145
Strike Group Training	--	46
Maintenance	--	475
Total Navy-related**	--	1,403-1,882
Annual Total Vessel Activity (Port Visits) without G&G		55,403-55,882
Annual Total Vessel Activity (Port Visits) with G&G		56,265-57,565
Annual Increase in Port Visits Attributed to G&G		1.5%-3.0%

G&G = geological and geophysical; HRG = high-resolution geophysical.

G&G survey vessel activity, when considered in the context of other commercial vessel activities and U.S. naval exercises, training, and testing operations within the AOI, represent a very small component (i.e., 1.5 to 3% of vessel port visits) of overall port traffic. Air emissions from survey vessels will contribute minor amounts of pollutants to the emissions inventories for each port. Due to distance offshore for most survey operations, impacts to Class I areas are not expected. For these reasons, air quality emissions associated with anticipated G&G operations have been screened out of detailed analysis for the Atlantic G&G Programmatic Environmental Impact Statement.

6. ACOUSTIC ENVIRONMENT

Various activities and processes, both natural and anthropogenic, combine to form the sound profile within the ocean, generally referred to as ambient ocean noise (Richardson et al., 1995). Most ambient noise is broadband (composed of a spectrum of numerous frequencies without a differentiating pitch) and encompasses virtually the entire frequency spectrum. Vessel traffic is a major contributor to ocean noise between 5 and 500 Hz (National Research Council, 2003). Spray and bubbles associated with breaking waves are the major contributions to ambient noise in the 500-100,000-Hz range. At frequencies greater than 100,000 Hz, "thermal noise" caused by the random motion of water molecules is the primary source. Ambient noise sources, especially noise from wave and tidal action, can cause coastal environments to have particularly high ambient noise levels.

A large portion of the noise from vessel traffic comes from vessel engines and propellers, and those sounds occupy the low frequencies used by most large whales (Richardson et al., 1995). In the open water, ship traffic can influence ambient background noise at distances of thousands of kilometers; however, the effects of ship traffic sounds in shallow coastal waters are much less far reaching, most likely because a large portion of the sound's intensity is absorbed by soft, nonreflective, unconsolidated materials (sands and mud) on the seafloor. Other anthropogenic sources include dredging, nearshore construction activities, and sonar signals (especially those used by the military). Offshore oil and gas operations contribute to the ambient noise in other regions, but are not currently occurring in the AOI.

Long-term data analyzed by McDonald et al. (2006) offshore California show an increase in ambient noise of approximately 10-12 dB in the frequency range 30-50 Hz over a 40-year period, suggesting an average noise increase rate of 2.5-3 dB per decade. The authors attributed the change to increased levels of shipping traffic. While comparable long-term data for the AOI have not been published, it is assumed that underwater noise from vessel traffic and other anthropogenic sources is increasing and will continue to increase incrementally over the next decade.

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APPENDIX G

RECENT PUBLICATIONS OF THE ENVIRONMENTAL STUDIES PROGRAM, ATLANTIC OCS REGION, 2006 TO PRESENT

The Bureau of Ocean Energy Management (BOEM) funds ocean research through the Environmental Studies Program to provide science in support of management decisions. This Appendix lists Environmental Studies Program publications issued from 2006 to the present that are relevant to the Atlantic Outer Continental Shelf (OCS). Atlantic OCS publications are available online through the BOEM Environmental Studies Program Information System (ESPIS) (http://www.data.boem.gov/homepg/data_center/other/espis/espismaster.asp?appid=1).

Study Number	Title
2013	
BOEM 2013-01163	*Information Synthesis on the Potential for Bat Interactions with Offshore Wind Facilities – Final Report* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5289.pdf
BOEM 2013-01157	*South Atlantic Information Resources: Data Search and Literature Synthesis* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5296.pdf
BOEM 2013-01110	*Meteorological and Wave Measurements for Improving Meteorological and Air Quality Modeling* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5287.pdf
BOEM 2013-123	*Improving Emission Estimates and Understanding of Pollutant Dispersal for Impact Analysis of Beach Nourishment and Coastal Restoration Projects* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5300.pdf
BOEM 2013-0116	*Evaluation of Lighting Schemes for Offshore Wind Facilities and Impacts to Local Environments* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5298.pdf
BOEM 2013-01130	*High-resolution Aerial Imaging Surveys of Marine Birds, Mammals, and Turtles on the US Atlantic Outer Continental Shelf—Utility Assessment, Methodology Recommendations, and Implementation Tools: Final Report* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5272.pdf
BOEM 2013-0119	*Review of Biological and Biophysical Impacts from Dredging and Handling of Offshore Sand* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5268.pdf
2012	
BOEM 2012-01156	*Underwater Hearing Sensitivity of the Leatherback Sea Turtle (*Dermochelys coriacea*): Assessing the Potential Effect of Anthropogenic Noise* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5279.pdf
BOEM 2012-085	*Atlantic Region Wind Energy Development: Recreation and Tourism Economic Baseline Development Impacts of Offshore Wind on Tourism and Recreation Economies* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5228.pdf
BOEM 2012-083	*Identification of Outer Continental Shelf Renewable Energy Space-Use Conflicts and Analysis of Potential Mitigation Measures* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5203.pdf
BOEM 2012-082	*Developing Environmental Protocols and Modeling Tools to Support Ocean Renewable Energy and Stewardship. National Oceanographic Partnership Program* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5208.pdf
BOEM 2012-076	*Compendium of Avian Occurrence Information for the Continental Shelf Waters along the Atlantic Coast of the United States: Final Report (Database Selection – Shorebirds)* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5193.pdf
BOEM 2012-008	*Inventory and Analysis of Archaeological Site Occurrence on the Atlantic Outer Continental Shelf* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5196.pdf
BOEMRE 2012-003	*Commercial Wind Lease Issuance and Site Characterization Activities on the Atlantic Outer Continental Shelf Offshore New Jersey, Delaware, Maryland, and Virginia* http://www.boem.gov/uploadedFiles/BOEM/Renewable_Energy_Program/Smart_from_the_Start/Mid-Atlantic_Final_EA_012012.pdf
No Number	*Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic from Energy Industry Sound-Generating Activities: Literature Synthesis* http://www.boemsoundworkshop.com/documents/Literature_Synthesis_Effects_of_Noise_on_Fish_Fisheries_and_Invertebrates.pdf

2011	
BOEMRE 049-2011	*Atlantic Wind Energy Workshop: Summary Report, Final* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5124.pdf
BOEMRE 2011-048	*New Insights and New Tools Regarding Risk to Roseate Terns, Piping Plovers, and Red Knots from Wind Facility Operations on the Atlantic Outer Continental Shelf: Final Report* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/5119.pdf
BOEMRE 2011-019	*A Comparison of Marine Productivity Among Outer Continental Shelf Planning Areas: Final Report* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5121.pdf
2010	
BOEMRE TA&R 648	*Offshore Wind Energy Installation and Decommissioning Cost Estimation in the U.S. Outer Continental Shelf* http://www.bsee.gov/uploadedFiles/BSEE/Research_and_Training/Technology_Assessment_and_Research/648aa.pdf
MMS 2010-010	*Analysis of Potential Biological and Physical Impacts of Dredging on Offshore Ridge and Shoal Features: Final Report* http://www.data.boem.gov/PI/PDFImages/ESPIS/5/5199.pdf
2009	
MMS 2009-020	*Determining Night-time Distribution of Long-tailed Ducks Using Satellite Telemetry* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4823.pdf
MMS 2009-011	*Workshop on Environmental Research Needs in Support of Potential Virginia Offshore Oil and Gas Activities* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4723.pdf
2008	
MMS 2008-060	*Final Biological Characterization and Numerical Wave Model Analysis within Borrow Sites Offshore of Florida's Northeast Coast Report: Volume I* http://www.boem.gov/Non-Energy-Minerals/2008-060_Volume1.aspx
2007	
MMS 2007-057	*Workshop to Identify Alternative Energy Environmental Information Needs* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4291.pdf
MMS 2007-048	*Examination of the Physical and Biological Implications of Using Buried Channel Deposits and Other Non-Topographic Offshore Features as Beach Nourishment Material* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4274.pdf
MMS-2007-038	*Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the Outer Continental Shelf* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4325.pdf
MMS 2007-033	*Cooperative Research to Study Dive Patterns of Sperm Whales in the Atlantic Ocean* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4247.pdf
2006	
MMS 2006-065	*Investigation of Dredging Impacts on Commercial and Recreational Fisheries and Analysis of Available Mitigation Measures to Protect and Preserve Resources* http://www.data.boem.gov/PI/PDFImages/ESPIS/4/4268.pdf

APPENDIX H

MARINE MAMMAL HEARING AND SENSITIVITY TO ACOUSTIC IMPACTS

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1. INTRODUCTION/OVERVIEW

Marine animals critically depend on sound to live, making and listening to it in various ways to perform various life functions. The ocean is a naturally noisy place, but humans make a host of sounds that are increasingly impinging on the ocean acoustic environment. There is clear evidence that some of these sounds can negatively impact marine life, but the types and magnitudes of impacts as they relate to different species and sound types remain poorly understood in all but a few conditions. However, there has been significant progress in the last decade, particularly in scientific knowledge in these areas, for some species and conditions, both in terms of hearing impacts and behavioral responses to various kinds of noise. From this evolution in understanding has emerged new ways of assessing and mitigating potential impacts. While much of the focus and discussion have been on potential injurious types of sound impacts (driven by concerns over hearing/tissue damage and the isolated mass strandings of beaked whales exposed to military sonar), more focus recently has been on the impacts of human noise on biologically significant behaviors and the overall acoustic ecology of marine life. There is a realization that the footprints within which direct harm may occur are relatively small, and the conditions in which marine mammals will become stranded appear to be restricted. However, the areas over which animals may be disturbed in significant ways that may impact vital life functions can be significantly larger. These considerations and the underlying complexity of understanding and assessing their probability of occurrence, as well as mitigation, have become more critical in noise exposure criteria and other means of assessment. Many of these issues and the underlying science are considered in detail in a major comprehensive review and application of science in the context of noise exposure criteria (Southall et al., 2007). That assessment forms the current basis for much of this appendix, but subsequent studies have provided additional important findings that are also summarized here.

This appendix summarizes the current state of scientific knowledge about the importance of sound and effects of noise on marine animals, with particular attention to marine mammals. It considers separately the effects of noise on physiology, hearing, communication, and behavior from a range of different impulsive and continuous sound sources. It also considers historical and emerging noise exposure criteria and operational mitigation measures, with attention to the types of acoustic sources present in the proposed geological and geophysical (G&G) operations off the U.S. East Coast. Finally, noise impacts for endangered/threatened species most likely to be present in these areas are considered.

2. ROLE OF ACOUSTICS IN MARINE MAMMAL ECOLOGY

The underwater acoustic environment can be a noisy place, receiving sound from a host of natural and anthropogenic sources. Some natural sounds are biological (e.g., fishes, marine mammals, some invertebrates), and others are environmental (e.g., waves, earthquakes, rain). Among the anthropogenic sources, many produce noise as a by-product of their normal operations (e.g., shipping, drilling, tidal turbines), whereas others (e.g., sonars, airguns) are produced for a specific remote sensing purpose (see Hildebrand [2009] for a recent review). Detailed measurements have been made for many of these sources, but their degree of overlap with and impacts on acoustically oriented marine life remains generally poorly understood.

For most marine vertebrates, the production and reception of sound serves critical biological functions, including communication, foraging, navigation, and predator-avoidance (e.g., Schusterman, 1981; Watkins and Wartzok, 1985; Richardson et al., 1995; Tyack, 1998; Wartzok and Ketten, 1999; National Research Council [NRC], 2003; 2005; Clark and Ellison, 2004; Southall et al., 2007). As a general statement, all studied marine mammals produce sounds in a variety of inter- and intra-individual contexts, most associated with vital life functions as identified by the NRC (2005). As described below and shown in **Figure H-1** in comparison with some of the major human noise sources, each species group utilizes different frequency ranges.

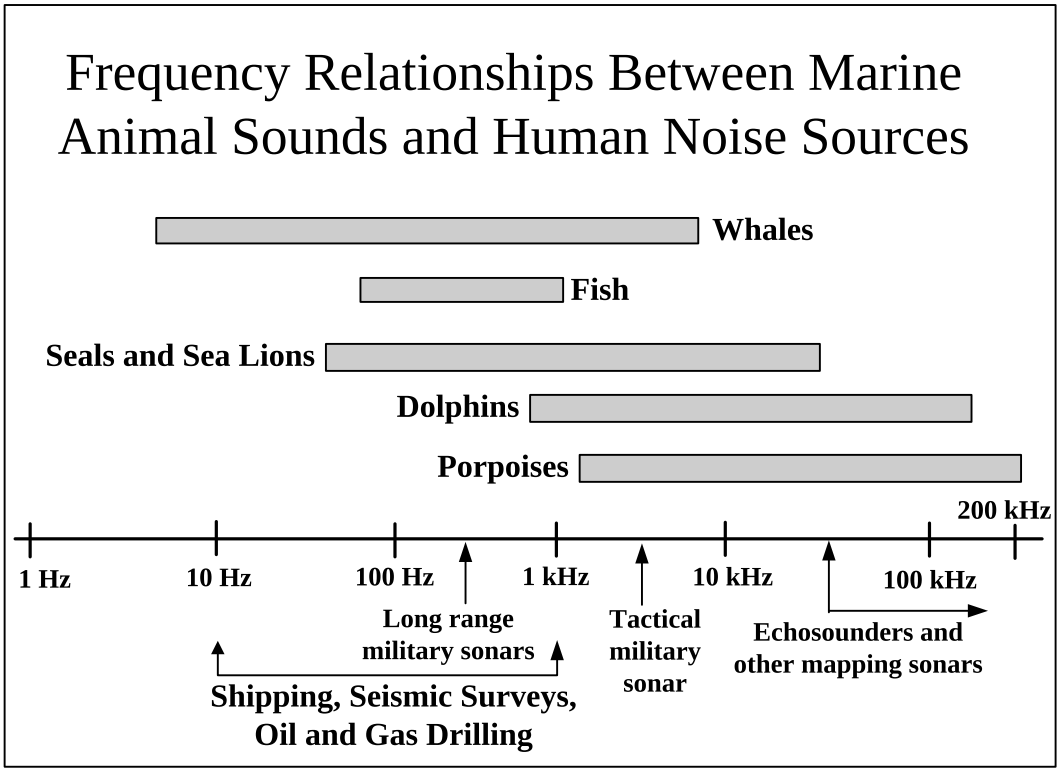

Figure H-1. Frequency Range of Sounds Generally Produced by Different Marine Animal Groups Shown Relative to Major Human Noise Sources.

Dolphins, porpoises, and other toothed whales (odontocete cetaceans) have developed sophisticated biosonar capabilities involving high frequency impulsive clicks to feed and navigate (Au, 1993) and use a variety of whistles and other calls to communicate in social interactions. These animals make sounds across some of the widest frequency bands that have been measured in any animal group. Communicative sounds generally range from a few hundreds of hertz to several tens of kilohertz, but echolocation clicks can extend above 100 kHz.

Baleen whales (mysticete cetaceans) have developed moderate to long-range communication capabilities for reproductive and social interactions and to orient themselves in the underwater world (e.g., Clark, 1990; Popper and Edds-Walton, 1997). Large whales generally produce low-frequency sounds in the tens of hertz to the several kilohertz band, with a few signals extending above 10 kHz.

Other marine mammals such as pinnipeds, manatees, and polar bears make and listen to sounds for a variety of communicative and spatial orientation functions, but like the large whales they appear to lack specialized echolocation capabilities (Schusterman, 1981; Schusterman et al., 2000). These sounds can extend above those used by mysticetes but occur over a narrower frequency band than those used by odontocetes, generally from ~100 Hz to several tens of kilohertz. Pinnipeds and polar bears spend time both at sea and on land, however, and thus rely on sounds both above and below the water.

Finally, many fishes make and listen to sounds in mating and other social interactions (Kaatz, 2002). Most of these sounds are generally low-frequency in nature, although some fishes produce more impulsive sounds as well. Aside from some simple hissing and other sounds produced in air, marine turtles generally do not appear to produce sounds in water for communicative or foraging purposes, but may rely on sound in a general orienting sense.

3. HEARING IN MARINE MAMMALS

Hearing has been measured using behavioral and/or electrophysiological methods in about a quarter of the known marine mammal species, although with a disproportional representation of species commonly found in captivity, and some entire groups (e.g., mysticete cetaceans) remain untested. For a detailed review, see Southall et al. (2007); key findings obtained since then are discussed below. Hearing sensitivity is generally quantified by determining the quietest possible sound that is detectable by an animal (either via a behavioral response or by quantifying an electrical response) on some signal presentations. By testing such responses across a range of test frequencies, a measure of the animal's overall hearing capability (typically called an "audiogram") may be obtained; an example is given in **Figure H-2**.

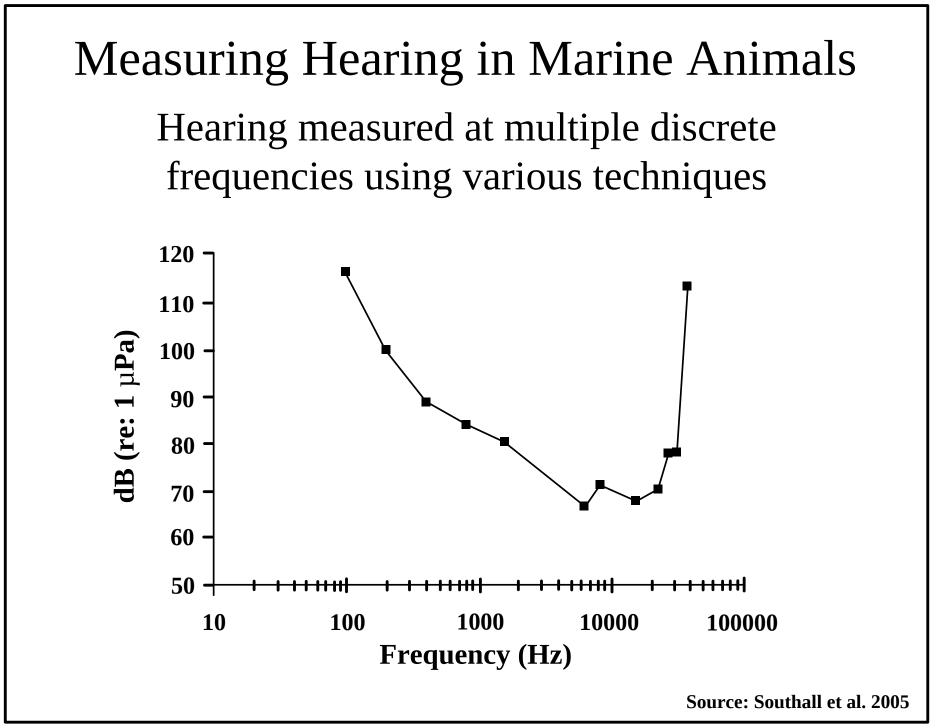

Figure H-2. Typical Hearing Curve or "Audiogram" Obtained from a California Sea Lion with a Behavioral Testing Technique.

Where detection threshold levels are lower, hearing sensitivity is greater (the animal can hear well), and vice versa. This sensitivity usually follows a U-shaped curve with regions of relatively good sensitivity that drop off on the low and high ends. The region of lowest overall average hearing is called the range of "best hearing sensitivity." Similarly, the region where hearing thresholds are within some range from the lowest overall threshold (e.g., 80 dB in Southall et al., 2007) is often referred to as the overall range of functional hearing.

Given the available direct measurements of hearing, extrapolations based on taxonomy, and predictions based on auditory morphology, vocalizations, or behavior, it is clear that not all marine taxa have equal hearing frequency ranges or absolute hearing sensitivity (Richardson et al., 1995; Wartzok and Ketten, 1999; Southall et al., 2007).

As shown in **Figure H-3**, most marine taxa have measured or estimated (in the case of baleen whales) functional hearing capabilities that occur in generally similar frequency ranges as those where their vocalizations occur. However, for some species there can be substantial differences in auditory capabilities relative to vocal parameters (Ladich and Yan, 1998); in some cases perception may be slightly broader than the frequency range of vocalizations (Luther and Wiley, 2009). It is important to note the differences in frequency ranges of vocalizations and hearing; both are given here in **Figures H-1** and **H-3** as vocal frequency ranges may be particularly important with regard to potential interference of communication from noise whereas hearing sensitivity is an important consideration with regard to direct auditory impacts such as temporary or permanent threshold shift.

Fishes generally hear in a relatively narrow frequency band up to just a few kilohertz, while marine mammals as a whole cover a very wide band, with baleen whales likely hearing down into very low frequencies, pinnipeds at low to intermediate frequencies (relatively), and odontocete cetaceans hearing over a very broad range extending well into the ultrasonic (for humans) range. Recently, functional hearing has been demonstrated in a marine invertebrate as well (longfin squid; see Mooney et al., 2010). Specific hearing characteristics for different marine mammal groups are described below.

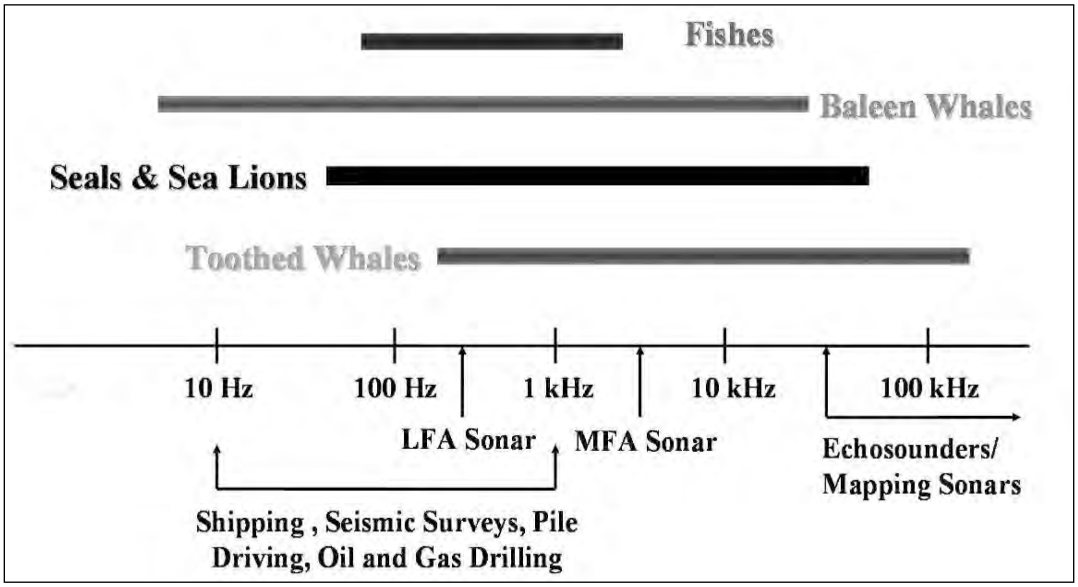

Figure H-3. Measured or Estimated Functional Hearing Ranges for Different Marine Vertebrate Groups Shown Relative to Various Human Noise Sources.

3.1. Hearing in Mysticete Cetaceans

Because of the lack of captive subjects and logistical challenges of bringing experimental subjects into the laboratory, direct measurements of mysticete hearing are unavailable, although there was an unsuccessful attempt to directly measure hearing in a stranded gray whale calf by Ridgway and Carder (2001). Consequently, hearing in mysticetes is estimated based on other means such as vocalizations (Wartzok and Ketten, 1999), anatomy (Houser et al., 2001; Parks et al., 2007), behavioral responses to sound (Frankel, 2005; Reichmuth, 2007), and nominal natural background noise conditions in the likely frequency ranges of hearing (Clark and Ellison, 2004).

The combined information from these and other sources strongly suggests that mysticetes are likely most sensitive to sound from perhaps tens of hertz to ~10 kHz. However, humpback whales (*Megaptera novaeangliae*) produce sounds with harmonics extending above 24 kHz (Au et al., 2006), and Ketten et al. (2007) suggested, based on anatomical data, that some mysticetes could hear frequencies up to 30 kHz. Southall et al. (2007) estimated the lower and upper frequencies for functional hearing in mysticetes, collectively, to be 7 Hz and 22 kHz, respectively, but based on the above information this may be a slight underestimate on the high frequency cutoff. Nevertheless, there appears to be little doubt that mysticetes operate primarily in the very low and low frequency ranges.

3.2. Hearing in Odontocete Cetaceans

Because of the presence of specialized, high frequency biosonar and lower frequency communication systems in odontocete cetaceans, it is almost certain that they hear over an extremely wide frequency range, spanning some 12 octaves in some species. Hearing has been directly measured in controlled conditions for over a dozen odontocete species with either behavioral or electrophysiological techniques. Southall et al. (2007) reviewed the available literature and (like Wartzok and Ketten [1999]) identified two functional hearing groups within the odontocetes, which they referred to as mid-frequency cetaceans (with functional hearing between 150 Hz and 160 kHz) and high-frequency specialists (functional hearing estimated between 200 Hz and 180 kHz). Subsequent to the Southall et al. (2007) publication, additional data have been obtained on several species that had been previously tested (such as harbor porpoise) and measurements or anatomical modeling results have been obtained for several new species – e.g., Cuvier's beaked whales (Cranford et al., 2008a,b) and false killer whales (Montie et al., 2011) suggesting that these additional species have similar basic hearing ranges and functional capabilities to other cetaceans. These and other studies have contributed to an increased understanding of hearing in odontocete cetaceans, but they are fundamentally consistent for these species with the Southall et al. (2007) assessment for these species in terms of the broad range and high-frequency extension of functional hearing in odontocete cetaceans.

3.3. Hearing in Pinnipeds and Manatees

Pinnipeds are amphibious mammals and have functional hearing both above and below the water, although they have broader functional hearing ranges in water (Kastak and Schusterman, 1998 for a discussion). Direct measurements of hearing using behavioral and electrophysiological methods have been obtained in nearly 10 different species (Southall et al., 2007; Mulsow and Reichmuth, 2010). Southall et al. (2007) estimated functional hearing across all pinnipeds as extending between 75 Hz and 75 kHz under water and between 75 Hz and 30 kHz in air. However, they also noted that, as in the odontocete cetaceans, there appears to be a segregation in functional hearing within pinniped taxa, with phocids (seals lacking external ear pinnae that are less mobile on land, such as harbor seals) extending to much higher frequencies, especially in water, than otariids (seal lions and fur seals that have distinct external ear pinnae and are more agile on land). This would be a logical additional segregation in terms of functional hearing within marine mammals.

Hearing has also been tested both in terms of absolute and masked hearing capabilities in manatees (Gerstein et al., 1999; Mann et al., 2005). The combined data suggest that manatees have hearing capabilities that are generally similar to phocid pinnipeds except perhaps at the lowest frequencies, with functional hearing between about 250 Hz and ~80 kHz. Based on these data, the extrapolation of pinniped data to manatees, where information is lacking, would seem reasonable.

3.4. Marine Mammal Hearing Weighting Functions

Because animals including marine mammals do not hear equally well at all frequencies, frequency-weighting functions are often used as a means of quantitatively compensating for differential frequency responses for different species. These are commonly applied in assessing the potential for the detection of a sound at a specific frequency and, more commonly, for assessing potential noise impacts. Noise exposure criteria are discussed in greater detail in **Section 4**. However, as they are related to the above generalizations regarding basic hearing in different marine mammal groups, the frequency weighting functions derived by Southall et al. (2007) are described briefly here.

Table H-1 shows the five functional hearing groups and estimated functional hearing ranges for marine mammals proposed in the Southall et al. (2007) noise exposure criteria.

Using the estimated lower and upper frequency cut-off limits as 6-dB down points on an exponential roll-off for the frequency-weighting functions (as is done in human C-weighting), Southall et al. (2007) developed frequency-weighting filters for each of the five functional hearing groups as shown in **Figure H-4**.

Table H-1

Marine Mammal Functional Hearing Groups and Estimated Functional Hearing Ranges Proposed by Southall et al. (2007)

Functional Hearing Group	Estimated Auditory Bandwidth	Genera Represented (Number Species/Subspecies)	Frequency-Weighting Network
Low-frequency cetaceans	7 Hz to 22 kHz	*Balaena*, *Caperea*, *Eschrichtius*, *Megaptera*, *Balaenoptera* (13 species/subspecies)	M_{lf} (lf: low-frequency cetaceans)
Mid-frequency cetaceans	150 Hz to 160 kHz	*Steno*, *Sousa*, *Sotalia*, *Tursiops*, *Stenella*, *Delphinus*, *Lagenodelphis*, *Lagenorhynchus*, *Lissodelphis*, *Grampus*, *Peponocephala*, *Feresa*, *Pseudorca*, *Orcinus*, *Globicephala*, *Orcacella*, *Physeter*, *Delphinapterus*, *Monodon*, *Ziphius*, *Berardius*, *Tasmacetus*, *Hyperoodon*, *Mesoplodon* (57 species/subspecies)	M_{mf} (mf: mid-frequency cetaceans)
High-frequency cetaceans	200 Hz to 180 kHz	*Phocoena*, *Neophocaena*, *Phocoenoides*, *Platanista*, *Inia*, *Kogia*, *Lipotes*, *Pontoporia*, *Cephalorhynchus* (19 species/subspecies)	M_{hf} (hf: high-frequency cetaceans)
Pinnipeds in water	75 Hz to 75 kHz	*Arctocephalus*, *Callorhinus*, *Zalophus*, *Eumetopias*, *Neophoca*, *Phocarctos*, *Otaria*, *Erignathus*, *Phoca*, *Pusa*, *Halichoerus*, *Histriophoca*, *Pagophilus*, *Cystophora*, *Monachus*, *Mirounga*, *Leptonychotes*, *Ommatophoca*, *Lobodon*, *Hydrurga*, *Odobenus* (41 species/subspecies)	M_{pw} (pw: pinnipeds in water)
Pinnipeds in air	75 Hz to 30 kHz	Same species as pinnipeds in water (41 species/subspecies)	M_{pa} (pa: pinnipeds in air)

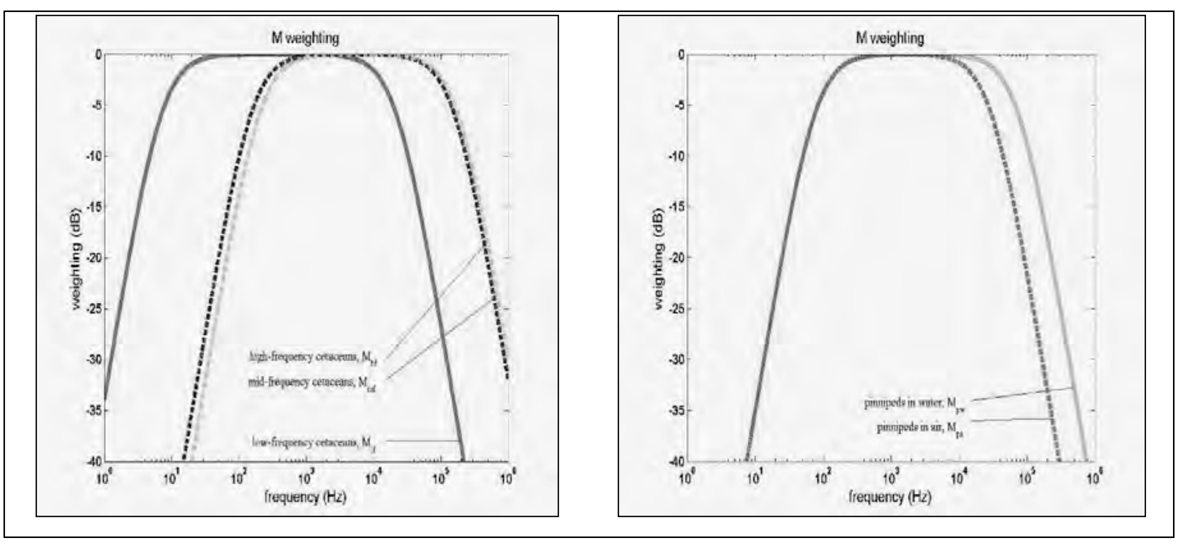

Figure H-4. Frequency-Weighting Functions for Cetaceans (left) and Pinnipeds in Air and Water (right) Proposed by Southall et al. (2007).

4. EFFECTS OF NOISE ON MARINE MAMMAL HEARING AND BEHAVIOR

Where there is an overlap between noise sources and the frequencies of sound used by marine life, there may be concerns related to how such sound may interfere with important biological functions. Noise, either natural or anthropogenic, can adversely affect marine life in various ways, inducing alteration of behavior, reduction of communication ranges or orientation capability, temporary or permanent damage to the auditory or other systems; and/or, in extreme cases, habitat avoidance or even death (e.g., Richardson et al., 1995; NRC, 2003, 2005; Nowacek et al., 2007; Southall et al., 2007). Noise impacts may also be additive or synergistic to those of other human stressors. While determining the biological significance of noise exposure impacts remains challenging (NRC, 2005), significant strides have been made in quantifying the effects of noise on marine mammals. The potential and measured effects of noise on physiology, hearing, and behavior are reviewed here, with attention to findings subsequent to the Southall et al. (2007) review and assessment of noise impacts on marine mammals.

4.1. EFFECTS OF NOISE ON MARINE MAMMAL PHYSIOLOGY

Noise can result in direct, physiological impacts on marine mammals, even in cases where hearing impacts or even behavioral responses may be lacking. These may include stress responses and direct physical injury (e.g., tissue damage). Stress responses can vary from an acute startle response to more chronic effects and can vary widely across individuals in type and magnitude according to a host of factors (Busch and Hayward [2009] for a recent review). Stress reactions in humans and other vertebrates include various physiological changes to pulmonary, respiratory cardiac, metabolic, neuro-endocrine, immune, and reproductive functions; these can vary from relatively benign to very detrimental or fatal in some conditions.

Direct measurements of physical stress responses in marine mammals from sound exposure are relatively limited (Thomas et al., 1990; Miksis et al., 2001; Romano et al., 2004), although the larger body of data for terrestrial mammals and other animals is available and, in some cases, may be useful where direct information is lacking (Wright et al., 2007a,b). The available literature for marine mammals indicates endocrine secretions of glucocorticoids and altered cardiovascular function in some conditions following relatively intense noise exposure.

Direct physical injury can occur from exposure to high levels of sound or, more commonly, to shock wave pulses associated with high intensity events such as explosions. These pulses are typically short, peak pressures that may damage internal organs or air-filled body cavities, such as lungs (Yelverton et al., 1973; Goertner, 1982; Young, 1991). Direct data on direct physical injury are limited to anecdotal or forensic investigations after accidental events because ethical considerations prevent direct empirical methods to measure such impacts in marine mammals. However, such observations (e.g., Todd et al., 1996) and modeling based on impact data for the human vestibular system as well as other organs (e.g., lungs) for underwater sound exposures (Cudahy and Ellison, 2002) suggest that marine mammals can be susceptible to direct physical injury to particular organ systems and tissues following intense exposure, particularly where high particle motion events occur.

Other forms of physiological damage that have been investigated and in some cases shown in marine mammals include the formation of gas bubble lesions and fat emboli, similar to those associated with human decompression sickness; these have been observed in some beaked whale species that stranded around naval mid-frequency sonar training exercises (Jepson et al., 2003; Fernández et al., 2005). Currently, these tissue impacts are thought to result from a behavioral response that changes diving patterns in some way and subsequently causes lesion/emboli formation, rather than as a direct physical effect of sound exposure (Cox et al., 2006; Zimmer and Tyack, 2007). These kinds of emboli have not been definitively shown in other marine mammals exposed to natural or anthropogenic sound to date.

4.2. EFFECTS OF NOISE ON MARINE MAMMAL HEARING

Much of the scientific and regulatory attention on the impacts of noise on marine life has centered on the issue of how sound affects hearing in marine mammals. While the available literature on the underlying issues remains quite limited compared to that available for some terrestrial species, considerable progress has been made in these areas, particularly in the last decade, for marine mammals. There have been numerous reviews of the available data on these issues (Richardson et al., 1995; Wartzok and Ketten, 1999; NRC, 2003, 2005), the most recent comprehensive assessment being the Southall et al. (2007) review and application of the available science in the context of proposing noise exposure criteria (see below). A summary description of temporary and permanent hearing losses and auditory masking is given here with reference to these reviews generally, and some discussion of more recent relevant literature on each issue.

4.2.1. Temporary and Permanent Threshold Shift in Marine Mammals

Noise-induced threshold shifts are increases in hearing thresholds within a certain frequency range (Yost, 2000). Following exposure, the magnitude of the threshold shift normally decreases over time following cessation of noise exposure. Threshold shifts can be temporary (TTS) or permanent (PTS) and can consist of both temporary and permanent components. Several important factors relate to the type and magnitude of hearing loss, including exposure level, frequency content, duration, and temporal pattern of exposure. A range of mechanical stress or damage (e.g., supporting cell structure fatigue) and metabolic (e.g., inner ear hair cell metabolism, such as energy production, protein synthesis, and ion transport) processes within the auditory system underlie both TTS and PTS (Kryter, 1994; Ward, 1997; Yost, 2000). Intense sound exposure more often results in mechanical processes, whereas prolonged exposure more typically results in metabolic changes (e.g., Saunders et al., 1985).

Temporary threshold shift is a relatively short-term reversible loss of hearing, often resulting from cellular fatigue and metabolic changes. Based on data from cetacean TTS studies (Southall et al., 2007), a threshold shift of 6 dB is generally considered the minimum threshold shift that is statistically larger than typical day-to-day or session-to-session variation in a subject's baseline threshold at a particular frequency. Conversely, PTS is an irreversible loss of hearing (permanent damage) that commonly results from inner ear hair cell loss and/or severe damage or other structural damage to auditory tissues (e.g., Saunders et al., 1985; Henderson et al., 2008). Permanent threshold shift data are typically not collected in marine mammals owing to ethical and permitting reasons, but a recent TTS experiment was found to unintentionally induce PTS in a harbor seal (Kastak et al., 2008). Southall et al. (2007) reviewed the available terrestrial literature and concluded that 40 dB of TTS was a reasonable and conservative approximation of PTS onset for marine mammals (Henderson et al., 2008 for a consideration of the human literature in this regard).

Temporary threshold shift has been measured in three cetacean and three pinniped species using both impulsive and continuous noise; many of these data were reviewed in detail by Southall et al. (2007), but there are some notable new data that change some of the conclusions reached in that assessment. In general, it appears that marine mammal auditory systems are relatively resilient to noise exposure and that relatively intense sounds are required to cause TTS and, given some simplifying assumptions to extrapolate to 40 dB TTS, PTS as well. However, there are clear differences in terms of the sound exposure types and some major differences between species as well. As in terrestrial mammals, marine mammals experience TTS at relatively lower onset levels for impulsive noise than for non-impulsive noise. The relative TTS onset levels for different marine mammal groups from the Southall et al. (2007) criteria are discussed in the section below regarding exposure criteria. However, some modifications to these criteria would now be in order, as expected, based on subsequent information.

New data are available demonstrating much lower (>20 dB) TTS-onset exposure levels for harbor porpoises exposed to impulse noise (airguns) than has been measured in other odontocetes (Lucke et al., 2009). These data are significant because they are the only TTS measurements available for any individual in the high-frequency cetacean functional hearing group and would arguably be used as the representative value for these species rather than using the extrapolated (though much more expansive) data for mid-frequency cetaceans in predicting auditory fatigue. In addition, several studies have contributed to an expanded understanding of TTS onset and growth at a range of sound frequencies in odontocete cetaceans. Mooney et al. (2009a,b) demonstrate conditions where equal energy assumptions about exposure of different durations and levels fail to accurately predict TTS onset and growth. Finneran and Schlundt (2010) and Finneran et al. (2010a,b) provide additional TTS data for bottlenose dolphins, demonstrating a greater sensitivity (10-20 dB) to noise exposure (lower absolute TTS onset levels) and a more rapid growth of TTS with increasing noise exposure level at higher frequencies within their region of best sensitivity than had been tested when the Southall et al. (2007) criteria were published. These data suggest that the exposure level relative to the subject's absolute hearing sensitivity (referred to as the sensation level) is particularly important in determining TTS onset. They also suggest that exposure levels in the region of best hearing sensitivity should be used as generic TTS-onset values against which frequency weighting functions could be applied to correct for frequency-specific hearing. These findings are significant for mysticetes despite being made with odontocete cetaceans, as they affect the selection of the appropriate TTS-onset values to apply for mysticetes from the odontocete literature (since no mysticete TTS values are or for the foreseeable future will be available).

4.2.2. Auditory Masking

In addition to potential effects on hearing from relatively high levels of sound exposure that would generally occur relatively close to anthropogenic sound sources in the field, noise interference ("masking") effects can occur, and likely do over much greater footprints around real sound sources. Noise can affect hearing and partially or completely reduce an individual's ability to effectively communicate, detect important predator, prey, and/or conspecific signals, and/or detect important environmental features associated with spatial orientation (Clark et al., 2009 for a review). Spectral, temporal, and spatial overlap between the masking noise and the sender/receiver determine the extent of interference; the greater the spectral and temporal overlap, the greater the potential for masking.

Southall et al. (2007) considered auditory masking issues and realized the much greater relative areas over which this phenomena occurs relative to TTS and PTS, but did not propose explicit exposure criteria for marine mammals, owing in part to the very divergent conditions in which masking can occur and a lack of clear understanding about defining an "onset" for masking that would be statistically definable and biologically meaningful. Largely for the same reasons, masking effects have generally been considered only qualitatively in planning of activities and regulatory decisions over noise impacts. Subsequent data have demonstrated vocal modifications in marine mammals exposed to noise that are presumably the result of anthropogenic masking noise (e.g., Holt et al., 2009). Additionally, Clark et al. (2009) provided a quantitative means of determining the relative loss of acoustic communication range for marine mammals using specific calls in conditions where they are exposed to specific anthropogenic noise sources.

There is particular concern that low-frequency anthropogenic noise may mask communication in baleen whales, which can communicate over long distances and within the same frequency band (e.g., Payne and Webb, 1971; Clark et al., 2009). An example of baleen whale calling behavior that is increasingly masked by nearby ship noise is shown in **Figure H-5**.

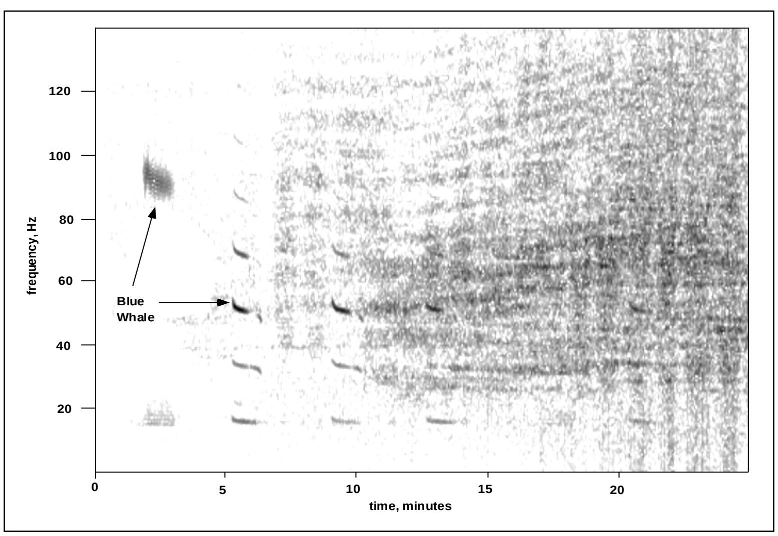

Figure H-5. Time Series Plot Showing a Calling Blue Whale and the Increasing Noise (and Masking) in the Same Low-Frequency Band from an Approaching Vessel (courtesy of C. Clark).

4.3. EFFECTS OF NOISE ON MARINE MAMMAL BEHAVIOR

Behavioral responses to sound are highly variable and critically depend on the context of sound exposure, as much or more than the level-duration-frequency characteristics that determine the probability of auditory effects (Wartzok et al., 2004, Southall et al., 2007). There is a very wide range of possible behavioral responses to sound exposure, given that the sound is audible to the particular animal, including, in approximate order of increasing severity but decreasing likelihood:

- none observable – animals can become less sensitive over repeated exposures;
- looking or increased alertness;
- minor behavioral responses such as vocal modifications associated with masking;
- cessation of feeding or social interactions;
- temporary avoidance behavior (emerging as one of the more common responses);
- modification of group structure or activity state;
- habitat abandonment; and/or
- injury and/or death via direct response or possibly exacerbated by physiological factors.

These effects clearly have differing probabilities to affect marine mammal vital rates (NRC, 2005), but it has proven (and remains) exceedingly difficult to establish a generally accepted definition and criterion for biologically meaningful behavioral disturbance. Assessing the severity of behavioral effects of anthropogenic sound exposure on marine mammals presents unique challenges associated with the inherent complexity of behavioral responses and the contextual factors affecting them, both within and between individuals and species. Severity of responses can vary depending on characteristics of the sound source (e.g., moving or stationary, number and spatial distribution of sound source[s], similarity to predator sounds, and other relevant factors) (Richardson et al., 1995; NRC, 2005; Southall et al., 2007; Wirsing et al., 2008; Bejder et al., 2009; Barber et al., 2010).

Southall et al. (2007) reviewed the considerable available literature on the effects of noise on marine mammal hearing in extensive detail, but (other than for single impulse exposures where TTS-onset was used as a threshold value for behavioral disturbance) did not find a single metric or identifiable exposure level that was broadly applicable as a benchmark for behavioral effects. Several general observations were made, including that many of the responses observed across taxa were temporary avoidance behavior. Additionally, certain species (e.g., harbor porpoises, beaked whales) appear to be categorically more sensitive to noise than other species observed, and certain behavioral states (e.g., migrating) can make species such as bowhead whales more sensitive to exposure. Subsequent data have demonstrated and quantified behavioral responses of various species, including some of the Endangered Species Act-listed marine mammals being considered in this Programmatic Environmental Impact Statement (Programmatic EIS), to seismic exploration using airguns (Weir, 2008a,b; Miller et al., 2009). Additional data have demonstrated behavioral responses of cetaceans to vessels associated with whale-watching activities (e.g., Bejder and Lusseau, 2008; Visser et al., 2010) and to the construction of offshore energy installations (Thompson et al., 2010). Finally, there has been considerable new information, using both controlled exposure experiments and opportunistic observations of anthropogenic noise source operations, on the behavioral responses of particularly sensitive marine mammals, including harbor porpoises (Kastelein et al., 2008a,b; Gilles et al., 2009) and beaked whales (Caretta et al., 2008; McCarthy et al., 2011; Southall et al., 2011; Tyack et al., 2011). These studies amplify the conclusions of Southall et al. (2007) that these are particularly sensitive species, although it remains unclear whether any additional species should be added to this general category.

5. MARINE MAMMAL NOISE EXPOSURE CRITERIA

Beginning in the 1980's with regulations on oil and gas exploration, sound-producing entities and regulatory agencies have been grappling with how to quantitatively predict and operationally mitigate the effects of human noise from industrial activities on marine life. While the marine noise issue is an increasingly global one, many of the developments on exposure criteria for marine mammals have involved U.S. regulatory processes.

In June 1997, the High Energy Seismic Survey team (HESS, 1999) convened a panel of experts to assess existing data on marine mammals exposed to seismic pulses and to predict exposures at which physical injury could occur. With the limited available data at that time, exposure to airgun pulses with received levels above 180 dB *re* 1 µPa (root-mean-square [rms] – averaged over the pulse duration) was determined to have a high potential for "serious behavioral, physiological, and hearing effects."

Based on the HESS (1999) panel conclusions, the National Marine Fisheries Service (NMFS) established a 180 dB_{rms} (received level) threshold criterion for injury from both impulse sound and "continuous" (non-impulsive) sound exposure for cetaceans and a 190 dB_{rms} threshold criterion for pinnipeds (*Federal Register*, 2003). Additionally, behavioral response criteria were developed as step-function (all-or-none) thresholds based solely on the rms value of received levels, and have been used by NMFS, although not entirely consistently. Thresholds for behavioral response from impulse sounds are 160 dB_{rms} (received level) for all marine mammals, based on behavioral response data for marine mammals exposed to seismic airgun operations (Malme et al., 1983, 1984; Richardson et al., 1986). Thresholds for behavioral response for "continuous" (non-impulsive) sounds have been 120 dB_{rms} (for some but not all sound sources) based on the results of Malme et al. (1984) and Richardson et al. (1990).

These acoustic thresholds for seismic and sounds other than those associated with U.S. Navy activities are based exclusively on dB rms measurements and 1980's estimates of such levels associated with hearing impact as opposed to the direct measurements that have been made subsequent to establishment of the thresholds. The duration over which the rms is calculated can vary significantly for impulsive sounds, and the use of this metric for characterizing impulse noise has been questioned (Madsen et al., 2006). In addition, the duration and impulsive nature of the sound also determine the potential level of PTS. Therefore, thresholds based on rms values alone are not very predictive of the likelihood of PTS onset.

Recognizing that the available data on hearing and noise impacts were rapidly evolving and that a more comprehensive and scientifically robust method of assessment would be required than these simplistic threshold estimates, NMFS supported an expert working group to develop more comprehensive and current marine mammal noise exposure criteria. This process ultimately resulted in the Southall et al. (2007) marine mammal noise exposure criteria. Within this process, several important segregations were made. First, the marine mammals were segregated into the functional hearing groups (not entirely taxonomy-based), as described above. Second, sound sources were categorized into functional categories, based on their acoustic and repetitive properties (**Table H-2**).

Table H-2

Sound Source Categories, Acoustic Characteristics, and Examples, as Proposed by Southall et al. (2007)

Sound Type	Acoustic Characteristics (at source)	Examples
Single Pulse	Single acoustic event; >3 dB difference between received level using impulse versus equivalent continuous time constant	Single explosion; sonic boom; single airgun, watergun, pile strike, or sparker pulse; single ping of certain sonars, depth sounders, and pingers
Multiple Pulse	Multiple discrete acoustic events within 24 hr; >3 dB difference between received level using impulse versus equivalent continuous time constant	Serial explosions; sequential airgun, watergun, pile strikes, or sparker pulses; certain active sonar (IMAPS); some depth sounder signals
Non-Pulse	Single or multiple discrete acoustic events within 24 h; <3 dB difference between received level using impulse versus equivalent continuous time constant	Vessel/aircraft passes, drilling; many construction or other industrial operations; certain sonar systems (LFA; tactical mid-frequency); acoustic harassment/deterrent devises; acoustic tomography sources (ATOC); some depth sounder signals

ATOC = Acoustic Thermometry of Ocean Climate; IMAPS = Integrated Marine Mammal Monitoring and Protection System; LFA = Low-Frequency Active.

Additionally, the potential for hearing and behavioral effects for noise exposures of these different categories was assessed for each of the different functional hearing groups according to a wider and more applicable set of acoustic exposure metrics. Using an alternate threshold such as sound energy (sound exposure level, or SEL) that incorporates amplitude level and duration as well as peak sound pressure into the noise metric is considered to be more biologically realistic. Consequently, Southall et al. (2007) suggest SEL thresholds for TTS onset and the predicted PTS-onset levels they estimated. As has been observed for humans (Kryter et al., 1996), recent work in marine mammals also demonstrates that TTS onset is not perfectly correlated with received SEL levels either; rather, duration appears to have a larger impact on TTS onset than predicted by SEL levels, and recovery time between noise exposure also has an impact on the levels of TTS (Mooney et al., 2009b; Finneran and Schlundt, 2010). At this point, SEL remains a better metric for the prediction of injury onset than rms, but with some demonstrated limitations similar to those observed in predicting TTS dependence on sounds of different exposure level and duration in terrestrial mammals; these threshold metrics will clearly need to be reevaluated regularly as new data are reported. For behavioral effects, the conventional rms levels for sound exposure were considered, in part because this is typically all of the information available regarding available studies.

Derivation of TTS and PTS Criteria

Southall et al. (2007) estimated PTS-onset as noise exposures estimated to result in 40 dB of TTS for different sound types, using both a peak pressure and an SEL criterion; the SEL threshold is ultimately the functional criteria for most realistic exposure scenarios. For all cetacean functional hearing groups, estimated TTS onset levels for both impulse and non-impulse noise were based on data obtained in a few individuals of two mid-frequency species (bottlenose dolphins and belugas). For pinnipeds, some data were available on non-impulsive noise but extrapolations to PTS-onset for impulsive noise (such as that associated with seismic airguns) also included extrapolations involving data from bottlenose dolphins. The SEL threshold for PTS-onset to impulse noise for mid-frequency cetacean species (198 dB re 1 µPa^2-s) and pinnipeds (186 dB re 1 µPa^2-s) remain as valid (given the underlying assumptions) as when they were initially presented by Southall et al. (2007). However, subsequent data require some modification for other species groups.

For high-frequency cetaceans (e.g., harbor porpoises), subsequent data are available from Lucke et al. (2009). These data indicate lower TTS onset value both in terms of SEL and peak pressure. In this analysis, these directly relevant data form the basis for estimating TTS onset and potential for injury for harbor porpoise and other high-frequency cetaceans, rather than the extrapolated predictions of Southall et al. (2007). A PTS-onset threshold of 179 dB re 1 µPa^2-s is used for this functional hearing group, based on Lucke et al. (2009) TTS-onset levels and the Southall et al. (2007) extrapolation procedure to PTS.

An additional consideration regards the assessment of potential auditory effects of impulse noise on low-frequency cetaceans (mysticetes). In the absence of direct measurements of hearing or noise impacts in any mysticete species, subsequent data on TTS in other cetaceans calls into question the hearing group extrapolation of results proposed by Southall et al. (2007). Specifically, Finneran and Schlundt (2010) recently demonstrated a greater sensitivity to non-impulse noise exposure for mid-frequency cetaceans at higher frequencies (within their region of best sensitivity) than had been tested when the Southall et al. (2007) criteria were published. Given the measurements of lower TTS onset values in the region of best hearing sensitivity for mid-frequency cetaceans and the low-frequency nature of seismic airgun impulses, a more conservative extrapolation of results to low-frequency cetaceans was considered justified (see Southall et al,. 2007). For reasons relating to the much higher natural ambient background levels at low frequencies and presumed adaptations in basic hearing capabilities of these species than for other cetacean species (Wartzok and Ketten, 1999), rather than a direct application of the high-frequency cetacean TTS-onset values, a more conservative extrapolation of the mid-frequency TTS onset data for impulse noise than that proposed by Southall et al. (2007) was applied by subtracting 6 dB (which is halving the magnitude in terms of sound pressure) from the original Southall et al. (2007) level, for a resulting PTS-onset threshold for mysticetes of 192 dB re 1 µPa^2-s (Wood et al., 2012).

As described briefly above, Southall et al. (2007) proposed explicit and numerical exposure level values for injury from sound exposure for each of the marine mammal functional hearing groups. Using measured onset-TTS levels where possible (or extrapolating them from related species where not) and a series of extrapolation procedures to estimate the growth of TTS and a reasonably conservative estimate of physical injury (40 dB TTS as described above), received level threshold values were determined. For sound exposure level values, the frequency weighting functions described above would be applied to the received sound to account for differential frequency sensitivity among the different marine mammal groups. The resulting thresholds for injury from sound exposure for different marine mammal groups, via these general methods and using all available relevant data as proposed by Southall et al. (2007), are summarized in **Table H-3**.

Table H-3

Marine Mammal Noise Exposure Criteria for Injury for Different Marine Mammal Functional Hearing Groups Proposed by Southall et al. (2007)

Marine Mammal Group	Sound Type		
	Single Pulses	Multiple Pulses	Non-Pulses
Low-frequency Cetaceans	**Cell 1**	**Cell 2**	**Cell 3**
Sound Pressure Level	230 dB_{peak} re 1 µPa (flat)	230 dB_{peak} re 1 µPa (flat)	230 dB_{peak} re 1 µPa (flat)
Sound Exposure Level	198 dB re 1 $µPa^2$-s (M_{lf})	198 dB re 1 $µPa^2$-s (M_{lf})	215 dB re 1 $µPa^2$-s (M_{lf})
Mid-frequency Cetaceans	**Cell 4**	**Cell 5**	**Cell 6**
Sound Pressure Level	230 dB_{peak} re 1 µPa (flat)	230 dB_{peak} re 1 µPa (flat)	230 dB_{peak} re 1 µPa (flat)
Sound Exposure Level	198 dB re 1 $µPa^2$-s (M_{mf})	198 dB re 1 $µPa^2$-s (M_{mf})	215 dB re 1 $µPa^2$-s (M_{mf})
High-frequency Cetaceans	**Cell 7**	**Cell 8**	**Cell 9**
Sound Pressure Level	230 dB_{peak} re 1µPa (flat)	230 dB_{peak} re 1 µPa (flat)	230 dB_{peak} re 1 µPa (flat)
Sound Exposure Level	198 dB re 1 $µPa^2$-s (M_{hf})	198 dB re 1 $µPa^2$-s (M_{hf})	215 dB re 1 $µPa^2$-s (M_{hf})
Pinnipeds (in water)	**Cell 10**	**Cell 11**	**Cell 12**
Sound Pressure Level	218 dB_{peak} re 1 µPa (flat)	218 dB_{peak} re 1 µPa (flat)	218 dB_{peak} re 1 µPa (flat)
Sound Exposure Level	186 dB re 1 $µPa^2$-s (M_{pw})	186 dB re 1 $µPa^2$-s (M_{pw})	203 dB re 1 $µPa^2$-s (M_{pw})
Pinnipeds (in air)	**Cell 13**	**Cell 14**	**Cell 15**
Sound Pressure Level	149 dB_{peak} re 20 µPa (flat)	149 dB_{peak} re 20 µPa (flat)	149 dB_{peak} re 20 µPa (flat)
Sound Exposure Level	144 dB re $(20\ µPa)^2$-s (M_{pa})	144 dB re $(20\ µPa)^2$-s (M_{pa})	144.5 dB re $(20\ µPa)^2$-s (M_{pa})

Several notable features of these criteria are the relatively high received level values predicted necessary to induce injury and that all of the cetaceans have numerically identical threshold values, with the exception of the frequency-weighting functions. The former is simply a function of the relatively high TTS-onset values in the marine mammal species tested thus far. The latter is the case because at the time of the Southall et al. (2007) criteria paper, there were no direct data on auditory fatigue in low- or high-frequency cetaceans, and the mid-frequency cetacean TTS-onset levels were used for these other groups. Subsequently, the Lucke et al. (2009) results have shown significantly lower onset values for TTS in high-frequency cetaceans; these will presumably be applied for these species.

There are no direct measurements of TTS/PTS in low-frequency mysticetes (baleen whales), given our inability to test their hearing in the wild. Some TTS data for mid-frequency cetaceans in regions of best sensitivity (Finneran and Schlundt, 2010) may be applicable in considering the appropriate TTS-onset value to extrapolate to the mysticetes, which are highly unlikely to test in a controlled hearing study to measure auditory fatigure. Gedamke et al. (2011) modeled the potential for TTS onset for baleen whales. Their model does suggest that TTS (and possibly PTS) onset from seismic surveys is plausible over ranges of several kilometers, however the uncertainty of the inputs to the model (i.e., the extrapolations of noise impacts and hearing in other species) as well as individual variation can have a large impact on the estimates, which must at this point be considered speculative (as the authors themselves state). In addition, much of the cumulative SEL is due to the loudest airgun pulses when the animal is closest to the airgun array.

Newer TTS measurements in mid- and high-frequency cetaceans (Finneran and Schlundt, 2010; Finneran et al., 2010a,b) will require reanalysis of the appropriate TTS-onset (and thus injury onset) point for this category as well. For example, onset of TTS from pulsed watergun/airgun noise has been tested in three species of cetaceans. Finneran et al. (2002) exposed a beluga whale and bottlenose dolphin to watergun noise. The beluga showed TTS onset at 186 dB re 1 $µPa^2 \cdot s$ (equivalent to 183 dB M-weighted), however the dolphin did not show indication of TTS at the levels this experiment was able to produce. The level for the beluga was therefore used in the initial Southall et al. (2007) threshold for all cetaceans

(198 = 183 + 15). However, Lucke et al. (2009) found a TTS onset in a harbor porpoise exposed to airgun noise at 164 dB re 1 µPa^2·s, considerably lower than reported by Finneran et al. (2002) for belugas. Whether this difference is due to species or individual difference or a combination of the two is difficult to say. Onset of TTS in pinnipeds in water has been tested for several species (e.g., Kastak et al., 2005), but only with non-pulsed sounds (Southall et al., 2007). As a result, Southall et al. (2007) used the relationship between TTS onset from non-pulsed sounds in belugas and harbor seals (~12 dB) to estimate TTS onset levels for pinnipeds in water exposed to pulsed sounds.

Such improvements based on additional data were envisioned, and in most cases specifically called for in terms of experimental approaches and priorities, and the conclusions and threshold values will continue to evolve over time. Despite the expected requisite re-thinking based on new data, the Southall et al. (2007) approach to marine mammal noise exposure represented a major evolution in the complexity and scientific basis for predicting the effects of noise on hearing in marine mammals over the extremely simplistic historical NMFS thresholds for injury.

Derivation of Behavioral Effects Criteria

In terms of behavioral impacts, the Southall et al. (2007) noise exposure criteria took a dual approach depending on the sound type. For exposure to single impulses (e.g., explosion), the acoustic component of the event was considered sufficiently intense to constitute behavioral harassment at levels consistent with TTS onset (**Table H-4**). The logic for this was that since these events are so brief and transient that any responses other than those affecting hearing would likely be similarly transient in nature and thus not affect the long-term health or fitness of animals. It was noted, however, that startle responses can trigger stress and other physiological responses, the biological significance of which remains poorly understood.

Table H-4

Marine Mammal Noise Exposure Criteria for Behavior for Different Marine Mammal Functional Hearing Groups Proposed by Southall et al. (2007)

Marine Mammal Group	Sound Type		
	Single Pulses	Multiple Pulses	Non-Pulses
Low-frequency Cetaceans	**Cell 1**	**Cell 2**	**Cell 3**
Sound Pressure Level	224 dB_{peak} re 1 µPa (flat)	see Tables 6 & 7 in Southall et al., 2007	see Tables 14 & 15 in Southall et al., 2007
Sound Exposure Level	183 dB re 1 µPa^2-s (M_{lf})	Not applicable	Not applicable
Mid-frequency Cetaceans	**Cell 4**	**Cell 5**	**Cell 6**
Sound Pressure Level	224 dB_{peak} re 1 µPa (flat)	see Tables 8 & 9 in Southall et al., 2007	see Tables 16 & 17 in Southall et al., 2007
Sound Exposure Level	183 dB re 1 µPa^2-s (M_{mf})	Not applicable	Not applicable
High-frequency Cetaceans	**Cell 7**	**Cell 8**	**Cell 9**
Sound Pressure Level	224 dB_{peak} re 1 µPa (flat)	see Tables 18 & 19 in Southall et al., 2007	see Tables 18 & 19 in Southall et al., 2007
Sound Exposure Level	183 dB re 1 µPa^2-s (M_{hf})	Not applicable	Not applicable
Pinnipeds (in water)	**Cell 10**	**Cell 11**	**Cell 12**
Sound Pressure Level	212 dB_{peak} re 1 µPa (flat)	see Tables 10 & 11 in Southall et al., 2007	see Tables 20 & 21 in Southall et al., 2007
Sound Exposure Level	171 dB re 1 µPa^2-s (M_{pw})	Not applicable	Not applicable
Pinnipeds (in air)	**Cell 13**	**Cell 14**	**Cell 15**
Sound Pressure Level	109 dB_{peak} re 20 µPa (flat)	see Tables 12 & 13 in Southall et al., 2007	see Tables 22 & 23 in Southall et al., 2007
Sound Exposure Level	100 dB re (20 µPa)^2-s (M_{pa})	Not applicable	Not applicable

For all other sound types (which are the majority), Southall et al. (2007) did not propose explicit threshold criteria, for the reasons of context-dependence and other complexities in the nature of behavioral responses and available literature described above. It was concluded that significant behavioral effects would likely occur at exposure levels below those required for TTS and PTS, but that simple step-function thresholds for behavior (such as the historical NMFS values) were simply inconsistent with the best available science. While an overarching exposure level approach for behavior as seems reasonable for injury is perhaps more convenient from an assessment standpoint, the underlying reasons behind the type and magnitude of behavioral response involve a multitude of factors and require a multivariate assessment method to adequately describe.

Southall et al. (2007) reviewed the available marine mammal literature and proposed a severity scaling for behavioral response applied to the available data, but did not present explicit step-function thresholds for behavioral response. This was because of the lack of convergence in the data on broadly-applicable exposure levels resulting in significant behavioral responses.

The Southall et al. (2007) severity scaling attempted for the first time to put some reasonable bounds on the likely significance of observed responses, highlighting the importance of responses with the potential to affect vital rates and survivorship (as in NRC, 2005). An ordinal ranking of behavioral response severity (see Table 4 in Southall et al., 2007) was developed, the intent being to delineate behaviors that are relatively minor and/or brief from those considered more likely to affect these vital rates. The observed behavioral responses in all 10 conditions for multiple pulses and continuous noise for each of the five functional hearing groups were reviewed in detail, and individual responses were assessed according to this severity scaling and measured or reasonably estimated exposure levels. An example of this severity scaling of the observed behavioral literature in one of these conditions (low-frequency cetaceans exposed to impulse noise, predominantly airguns) that may be particularly relevant to this assessment is shown in **Table H-5**. Blank cells in this table indicate the lack of measured responses for these received sound levels and response categories; an overarching conclusion of Southall et al. (2007) was the striking lack of data in most exposure conditions for marine mammals.

This severity scaling, as evident in **Table H-5**, did not reveal broadly applicable patterns of response in most cases – i.e., where no response occurs below some specific received level and a high probability of response occurs above some point (as step-functions would presume). Certain observations were made, including the behavioral context-dependence of response for different received levels in migrating bowhead whales and the particular sensitivity of harbor porpoises both in field and laboratory experiments. But the primary advances made in the Southall et al. (2007) criteria in terms of behavioral response were to very clearly demonstrate that step-function thresholds for response using a single received level and no other considerations related to behavioral context are overly simplistic and outdated and to develop at least a qualitative means of addressing behavioral response severity issues.

The Southall et al. (2007) review found that contextual factors of sound exposure relating to different animal groups, sound types, and exposure conditions and differing activity states complicate efforts to derive simple step-function thresholds for all species. The approach proposed was to make efforts to account for both species and contextual differences. That approach has been adapted for this analysis. For the majority of marine mammal species, a method similar to the NMFS step-function threshold (160 dB re 1 µPa (rms)) for impulse noise is used. As reviewed in detail in Appendix II ("Studies Involving Marine Mammal Behavioral Responses to Multiple Pulses") of Southall et al. (2007), most marine mammals exposed to impulse noise demonstrate responses of varying magnitude in the 140-180 dB re 1 µPa (rms) exposure range, including the mysticetes in the Malme et al. (1983, 1984) studies on which the NMFS threshold is based. Potential disturbance levels at SPL above 140 dB re 1 µPa (rms) were also highlighted in HESS (1999). For the current assessment, a probabilistic metric is applied at which 10, 50, and 90 percent of individuals exposed are assumed to produce a behavioral response at exposures of 140, 160, and 180 dB re 1 µPa (rms), respectively. One final difference is that frequency weighting curves (the M-weighting of Southall et al. [2007]) is applied to these exposure estimates.

As noted by Southall et al. (2007) and supported by subsequent data, certain marine mammal species and certain marine mammals in specific behavioral modes appear to be significantly more sensitive to noise exposure. For instance, migrating bowhead whales are much more likely than other mysticetes (including feeding bowhead whales) to respond clearly to seismic airgun noise at much lower (~120-140 dB re 1 µPa (rms)) received sound levels (Richardson et al., 1999). As a protective approach for this behavioral state, 10, 50, and 90 percent response probability for migrating mysticetes is estimated to occur at M-weighted exposure levels of 120, 140, and 160 dB re 1 µPa (rms), respectively.

Table H-5

Southall et al. (2007) Assessment of Individual Behavioral Responses of Low-Frequency Cetaceans to Multiple-Pulse Exposure for Various Received Levels

(Individual observations are weighted to account for statistical considerations, and source data are indicated by parenthetical subscript: Malme et al. (1983)[1]; Malme et al. (1984)[2]; Richardson et al. (1986)[3]; Ljungblad et al. (1988)[4]; Todd et al. (1996)[5]; McCauley et al. (1998)[6]; Richardson et al. (1999)[7]; and Miller et al. (2005))[8]

Response Score	Received Exposure Level (dB_{rms} re 1 µPa)											
	80 to <90	90 to <100	100 to <110	110 to <120	120 to <130	130 to <140	140 to <150	150 to <160	160 to <170	170 to <180	180 to <190	190 to <200
9												
8												
7										1 (6)		
6				9.5 (3,7)	47.4 (3,7)	2.2 (3,7)	1.4 (4)	2 (1,2)	5.5 (1,2,4,6)	9.3 (1,2,4,6,8)		
5					1 (3,7)		1 (4)	1 (1,2)				
4												
3									1 (1,2)	1 (1,2)		
2												
1				5 (3,7)	6 (3,7)	1 (3,7)	2 (1,2)	3 (5)				
0				59.8 (3,7)	17.7 (3,7)	1.1 (3,7,8)	0.1 (8)	0.1 (8)	6.8 (1,2,8)	6.3 (1,2,8)		

Finally, certain species including harbor porpoises and beaked whales appear to have a categorically different level of response than other marine mammals to much lower received levels. As reviewed in Southall et al. (2007), for harbor porpoises this appears to be consistent across sound types and laboratory and field settings. As recently demonstrated by Tyack et al. (2011), beaked whales appear to share this particular sensitivity, which may in part explain their disproportionate representation in marine mammal stranding events associated with sound exposure. Based on the initial assessment of Southall et al. (2007) and considering the more recent supporting evidence for beaked whales specifically, a particularly sensitive behavioral response category for these species and porpoises is assessed here. NMFS also recognizes species and contextual factors in setting behavioral response thresholds, the most obvious being the use of a 120 dB re 1 µPa threshold for behavioral response of harbor porpoise to Navy acoustic sources with a wide range of activities (U.S. Dept. of the Navy, 2008). Thus, for these species groups, independent of behavioral state, 50 and 90 percent behavioral response probabilities are calculated for M-weighted exposure levels of 120 and 140 dB re 1 µPa (rms), respectively. The 10 percent probability was not modeled in this case, but the 50 percent criterion is used as a step function.

Table H-6 provides a summary of the Injury SEL thresholds used for the Wood et al. (2012) technical report to estimate Level A takes and compares these thresholds with those published in Southall et al. (2007). Only low frequency and high frequency cetacean thresholds change. **Table H-7** provides a synopsis of the thresholds and the probability of a Level B behavioral response. Probabilities are not additive and reflect single points on a theoretical response curve.

Table H-6

Modified Injury Sound Exposure Level (SEL) Thresholds for Multiple Pulses Used in This Analysis and Those Originally Proposed by Southall et al. (2007) to Estimate Onset of Acoustic Injury (Level A - PTS)

Marine Mammal Group	Injury SEL Thresholds Used in This Analysis (dB re 1 μPa^2-s)	Southall et al. (2007) – Published SEL (dB re 1 μPa^2-s)
Low-frequency cetacean	192	198
Mid-frequency cetacean	198	198
High-frequency cetacean	179	198
Pinniped (in water)	186	186

Table H-7

Probabilistic Disturbance rms Sound Pressure Level Thresholds (M-Weighted) Used in the Current Analysis to Predict a Level B Behavioral Response

(For comparison, the NMFS threshold for behavioral response for all marine mammals is 160 dB re 1 µPa (rms, unweighted). Probabilities are not additive and reflect single points on a theoretical response curve.)

Marine Mammal Group	Probabilistic Disturbance rms Thresholds M-Weighted dB re 1 μPa (rms)			
	120	140	160	180
	Behavioral Response Probability			
Porpoises/beaked whales	50%	90%		
Migrating mysticete whales	10%	50%	90%	
All other species/behaviors		10%	50%	90%

Note: Behavior Response Probability is based on low (10%), moderate (50%), and high (90%) categories of probability for different response levels in different contexts

Clearly, the Southall et al. (2007) criteria for behavior are a starting point to develop a rudimentary framework in moving toward a more multivariate and biologically-meaningful way of assessing the type and magnitude of behavioral responses of marine mammals to noise than historical thresholds. As evidenced by the absence of data in many exposure level and response types above, significant data gaps exist in almost all areas, and many of the available studies lack key information about the nature of exposure in which behavioral responses were observed (which is why many studies were excluded from the Southall et al. [2007] analysis). This is an active area of research, and subsequent studies (some described above) have begun to report additional information on background noise, various exposure metrics, and behavioral contexts.

Broad application of the Southall et al. (2007) criteria for both injury and behavior has been relatively slow in evolving, in part due to the increased complexity of the recommendations over the previous simplistic approaches, such as step-functions used by NMFS. However, NMFS has used exposure criteria consistent with the Southall et al. (2007) thresholds for injury from sound exposure for assessing potential impacts of Navy active sonar operations (*Federal Register*, 2009a,b) for a host of species, including large whales and pinnipeds. In fact, these regulations actually include higher exposure values for certain species for which higher TTS onset values were directly measured than the more conservative values used in Southall et al. (2007). Additionally, recent NMFS regulations (*Federal Register*, 2009a,b) have also begun to use a more graduated dose-function based approach to behavioral response rather than the historical step-function thresholds. NMFS is preparing acoustic exposure guidelines that are expected to increasingly consider the increased complexity and context-dependence of responses of marine mammals to sound.

6. ASSESSMENT OF HEARING INFORMATION FOR SPECIES/ GROUPS IN THE AREA OF INTEREST

Specific sound sources that will be used in G&G exploration activities off the U.S. East Coast, as discussed in **Chapter 3.0** of the Programmatic EIS, include both impulsive (e.g., 2D and 3D seismic exploration surveys using conventional airguns) and continuous noise sources such as side-scan sonars, sediment sampling, electromagnetic surveys, and various vessel activities.

Most of the marine mammals likely to be present in the Area of Interest (AOI), as discussed in Programmatic EIS **Chapter 4.2.2**, are cetaceans, with some pinnipeds possibly present at very low densities in the northern extent of the area and manatees potentially present in southern, near-coastal waters. For some of these species (e.g., bottlenose dolphins), relatively good information exists about hearing and behavioral responses to some types of sounds (e.g., Nowacek et al., 2001), though not particularly for seismic exploration specifically. For most of the mid-frequency cetacean species, including the endangered sperm whale, the injury criteria proposed by Southall et al. (2007) and general conclusions on behavioral response would be expected to be applicable; direct recent information on behavioral responses in sperm whales to seismic airguns are available as well (e.g., Miller et al., 2009).

For West Indian manatees, direct measurements of hearing are available (Gerstein et al., 1999; Mann et al., 2005), as well as responses to vessel presence and noise (Nowacek et al., 2004a). From the perspective of hearing injury, the use of pinniped exposure criteria from the Southall et al. (2007) criteria would seem reasonable, as described above. These animals are generally very coastal-oriented, which would likely mean they would encounter G&G activities only in nearshore waters.

For the endangered mysticetes that occur in the area (North Atlantic right whale, blue whale, fin whale, humpback whale, and sei whale), as for all low-frequency cetaceans, no direct information regarding hearing is available. As described above, the Southall et al., 2007 exposure criteria for injury are based on assumptions and extrapolations from mid-frequency cetacean data that may need to be reassessed to some degree based on the subsequent measurements of lower onset TTS levels in bottlenose dolphins within their range of best hearing sensitivity (Finneran and Schlundt, 2010). In terms of behavioral response, substantial effort has been made and data are available for impulse noise (seismic airguns specifically) for mysticetes, though not for all of the species present in the AOI. Nowacek et al. (2004b) showed that North Atlantic right whales may be particularly responsive to alarm-like non-impulsive noise in controlled exposure studies. Similarly and more recently, Southall et al. (2011) demonstrated behavioral responses, and an apparent context-dependence in response based on behavioral state, in some blue and fin whales exposed to simulated sonar sounds off the coast of California. The fact that many of the mysticetes in the AOI may be engaged in migratory behavior during the course of operations, the increased sensitivity of some other mysticetes (e.g., bowhead and gray whales) during migrations should be considered in assessing potential responses of species where no direct data on responses to certain sound types (airguns) are available (e.g., blue, fin, and sei whales).

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APPENDIX I

SEA TURTLE HEARING AND SENSITIVITY TO ACOUSTIC IMPACTS

TABLE OF CONTENTS

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1. INTRODUCTION

There is growing concern over anthropogenic sound in the world's oceans and its potentially harmful effects on protected marine organisms, including sea turtles. Similar to other migratory marine species, sea turtles occupy different ecological niches throughout ontogeny, each characterized by unique acoustic conditions. Sea turtles spend the majority of their lives in the ocean; their only land-linked behaviors are egg deposition and hatching. Like many marine fishes and mammals, sea turtles use a range of habitats for each developmental stage (see review by Bolton, 2003). Once hatchlings reach the sea, they are pelagic, moving primarily with ocean currents. After a period of years, which varies both among species and populations, a critical ontogenetic habitat shift occurs whereby most sea turtles actively recruit to a demersal, neritic habitat and are considered juveniles. Finally, upon reaching maturity, all sea turtles maintain a discrete foraging area (this region frequently overlaps with the juveniles), migrating only to return to their natal nesting beach. The exception to this life history model in North Atlantic populations is the leatherback turtle (*Dermochelys coriacea*). Leatherbacks remain pelagic as both juveniles and adults and return to the neritic zone only for reproduction (Bolton, 2003).

Few studies have examined the role acoustic cues play in the ecology of sea turtles (Mrosovsky, 1972; Samuel et al., 2005; Nunny et al., 2008). There is evidence that sea turtles may use sound to communicate; the few vocalizations described for sea turtles are restricted to the "grunts" of nesting females (Mrosovsky, 1972). These sounds are low frequency and relatively loud, thus leading to speculation that nesting females use sounds to communicate with conspecifics (Mrosovsky, 1972). We know very little about the extent to which sea turtles use their auditory environment ("soundscape"). However, the passive acoustic environment for sea turtles changes with each ontogenetic habitat shift. In the inshore environment where juvenile and adult sea turtles generally reside, the ambient environment is noisier than the open ocean environment of the hatchlings; this inshore environment is dominated by low frequency sound (Hawkins and Myrberg, 1983), and, in highly trafficked areas, virtually constant low frequency noises from shipping, recreational boating, and seismic surveys compound the potential for acoustic impact (Hildebrand, 2005).

2. MORPHOLOGY

Much of the research on the hearing capacity of sea turtles is limited to gross morphological dissections (Wever, 1978; Lenhardt et al., 1985). The tympanum is a continuation of the facial tissue and is distinguishable only by palpitation of the area. Beneath the tympanum is a thick layer of subtympanal fat (**Figure I-1**), a feature that distinguishes sea turtles from both terrestrial and semi-aquatic turtles. Recent imaging data suggests that this layer of fat is similar to the fats found in the jaws of odontocete whales and functions as a low-impedance channel for sounds to the ear (Ketten et al., 1999). The middle ear cavity lies posterior to the tympanum; the Eustachian tube connects the middle ear with the throat (Wever, 1978; Lenhardt et al., 1985). As with most turtles, the middle ear is small and encased by bone. The ossicular mechanism consists of two elements: the extracolumella and the columella (stapes). The extracolumella is a cartilaginous disk under the tympanic membrane attached to the columella by ligaments. The columella, a long rod with the majority of its mass concentrated at each end, extends medially from the middle ear cavity through a narrow bony channel and expands within the oval window to form a funnel shaped end. The columella is free to move only longitudinally within this channel so when the tympanum is depressed directly above the middle of the extracolumella, the columella moves readily in and out of the oval window, without any flexion of the columella. The stapes and oval window are connected to the saccular wall by fibrous strands. It is thought that these stapedo-saccular strands relay vibrational energy of the stapes to the saccule (Wever and Vernon, 1956; Wever, 1978; Lenhardt et al., 1985). For semi-aquatic turtles, the columella is the main pathway for sound input to the inner ear; when the columella is clipped while leaving the tympanum intact, the animal displayed an extreme decrease of sensitivity of hearing (Wever and Vernon, 1956).

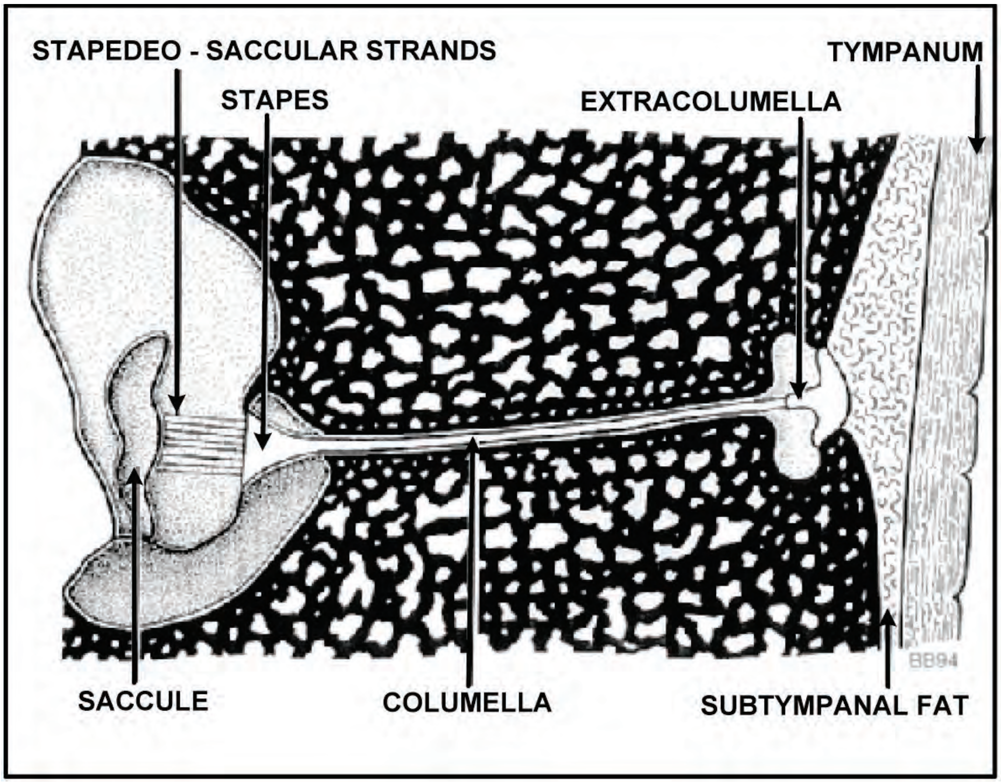

Figure I-1. Middle Ear Anatomy of the Juvenile Loggerhead Sea Turtle (Moein, 1994).

The auditory sense organ within the inner ear of the sea turtle cochlea is the basilar papilla (basilar membrane). This membrane is large and composed of dense connective tissue in sea turtles (rather than a thin basilar membrane found in terrestrial turtles) (Wever, 1978; Hetherington, 2008). This basilar papilla is positioned opposite the round window and lies within the pathway of fluid displacement due to columella motion. In most reptiles, and presumably in sea turtles as well, the tectorial membrane lays over the hair cells of the basilar papilla. For sea turtles, the innervations of the hair cells may be accomplished through the movement of the overlying tectorial membrane rather than the movement of the papillae (Hetherington, 2008).

Based on the functional morphology of the ear, it appears that sea turtles receive sound through the standard vertebrate tympanic middle ear path. This ear, however, is adapted to underwater sound, not aerial. For the terrestrial vertebrate, the middle ear is an impedance transformer between sound in air (environment) and sound in fluid (inner ear). This impedance mismatch can be overcome by having a high convergence ratio between the tympanic membrane and oval window (thus amplifying the force acting on the inner ear) and by having a multiple bone ossicular mechanism that acts as a lever system to amplify force. The convergence ratio of the tympanic membrane to oval window in sea turtles is reported to be lower than other semi-aquatic turtles (Lenhardt et al., 1985), and sea turtles lack an osscicular mechanism that acts as a lever (having only a single straight columella). Thus, the sea turtle ear appears to be a poor receptor for aerial sounds. However, this ear is well adapted to water conduction sound. The dense layer of fat under the tympanum acts as a low-impedance channel for underwater sound (similar to that pathway found in odontocetes [Ketten et al., 1999]). Furthermore, the retention of air in the middle ear of these sea turtles suggests that they are able to detect sound pressures.

3. ELECTROPHYSIOLOGICAL RESPONSE TO SOUND

Electrophysiological studies on hearing have been conducted on juvenile green turtles (*Chelonia mydas*) (Ridgway et al., 1969; Bartol and Ketten, 2006), juvenile Kemp's ridley turtles (*Lepidochelys kempii*) (Bartol and Ketten, 2006), juvenile loggerhead turtles (*Caretta caretta*) (Bartol et al., 1999;

Lavender et al., 2011, 2012), and leatherback (*Dermochelys coriacea)* hatchlings (Dow Piniak et al., 2012a). Electrophysiological responses, specifically auditory evoked potentials (AEPs), are the most widely accepted technique for measuring hearing in situations in which normal behavioral testing is impractical. The AEPs reflect the synchronous discharge of large populations of neurons within the auditory pathway and, thus, are useful monitors of the functioning of the throughput of the auditory system. Most AEP research has concentrated on the use of responses occurring within the first 10 ms following presentation of click or brief tone burst stimuli. This response has been termed the auditory brainstem response (ABR) and consists of a series of five to seven patterned and identifiable waves. Corwin et al. (1982) recorded AEPs from five classes of non-mammalian vertebrates (including the red eared turtle, *Pseudemys scripta elegans*) and found the response, recorded outside the brain, to be congruous with the criteria for "conventional" ABRs. Furthermore, these techniques are noninvasive and can be performed on conscious subject animals (Bullock, 1981; Corwin et al., 1982).

Ridgway et al. (1969) measured auditory cochlear potentials of green turtles using both aerial and vibrational stimuli. Thresholds were not measured; instead, cochlear response curves of 0.1 µV potential were plotted for frequencies ranging from 50-2,000 Hz. Green turtles detect a limited frequency range (200-700 Hz) with best sensitivity at the low tone region of about 400 Hz. Though this investigation examined two separate modes of sound reception (i.e., air and bone conduction), sensitivity curves were relatively similar, suggesting that the inner ear is the main structure for determining frequency sensitivity. To measure electrophysiological responses to sound stimuli, Bartol et al. (1999) collected ABRs from juvenile loggerhead turtles. Vibratory stimuli were delivered directly to the dermal plates over the loggerhead turtle's tympanum. Thresholds were recorded for both tonal and click stimuli. Best sensitivity was found in the low frequency region of 250-1,000 Hz. The decline in sensitivity was rapid after 1,000 Hz, and the most sensitive threshold tested was at 250 Hz. More recently, Bartol and Ketten (2006) collected underwater ABRs from hatchling and juvenile loggerhead and juvenile green turtles. For these experiments, the speaker was suspended in air while the turtle's tympanum remained submerged underwater. All turtles tested responded to sounds in the low frequency range, from at least 100 Hz (lowest frequency tested) to no greater than 900 Hz. Interestingly, the smallest turtles tested, hatchling loggerheads, had the greatest range of hearing (100-900 Hz) while the larger juveniles responded to a much narrower range (100-400 Hz). Hearing sensitivity of green turtles also varied with size; smaller greens had a broader range of hearing (100-800 Hz) than that detected in larger subjects (100-500 Hz). Lavender et al. (2011, 2012) have recorded underwater AEPs using a Navy J9 underwater speaker from loggerhead turtles, their ages ranging from yearlings to subadults. Under these conditions, loggerheads were found to respond to frequencies between 50-1,000 Hz.

AEP responses from hatchling leatherback turtles showed that they are able to detect sounds underwater and in air, responding to stimuli between 50 and 1,200 Hz in water and 50 and 1,600 Hz in air, with maximum sensitivity between 100 and 400 Hz in water (84 dB re: 1 µPa-rms at 300 Hz) and 50 and 400 Hz in air (62 dB re: 20 µPa-rms at 300 Hz) (Dow Piniak et al., 2012a).

Dow Piniak et al. (2012b) recorded both in-air and in-water AEP responses from juvenile green turtles. The sea turtle AEP signal signature was similar to that seen in studies of fish evoked potentials, with a frequency-doubling response (i.e., where response waves oscillate at twice the stimulus frequency) observed at 400 Hz. As observed in other studies, juvenile green turtles responded to stimuli between 50 and 1,600 Hz in water and 50 and 800 Hz in air. Ranges of maximum sensitivity were between 50 and 400 Hz in water and 300 and 400 Hz in air. In both media, sensitivity decreased sharply for frequencies above 400 Hz. These studies show that sea turtles are particularly sensitive to low frequency sounds and so are able to hear much of the low-frequency and high-intensity anthropogenic noise in the ocean such as vessel traffic and offshore oil and gas exploration activities (e.g., drilling, low-frequency sonar).

4. BEHAVIORAL RESPONSES TO SOUND

Multiple studies have attempted to examine the behavioral responses of juvenile loggerheads to sound in their natural environment, both in controlled settings (O'Hara and Wilcox, 1990; Moein et al., 1995; McCauley et al., 2000; Lavender et al., 2011) and as observed *in situ* (Holst et al., 2007; Weir, 2007; DeRuitter and Doukara, 2010). Behavioral audiograms have been collected from multiple size classes of loggerhead turtles (Lavender et al., 2011). Behavioral audiograms require the animal to perform a task in the presence of auditory stimuli; though time consuming (it can take months to train a turtle to sound), behavioral audiograms are a more sensitive measure of hearing threshold than electrophysiological responses and ascribe a critical behavioral component to hearing trials. Lavender et al. (2011) recorded audiograms using a two-response, forced-choice approach, whereby the turtles were required to vary behavior according to presence or absence of sound, permitting a behavioral measure of acoustic sensitivity. Lavender et al. (2011) have found that while loggerheads respond to similar frequencies as previous studies (50-1,000 Hz), their threshold levels are actually more sensitive than reported using electrophysiological methods.

Several sea turtle behavioral studies have been initiated to assist in the development of an acoustic repelling device for sea turtles. O'Hara and Wilcox (1990) attempted to create a sound barrier for loggerhead turtles at the end of a canal using seismic airguns. The test results indicated that airguns were effective as a deterrent for a distance of about 30 m when the sound output of this system was approximately 220 dB re 1 μPa at 1 m in the 25-1,000 Hz range. However, this study did not account for the reflection of sound by the canal walls, and the stimulus frequency and intensity levels are ambiguous. Moein et al. (1995) investigated the use of airguns to repel juvenile loggerhead turtles from hopper dredges. A net enclosure was erected in the York River, Virginia to contain the turtles, and an airgun was stationed at each end of the net. Sound frequencies of the airguns ranged from 100-1,000 Hz at three decibel levels (175, 177, and 179 dB re 1 μPa at 1 m). Avoidance of the airguns was observed upon first exposure. However, after three separate exposures to the airguns, the turtles habituated to the stimuli. McCauley et al. (2000) examined the response of sea turtles (one green and one loggerhead turtle) to an airgun signal. For these trials, the turtles were placed in cages, and behavior was monitored as a single airgun approached and departed. During these trials, the turtles showed a noticeable increase in swimming behavior when the airgun level was above 166 dB re 1 μPa at 1 m and became erratic and increasingly agitated above 175 dB. Because these animals were caged, avoidance behavior could not be monitored. However, the researchers speculated that avoidance would occur at 175 dB re 1 μPa at 1 m, the point at which the animals were acutely agitated (McCauley et al., 2000).

Researchers have also attempted to monitor sea turtle avoidance to sound during an active seismic survey (Weir, 2007; DeRuiter and Doukara, 2010). Weir (2007) observed 240 animals during a 10-month seismic survey off the coast of Angola. Behaviors were recorded at time of first sighting and as the vessel and towed equipment moved in relation to the turtle. Fewer turtles were observed near the airguns as they were firing (as opposed to the "gun-off" state). However, the source of agitation for the turtle could not be identified; the turtle could have reacted to the ship and towed equipment rather than specifically to the airgun (Weir, 2007). DeRuiter and Doukara (2010) observed turtles during active operation of an airgun array as well and found a startle response (rapid dive) to the airgun. However, again, these authors could not distinguish the stimulus source of the startle response as they did not perform a control with the airguns off (DeRuiter and Doukara, 2010).

5. EFFECTS OF ANTHROPOGENIC NOISE

There is growing concern over anthropogenic sound in the world's oceans and the potentially harmful effect it has on protected marine organisms. Anthropogenic noises can originate from a multitude of sources, including (but not limited to) shipping traffic, seismic surveys for petroleum exploration, military sonar operations, pile driving, etc. These sounds have the potential to impact an animal in several ways: trauma to hearing (temporary or permanent), trauma to non-hearing tissue (barotraumas), alteration of behavior, and masking of biologically significant sounds (McCarthy, 2004).

Hearing damage is usually categorized as either a temporary or permanent injury. Temporary threshold shifts (TTS) are recoverable injuries to the hearing structure and can vary in intensity and duration. Normal hearing abilities return over time; however, animals often lack the ability to detect prey and predators and assess their environment during the recovery period. In contrast, permanent threshold shifts (PTS) are permanent loss of hearing through loss of sensory hair cells (Clark, 1991). Few studies have looked at hair cell damage in reptiles, and it is still unknown if sea turtles are able to regenerate hair cells (Warchol, 2011). There are almost no data on the effects of intense sounds on marine turtles and, thus, it is difficult to predict the level of damage to hearing structures. Clear avoidance reactions to seismic signals at levels between 166 and 179 dB re 1μPa have been observed (Moein et al., 1995; McCauley et al., 2000); however, both of these studies were done in a caged environment, so the extent of avoidance could not be monitored. Moein et al. (1995) did observe a habituation effect to the airguns; the animals stopped responding to the signal after three presentations. This lack of behavioral response could be a result of TTS or PTS.

The Bureau of Ocean Energy Management (BOEM) concludes that there is incomplete or unavailable information (40 CFR § 1502.22) about sea turtles that use the Area of Interest (AOI) with respect to their physiology and behavioral response to intense sounds. The available data and information about sea turtles using the AOI is reported to the best of our ability in this document. BOEM has used what scientifically credible information is available and applied it using accepted scientific methodologies. What is known about representative species, however, in combination with observation and interpretation of behavioral response to stimuli does allow some inferences to be drawn that allow reasonably foreseeable significant adverse impacts on sea turtles to be understood well enough so that mitigations can be designed to avoid or reduce them.

BOEM has determined that incomplete or unavailable data or information on sea turtle physiology and behavioral response to intense sounds is adequate to understand reasonably foreseeable adverse impacts and is not essential to a reasoned choice among the alternatives, including the No Action alternative.

Anthropogenic noises below injury level have the potential to mask relevant sounds in the animals' environment. Masking sounds can interfere with the acquisition of prey or mate, the avoidance of predators, and, particularly in the case of sea turtles, identification of an appropriate nesting site (Nunny et al., 2008). Sea turtles appear to be low frequency specialists and, thus, the potential masking noises would fall within at least 50-1,000 Hz. These maskers could have diverse origins, ranging from natural to anthropogenic sounds (Hildebrand, 2005). The overall behavioral changes that can occur due to obscuration of sound scenery can have major ecological consequences for sea turtles. However, there are no quantitative data demonstrating masking effects for sea turtles.

Clearly, more research on the behavioral and physiological responses to sounds needs to be conducted on sea turtles before appropriate noise exposure criteria can be developed for reduced fitness, injury, and death. While the research community is making progress in the frequency range of hearing for sea turtles, there are few data on hearing loss/damage, hair cell regeneration, masking, and behavioral responses. Inner ear research on hair cell population needs to be conducted on multiple species and multiple age classes by using histology/imaging techniques to analyze variations in auditory anatomy among stages and species. The critical point that noise disrupts scene analysis and masks signals should be explored and quantitative data on masking needs to be collected for sea turtles. When looking at behavioral responses, research beyond the "startle response" must be conducted. Controlled experiments in the natural environment need to be conducted to document and classify reactions to sound as either nuisance (i.e., causing the animal to move away, changing the animals' behavior to another acceptable consequence) or injurious (i.e., preventing the animal from completing essential behavior). The results of these research studies could provide new data on the hearing ability and response to sound for sea turtles and a quantitative base for assessing potential impact of man-made sound sources on multiple species of sea turtles across habitats and developmental stages.

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APPENDIX J

FISH HEARING AND SENSITIVITY TO ACOUSTIC IMPACTS

FISH HEARING AND SENSITIVITY TO ACOUSTIC IMPACTS

ATLANTIC G&G PROGRAMMATIC EIS

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1. INTRODUCTION

This report considers the effects of human-generated (anthropogenic) sound on fishes, with particular reference to seismic airguns and sonars. However, since there are few data on the effects of any anthropogenic sources on fishes, much of the discussion will be based upon a wider range of sound sources, with a goal of some extrapolation to help inform potential effects from airguns and sonars. Emphasis will be placed upon peer-reviewed studies in the scientific literature. However, gray literature reports of high scientific quality will be cited as appropriate.

It should be noted that this review will not be comprehensive. Readers interested in more extensive analysis of the effects of anthropogenic sounds on animals are referred to Popper (2003), Hastings (2008), Popper and Hastings (2009a), and Slabbekoorn et al. (2010) for general reviews and to Popper and Hastings (2009b), Normandeau Associates, Inc. (2012), and the papers in Popper and Hawkins (2012) for a more detailed overview.

1.1. WHAT IS INJURY FOR FISHES?

A fundamental issue of concern with regard to fishes is what constitutes “injury.” As defined in the marine mammal literature (see Southall et al. [2007]) and the Marine Mammal Protection Act, permanent hearing loss (or permanent threshold shift [PTS]) is considered injury. But, as discussed below, PTS is not likely to occur in fishes, and all evidence for temporary hearing loss (or temporary threshold shift [TTS]) shows that fishes recover quickly from this physiological effect. Thus, for the sake of this discussion addressing fish, “injury” will not include effects on hearing.

So, a question of importance is when “injury” starts in fishes and the nature of physiological effects that can lead to injury. Injury caused by changes in pressure is called barotrauma. Since sound is a pressure disturbance, physiological injury caused by sound is called barotrauma. In the very limited literature on interim criteria for regulation of exposure of fishes to pile driving sound (regulations have not be promulgated for other sound sources), the concern is for the onset of physiological effects (barotrauma), but this is not clearly defined. In a recent series of peer-reviewed studies (Halvorsen et al., 2011, 2012a,b; Casper et al., 2012a) on effects of pile driving sounds on several different species, it has been demonstrated that there are some effects resulting from exposure to sound that have the potential for impacting the survival of fishes (e.g., burst swim bladder, internal bleeding from ruptured veins), whereas other observed effects have no more impact on survival than does a small cut on the arm of a human (e.g., external bleeding at the base of fins).

Therefore, until a better definition of “injury” (i.e., criteria that identify the physiological effects and their severity at the onset of injury) is available and agreed upon for fishes, for the purposes of this report an injury will be defined as a physiological effect that leads to immediate or potential death. Given this definition of injury, behavioral effects, such as moving from a site of feeding, masking, or TTS, would not be considered an injury.

At the same time, it might ultimately be possible and worthwhile to attempt to define criteria for behavioral impacts. However, as discussed in the body of this report, there are no data currently available that provide guidance on this topic.

1.2. FISH

The term “fish” generally refers to three groups of vertebrates: (1) the Agnatha or jawless vertebrates; (2) the cartilaginous fishes; and (3) the bony fishes (see Nelson [2006]). The Agnatha are a small group of very ancient vertebrates that includes lamprey, and they will not be considered further. See Nelson (2006) for a complete review of fishes and their evolutionary relationships and www.fishbase.org for a listing of the more than 32,000 known living species.

The cartilaginous fishes, or elasmobranchs, include sharks and rays and their relatives. Virtually nothing is known about effects of human-generated sound on cartilaginous fishes, but there is concern about potential effects since these animals are integral to the ecosystem in many parts of the marine environment (Casper et al., 2012b).

Bony fishes include most of the species of aquatic vertebrates, including the majority of the species of fishes that are consumed by humans[1]. Unless otherwise stated, the term "fishes" in this report will refer to bony fishes. By convention, the word "fish" refers to one or more members of the same species, whereas "fishes" refers to multiple species.

1.3. FISH BIOACOUSTICS – OVERVIEW

Sound plays a major role in the lives of all fishes (e.g., Zelick et al., 1999; Fay and Popper, 2000). This is particularly the case since sound is attenuated at a much lower rate than other forms of energy, such as light, and the lower frequencies important for communication and environmental sensing by fishes travel long distances while retaining their information content. Thus, fishes can glean a great deal of information about biotic (living) and abiotic (environmental) sources and get a good "image" of the environment at a very substantial distance from the animal (e.g., Fay and Popper, 2000; Popper et al., 2003; Slabbekoorn et al., 2010).

In addition to listening to the overall environment and being able to detect sounds of biological relevance (e.g., the presence of a reef, the sounds produced by swimming predators), many species of bony fishes (but not elasmobranchs) communicate with sounds and use sounds in a wide range of behaviors including, but not limited to, mating and territorial interactions (see Zelick et al. [1999] for review). Consequently, anything that impedes the ability of fishes to hear biologically relevant sounds, such as those produced by anthropogenic sound sources could interfere with the normal behaviors and even the survival of individuals, populations, or a species. Much more detailed discussions of all aspects of fish bioacoustics can be found in the papers in Webb et al. (2008) and in papers by Fay and Megela-Simmons (1999), Zelick et al. (1999), and Popper et al. (2003). A broad discussion of interactions of anthropogenic sounds and fishes can be found in Popper and Hastings (2009a,b) and in the papers in Popper and Hawkins (2012).

In addition to hearing and behavior-related effects, sound can cause physiological injury (barotrauma) to many of the tissues in the body of a fish (Halvorsen et al., 2011). While generally not considered in discussion of bioacoustics, many of the same sounds that may cause bioacoustics effects may also cause barotrauma. This is particularly true of the impulsive sounds caused by pile driving and geophysical exploration sound sources. High-energy impulsive sounds can cause barotrauma by physiological responses to rapid decompression (Stephenson et al., 2010), and in the case of sound generated by in-water exposions, by tissue responses to percussion (Hastings and Popper, 2005). Barotrauma will be discussed further in following sections of this appendix.

1.4. METRICS OF SOUND EXPOSURE

Before discussing effects of anthropogenic sound on fishes, it is important to understand that, to date, it has not been possible to easily compare results from studies with different anthropogenic sources. In part, this is because of the fact that while different sources may be reasonably similar in average acoustic intensity, they have different spectral characteristics, duration, rise times, and other characteristics. In particular, peak pressure relative to the static pressure at the location of the fish, and rise time, which is the time from the onset of the signal to when it reaches the signal's peak pressure, are important factors in the risk of barotrauma to fish from pressure changes in the signal. The maximum pressures, particularly maximum negative pressures relative to static pressure, determine the maximum change in volume of air-filled bodies within a fish. If the change is large, the risk of injury is high. If the rate of change in pressure is very slow, that may permit the fish, particularly physostomous species, to accommodate the change in volume of internal bodies such as the swim bladder with less risk of injury. However, for most impulsive signals from pile driving and seismic sources, the range of rise times is relatively small when the peak pressures are high enough to be a risk for injury.

The second issue in comparing results arises from the spectrum and time course of the signal and how these are described and calibrated. Until recently, most sound sources were described in terms of peak pressure and root-mean-square (rms) pressure. Peak pressure represents the maximum point of the energy in a signal whereas rms describes the average level of energy in the signal. The problem with both measures is that they do not give a good representation of the total energy in the signal over time – and it

[1] e.g., tuna, salmon, cod, herring, pollack, and many others.

is this total energy that is likely to be the critical factor in determining potential effects on a receiver (Popper and Hastings, 2009b).

In comparing sounds such as sonars, seismic airgun arrays, and pile driving, there may be similarities in both peak and rms, but neither measure shows the actual differences in the total energy to which a receiver may be exposed. More recently, investigators have started to use a third measure, the Sound Exposure Level (SEL). SEL is a level expressed in decibels equal to the log-transformed integration of the square of the acoustic pressure over the duration of the signal (Popper and Hastings, 2009b) and is an index of the total acoustic energy received by an organism, representing the total energy in a signal or sequence of signals (see Popper and Hastings [2009b] for discussion of SEL and how it is calculated). SEL allows for a comparison between signals since it provides a measure of all energy present in a signal and can also be used to estimate the sum of the energy in a sequence of signals, and it has, accordingly, been more and more accepted by investigators (e.g., Popper et al., 2005, 2007; Hastings et al., 2008; Halvorsen et al., 2011, 2012a,b; Hastings and Miskis-Olds, 2011; Normandeau Associates, Inc., 2012).

There are two uses of SEL. One is referred to as single-strike SEL (SEL_{ss}), and the other is cumulative SEL (SEL_{cum})[2]. SEL_{ss} is the index of energy in a single signal, such as a single pile driving strike or a single blast from a seismic airgun. SEL_{cum} is the index of energy in all of the signals presented, such as in all of the strikes during a pile driving operation or seismic study[3].

2. BACKGROUND ON FISH HEARING

2.1. SOUND IN WATER

The basic physical principles of sound in water are the same as sound in air. Any sound source produces both pressure waves and actual motion of the medium particles. However, whereas the actual particle motion in air is inconsequential even a few centimeters from a sound source, particle motion travels (propagates) much further in water because of the density of water compared to air[4]. For a more extensive discussion of underwater acoustics see Urick (1983) and Rogers and Cox (1988).

All fishes, including elasmobranchs, detect particle motion since it directly stimulates the inner ear (Popper et al., 2003; Casper et al., 2012b). In essence, the oscillatory particle motion "shakes" the fish when, because of differences in density, otolyths within the fish's ear move differentially to clusters of hair cells thereby stimulating the hair cells that allow the fish to hear the stimulating sound (see **Section 2.3**). Bony fishes with an air bubble (most often the swim bladder) are also likely to detect pressure signals that are reradiated to the inner ear as particle motion. Species detecting pressure hear a wider range of frequencies and sounds of lower intensity than fishes without an air bubble since the bubble re-radiates the received signal, which is then detectable by the ear as a secondary sound source (Popper et al., 2003; Popper and Fay, 2010).

Exactly how well fishes with an air bubble hear depends on the relative position of the air bubble and ear. When the two structures are close together or when there is some kind of physical coupling between them, the bandwidth of hearing and sensitivity is greater than it is in fishes where the air bubble and ear are further apart or not coupled. In the latter case, the signal that is re-radiated from the air bubble attenuates (decreases) over the distance between the structures, whereas in the other species the proximity of the structures, or the coupling, ensures that most of the energy re-radiated from the bubble gets to the ear[5].

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[2] Note: Abbreviations for single strike and cumulative SEL have not been standardized and are adopted here from Halvorsen et al. (2011, 2012a).

[3] As discussed below, there is some indication that if there is sufficient time (e.g., more than 12 hr) between an accumulation period for SEL, then the accumulation for the next exposure period starts again at 0.

[4] The wavelength of a sound in water is about 1,500 m/sec (it varies depending on salinity, depth, temperature, etc.). The wavelength is defined as 1500/frequency which means for a 500 Hz signal the wavelength is 3 m. For a 100 Hz signal the wavelength is 15 m and the near field transition point would be 15/6.28 = ~2.8 m.

[5] Until recently the literature talked about hearing "generalists" and "specialists." However, these terms are no longer in use. See Popper and Fay (2010) for explanation and discussion.

2.2. HEARING SENSITIVITY

Basic data on hearing provides information about the range of frequencies that a fish can detect and the lowest sound level that an animal is able to detect at a particular frequency (**Figure J-1**). This level is often called the "threshold"[6]. Sounds that are above threshold are detectable by fishes.

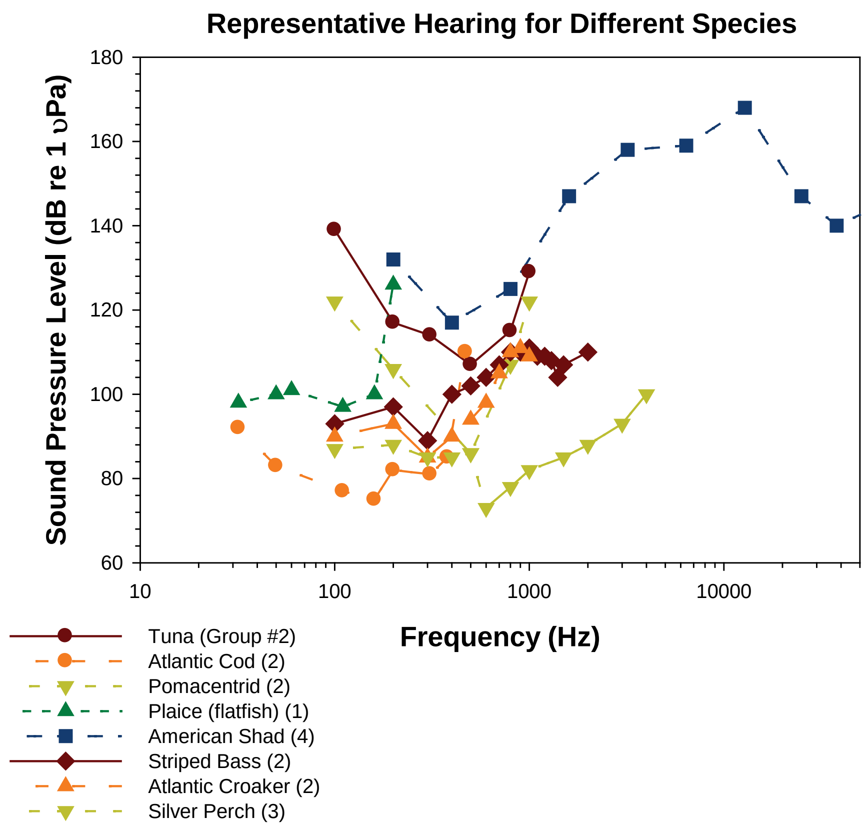

Figure J-1. Hearing Curves (Audiograms) for Select Bony Fishes (See Fay [1988], Nedwell et al. [2004], and Ramcharitar [2006] for Data). Each Data Point Indicates the Lowest Sound Level the Species Could Detect at a Particular Frequency (See Text for Caveats on Data). Group Number Given in the Legend Refers to the Discussion within the Text. Data for American Shad are Truncated at 50 kHz to Keep the Size of the Graph Reasonable, but It Should Be Noted That this Species Can Hear Sounds to At Least 180 kHz (Mann et al., 1997). Note, That in Some Cases (E.G., plaice, Tuna), the Actual Threshold Measures Were in Terms of Particle Motion, and Use of a Pressure Scale is Not Appropriate. This May Be the Same for Other Species as Well. The Significance of This Figure, However, is the Hearing Range and the Relatively Differences in Sensitivity (Thresholds) for the Various Species. The Actual Threshold Values are Likely in Need of Re-evaluation.

Hearing thresholds have been determined for perhaps 100 species (examples in **Figure J-1**) (for data on hearing thresholds, see Fay [1988], Popper et al. [2003], Ladich and Popper [2004], Nedwell et al. [2004], Ramcharitar et al. [2006], and Popper and Schilt [2008]). These data demonstrate that, with few exceptions, fishes cannot hear sounds above about 3-4 kHz, and the majority of species are only able to

[6] Very often, for fish, hearing thresholds are the lowest levels at which sound is detected 50% of the time. In other words, whereas a fish will detect a particular signal 50% of the time, it will not detect the same signal 50% of the time. Variation in threshold is well known and reflects momentary changes in the detecting structure, in the motivation of the animal, and innumerable other factors.

detect sounds to 1 kHz or below[7]. There have also been studies on a few species of cartilaginous fishes, with results suggesting that they detect sounds to no more than 600 or 800 Hz (e.g., Myrberg et al., 1976; Myrberg, 2001; Casper et al., 2003; Casper and Mann, 2006).

The data available, while very limited, suggest that the majority of marine species do not have specializations to enhance hearing and probably rely on both particle motion and sound pressure for hearing, although species without a swim bladder (e.g., plaice, elasmobranchs) are certainly only detectors of particle motion. Most importantly, it should be noted that hearing capabilities vary considerably between different bony fish species (**Figure J-1**; **Table J-1**), and there is no clear known correlation between hearing capability and environment. There is also broad variability in hearing capabilities within a single fish group. As just one example, there is broad diversity in hearing capabilities and hearing structures within the family Sciaenidae (drumfish, croakers) (**Figure J-1**; data reviewed in Ramcharitar et al. [2006]; see also Popper and Schilt [2008]).

Table J-1

Marine Fish Hearing Sensitivity. See Text for Caveats about the Data. For a Number of Additional Species, Hearing Capabilities can only be Surmised from Morphological Data. These Data are Shown Shaded in Gray

Family	Common Name of Taxa	Highest Frequency Detected (Hz)[a]	Hearing Category[b]	Reference	Notes
Asceripensidae	Sturgeon	800	2	Lovell, et al., 2005; Meyer et al., 2010	Several different species tested. Relatively poor sensitivity
Anguillidae	Eels	300	2	Jerkø et al., 1989	Poor sensitivity
Batrachoididae	Toadfishes	400	2	Fish and Offutt, 1972; Vasconcelos and Ladich, 2008	
Clupeidae	Shad, menhden	>120,000	4	Mann et al., 1997, 2001	Ultrasound detecting, but sensitivity relatively poor
	Anchovy, sardines, herrings	4,000	4	Mann et al., 2001	Not detect ultrasound, and relativley poor sensitivitiy
Chondrichthyes [Class]	Rays, sharks, skates	1,000	1	Casper et al., 2003	Low frequency hearing, not very sensitive to sound
Gadidae	Atlantic cod, haddock, pollack, hake	500	2	Chapman and Hawkins, 1973; Sand and Karlsen, 1986	Probably detect infrasound (below 40 Hz). Best hearing 100-300 Hz
	Grenadiers	--	3?	Deng et al., 2011	Deep sea, highly specialized ear structures suggesting good hearing, but no measures of hearing
Gobidae	Gobies	400	1 or 2	Lu and Xu, 2009	
Labridae	Wrasses	1,300	2	Tavolga and Wodinksy, 1963	
Lutjanidae	Snappers	1,000	2	Tavolga and Wodinksy, 1963	
Malacanthidae	Tilefish	--	2	Not applicable	No data
Moronidae	Striped bass	1,000	2	Ramcharitar unpublished	
Pomacentridae	Damselfish	1,500 – 2,000	2	Myrberg and Spires, 1980	

[7] The lowest detectable frequency is often hard to determine since the limiting factor in experiments trying to measure this is often the equipment. In many cases, the equipment does not work well at frequencies below 50-100 Hz, making it hard to determine if fishes can detect lower frequencies. However, recent studies using specialized equipment have demonstrated that some species can detect sounds below 50 Hz (called infrasound), but it is still not clear if this is done by the ear or by the lateral line (Karlsen, 1992; Knudsen et al., 1994).

Family	Common Name of Taxa	Highest Frequency Detected (Hz)[a]	Hearing Category[b]	Reference	Notes
Pomadasyidae	Grunts	1,000	2	Tavolga and Wodinsky, 1963	
Polyprionidae	Wreckfish	--	2	Not applicable	No data
Sciaenidae	Drums, weakfish, croakers	1,000	2	Ramcharitar et al., 2006	Hear poorly
	Silver perch	3,000	3	Ramcharitar et al., 2004, 2006	
Serranidae	Groupers	--	2	Not applicable	No data
Scombridae	Yellowfin tuna	1,100	2	Iversen, 1967	With swim bladder
	Tuna	1,000	1	Iversen, 1969	Without swim bladder
	Bluefin tuna	1,000	2	Song et al., 2006	Based only on ear anatomy

[a] Lower frequency of hearing is not given since, in most studies, the lower end of the hearing bandwidth is more a function of the equipment used than determination of actual lowest hearing threshold. In all cases, fish hear below 100 Hz, and there are some species studied, such as Atlantic cod, Atlantic salmon, and plaice, where fish have been shown to detect infrasound, or sounds below 40 Hz.
[b] See text for explanation.
Sources: Data compiled from reviews in Fay (1988) and Nedwell et al. (2004). Updated names: www.fishbase.org

Table J-1 and **Figure J-1** provide data on a number of fish groups of potential interest for this report. The data in **Table J-1** are presented in terms of fish taxa (family level) since data are often not available for specific species of interest. However, it is possible to extrapolate between broad groups of fishes in most cases. Where that is not the case, as in the sciaenids (reviewed in Ramcharitar et al., 2006), several different sets of data are shown. Moreover, this is also done when species within a group differ substantially in hearing structures. Thus, in the case of tuna, there are some species with a swim bladder (involved in pressure detection) and others that do not have a swim bladder (Iversen, 1967, 1969). Indeed, in the case of tuna, while the hearing range of the species with and without swim bladders is quite similar, it is likely that the sensitivity is poorer in the species without this structure.

It should also be noted that **Table J-1** only gives the likely highest frequency of hearing for a fish and leaves out the low frequency end of the hearing bandwidth. This is done because what is known about low frequency hearing is often a function of the equipment used in the study and not what the fish actually hears. Thus, if the sound source used to study hearing is only good to 100 Hz, then that might be the lowest frequency that investigators report. As a consequence, the low frequency range, with a few exceptions, must be viewed with caution, even as presented in **Figure J-1**. However, it is accurate to state that most, if not all, fishes can detect sounds to below 100 Hz and likely to below 50 Hz.

Another point to note is that **Table J-1** does not show hearing sensitivity, and the data in **Figure J-1** are not presented as thresholds but as relative levels of hearing within a single fish's hearing capabilities. Thus, **Table J-1** does not show the lowest sound levels that a fish can hear, nor does it indicate at what frequency best hearing occurs. The table is presented as it is because there is wide variation in data even for a single species (e.g., see Fay [1988] for a demonstration of different data on hearing for goldfish). The variation is likely a result of experimental design. It is often the case that the investigators did not use the right stimulus parameter (pressure or particle motion) to test a species. Thus, investigators have often presented hearing sensitivity data for fishes in terms of pressure sensitivity, even when the fish is likely not to detect sound pressure as it primarily detects particle motion (something that, until recently, has been very hard to measure).

With these caveats, it is possible to make some useful generalizations with regard to fish hearing that remove some of the "variability" in the data and help focus understanding of fish hearing capabilities. Such generalizations also make it possible to "predict" hearing range and sensitivity of some species for which there are data on the structure of the ear and auditory system but no hearing data. Indeed, such is the case for bluefin tuna, where, despite lack of hearing data, it is possible to predict that the hearing range for this species is similar to that of other tuna based on similarities in ear structure (Song et al., 2006). Similarly, morphological data on the ears of deep-sea grenadiers leads to the suggestion that these species have inner ear specializations that are often associated with fishes that hear to 2,500-4,000 Hz and have good hearing sensitivity (Deng et al., 2011); a similar observation has been made for myctophids (Popper, 1980).

Based on this kind of analysis, it is possible to "categorize" fish groups as to their hearing capabilities. This is presented in **Table J-1** where a column provides the categories of each species represented, which are defined as follows:

- *Group 1*: Fishes that do not have a swim bladder (e.g., plaice in **Figure J-1**). These fishes are likely to use only particle motion for sound detection. The highest frequency of hearing is likely to be no greater than 400 Hz, with poor sensitivity compared to fishes with a swim bladder. Fishes within this group would include flatfish, some gobies, some tunas, and all sharks and rays (and relatives).
- *Group 2*: Fishes that detect sounds from below 50 Hz to perhaps 800-1,000 Hz (though several probably only detect sounds to 600-800 Hz). These fishes have a swim bladder but no known structures in the auditory system that would enhance hearing, and sensitivity (lowest sound detectable at any frequency) is not very great. Sounds would have to be more intense to be detected when compared to fishes in Group 3. These species detect both particle motion and pressure, and the differences between species are related to how well the species can use the pressure signal. A wide range of species fall into this category, including tuna with swim bladders, sturgeons, salmonids, etc.
- *Group 3*: Fishes that have some kind of structure that mechanically couples the inner ear to the swim bladder (or other gas bubble), thereby resulting in detection of a wider bandwidth of sounds and lower intensities than fishes in other groups (e.g., silver perch in **Figure J-1**). These fishes detect sounds to 3,000 Hz or more, and their hearing sensitivity, which is pressure driven, is better than in fishes of Groups 1 and 2. There are not many marine species known to fit within Group 3, but this group may include some species of sciaenids (Ramcharitar et al., 2006). It is also possible that a number of deep-sea species fall within this category, but that is only predicted based on morphology of the auditory system (e.g., Popper, 1980; Deng et al., 2011). Other members of this group would include all of the Otophysan fishes, though few of these species other than catfishes are found in marine waters.
- *Group 4*: All of these fishes are members of the herring family and relatives (Clupeiformes). Their hearing below 1,000 Hz is generally similar to fishes in Group 1, but their hearing range extends to at least 4,000 Hz (e.g., sardine), and some species (e.g., American shad) are able to detect sounds to over 180 kHz (Mann et al., 2001).

2.3. OTHER ASPECTS OF FISH HEARING

Besides being able to detect sounds, a critical role for hearing is to be able to discriminate between different sounds (e.g., frequency and intensity), detect biologically relevant sounds in the presence of background noises (called maskers, see below), and determine the direction and location of a sound source in the space around the animal. While actual data are available on these tasks for only a few fish species, all species are likely to have similar capabilities (reviewed in Fay and Megela-Simmons, 1999; Popper et al., 2003; Fay, 2005).

Only a few points about the hearing structure in fishes is critical for this report, and readers interested in more detail can find reviews by Popper et al. (2003) and Popper and Schilt (2008). The fundamental structure for hearing by fishes is the inner ear. This is, in many ways, very similar in structure and function to the ear found in all other vertebrates. The inner ear has three otolith organs – the saccule, lagena, and utricle – each containing a dense structure called an otolith. The otolith lies in close proximity to a sensory surface called the sensory epithelium. Each epithelium contains sensory hair cells that are very similar to those found in the mammalian ear. On their top surfaces, sensory hair cells have hair-like projections, called cilia that are bent when the epithelium and otolith move out of phase from one another – something that takes place when sound stimulates the ear. The sensory cells respond physiologically to the bending of the cilia and send signals on to the brain via the eighth cranial nerve – the same nerve involved in hearing in humans.

Germane to issues of effects of loud sounds on fishes is that the sensory hair cells in fishes, as in mammals (including humans), can be damaged or actually killed by exposure to very loud sounds (Le Prell et al., 2011). However, whereas in humans once sensory cells die they are not replaced, resulting in deafness, fishes are able to repair and replace cells that die (e.g., Lombarte et al., 1993; Smith et al., 2006). Moreover, whereas in humans the ear has its full complement of sensory hair cells at birth, fishes continue to produce (proliferate) sensory hair cells for much of their lives, which results in fishes having more and more sensory hair cells as they age (Popper and Hoxter, 1984; Lombarte and Popper, 1994). Indeed, large Mediterranean hake (*Merluccius merluccius*) have been shown to have a million or more sensory hair cells in a single saccule (Lombarte and Popper, 1994), as compared to humans which have, at birth, no more than 20,000 sensory cells in the auditory part of the ear.

Because fishes have the ability to repair damaged sensory hair cells and continuously add to their number, fishes are not likely to ever become deaf permanently. As discussed below, there is some chance of temporary hearing loss, but this is quickly repaired (Smith et al., 2006), and there is no evidence in fishes for permanent hearing loss.

3. EFFECTS OF HUMAN-GENERATED SOUND ON FISHES – OVERVIEW

There is a wide range of potential outcomes of exposing fishes to sound, from no effect to immediate death. Data on effects of sounds are limited, and broad extrapolations about effects on different species (or on the same species at different ages or sizes) is not yet possible (see discussion in Popper and Hastings [2009b] and Popper and Hawkins [2012]). Moreover, while there are some (albeit limited) data on effects on physiology, far less is known about effects on behavior.

The actual effects will vary based on a large number of factors. In particular, other than for physiological damage, which does not depend on hearing per se, the likelihood of TTS, masking, and/or behavioral change will depend on whether the fish hears the sound. **Figure J-2** illustrates the idea that there is a likelihood of any number of different potential effects close to the source and that the range of potential effects declines with increased distance from the source.

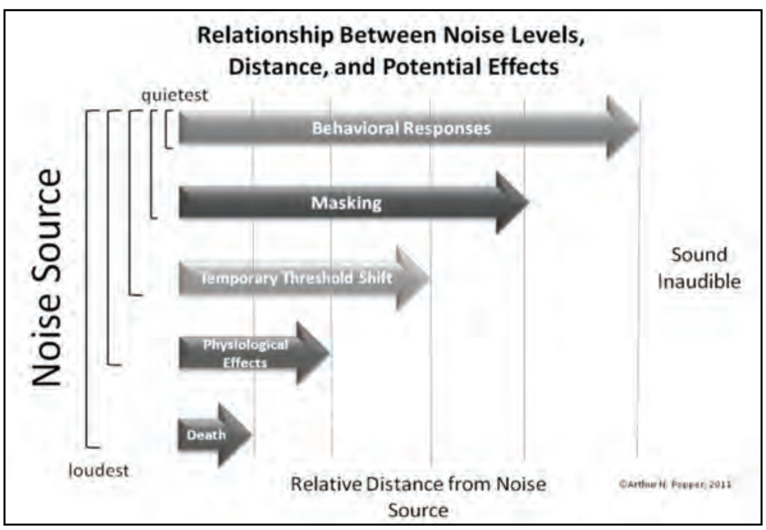

Figure J-2. Relationship between Noise Levels, Distance, and Potential Effects. Note That Close to the Source, There is a Range of Potential Effects, but as the Distance from the Source Increases and Sound Levels Get Lower, the Likelihood of Some Potential Effects Decreases. The Actual Effects Will Vary Depending on the Source. If the Source is Very Intensive, Then Mortality May Occur. But, If the Source is Less Intensive, Mortality and Physiological Effects May Not Be an Issue. At the Lowest Source Levels, Such as with Increases in Ambient Sounds, Behavioral Responses and/or Masking May be the Only Issues of Concern.

The actual effects are also likely to depend on the nature of the sound source itself. One may divide sounds into two very overlapping "classes": intermittent (or acute) and long-term (or chronic) (Popper and Løkkeborg, 2008). Intermittent sounds usually are of short duration and high intensity, and they are only present in a particular area for a short period of time. These include sounds produced by seismic airguns, sonars, and similar sources. Pile driving would also fit into this category, although it may last for hours, days, or even weeks. But, ultimately, pile driving ends. Loud intermittent sounds have the potential to cause death or injury if the animal is close to the source. They could also produce hearing impairment, masking, and behavioral effects to distances beyond those that would result in death or injury (**Figure J-2**).

Long-term (chronic) sources are generally lower in intensity than acute signals, may extend over a broad area, and, in general, raise the ambient noise level from a few to many decibels. In essence, chronic noise sources raise the overall background ambient level of the environment similar to what might be encountered when new machinery is added to a factory. In the case of the aquatic environment, perhaps the most dominant changes in the chronic noise environment come from boats which, is more likely to occur in a harbor, major shipping lanes, and similar areas. Long-term rises in sound level are not likely to result in death or physiological effects (though it is possible that there may be long-term changes in stress levels and immune response), but they could also produce hearing impairment, masking, and/or behavioral effects (**Figure J-2**).

4. EFFECTS OF ANTHROPOGENIC SOUNDS ON HEARING

While there are few data on behavioral effects of sounds on fishes in the wild (see **Section 6**), there are substantial data on effects of such sounds on the ability of fishes to hear. If hearing is impaired, even temporarily, a fish may not be able to find food or detect predators as successfully. Such impairment may be by auditory masking or temporary impairment of hearing.

4.1. AUDITORY MASKING

Masking is a key issue for potential effects of human-generated sound on all vertebrates, including fishes (reviewed in Fay and Megela-Simmons, 1999; Popper et al., 2003). Masking occurs when there are sounds in the environment that are in the same frequency range as the sound of biological relevance to the animal and/or within the hearing range of the fishes. Thus, if a fish has a particular threshold for a biologically relevant sound in a quiet environment and a background noise in the same frequency range is introduced, this will decrease the ability of the fish to detect the biologically relevant signal. In effect, the threshold for the biologically relevant signal will become poorer. Thus, if background noise increases, it may be harder for a fish to detect the biologically relevant sounds that it needs to survive. Specifically, if the ambient noise (or masker) is raised by 10 dB, the threshold of the fish will increase by about 10 dB in the frequency range of the masker.

The actual concern with regard to masking is that fishes will not be able to hear sounds of biological relevance as well as they would without the masking sound. Thus, if a fish uses sounds to detect predators, the presence of the increased ambient sound would keep the fish from hearing the predator until it was much closer. Similarly, if male fishes use sounds to attract females, as occurs in toadfish (reviewed in Zelick et al., 1999), sciaenids (reviewed in Ramcharitar et al., 2006), and many other species, the female would have to be much closer to the males before they could hear the sound. In other words, the effectiveness of a male's call would decline in the presence of masking sounds since the females would be less likely to detect the sounds unless they are closer to the source (where the source is louder in the presence of the masker). Indeed, this effect is well known and has been described for a wide range of other vertebrates, including birds and amphibians (reviewed in Slabbekoorn et al., 2010).

More recently, it has been suggested that at least some larval fishes find the reefs upon which they will settle using sounds from the reef (e.g., Leis et al., 2003; Wright et al., 2005). These studies have suggested that if there is an increase in ambient (masking) noise, the larval fish would be less likely to hear the sounds of the reef and, thus, less likely find a place to settle. The reef sounds could be produced by a variety of sources, including snapping shrimp, water moving over reefs, other fishes, etc. and would be subject to masking by anthropogenic sounds within the hearing range of fishes. Clearly, if this observation is correct, then the presence of masking sounds could have a significant impact on long-term survival of populations of reef fishes.

4.2. TEMPORARY THRESHOLD SHIFT

A second concern is that exposure to sounds can result in a temporary loss of hearing sensitivity, or TTS. Temporary threshold shift recovers after some period of time following the termination of the noise and results from temporary, but recoverable, damage to the sensory cells of the inner ear that are involved with for hearing (Smith et al., 2006). Permanent hearing loss (i.e., PTS), resulting from exposure to very loud sounds, occurs in humans and other mammals. Permanent threshold shift is not, however, known to occur in fishes, since unlike mammals, they can repair and regenerate the sensory cells of the ear that are damaged (e.g., Lombarte et al., 1993; Smith et al., 2006)[8].

Data on TTS in fishes are reviewed in Popper and Hastings (2009b) and are only briefly summarized here. The data suggest that TTS occurs after long-term exposure to sounds that are as high as 170-180 dB re 1 µPa (rms), but only in species that have specializations that result in their having relatively wide hearing bandwidths (to over 2 kHz) and lower hearing thresholds than fishes without specializations. For example, TTS of 10-20 dB has been demonstrated in goldfish (*Carassius auratus*) and lined Raphael catfish (*Platydoras costatus*) (e.g., Scholik and Yan, 2002; Smith et al., 2004a, 2006; Wysocki and Ladich, 2005), but little or no TTS has been found in fishes such as cichlids, sunfishes, and perch (e.g., Scholik and Yan, 2001; Amoser and Ladich, 2003; Smith et al., 2004a,b; Wysocki and Ladich, 2005). Moreover, studies of the effects of exposure to 150 dB re 1 µPa (rms, received level) for 9 months showed no effect on hearing or on survival and growth of young rainbow trout (*Oncorhynchus mykiss*) (Wysocki et al., 2007). Significantly, in those species where TTS was found, hearing returned to normal starting well within 24 hr after the end of exposure (e.g., Smith et al., 2004b, 2006).

While TTS is not as likely to be particularly irrelevant with regard to repetitive sound sources, concerns have still arisen that fishes may temporarily have impaired hearing as a result of exposure to loud sounds (e.g., Popper et al., 2005, 2007; reviewed in Popper and Hastings, 2009b). Several studies show varying results, but overall, if TTS occurs as a result of exposure to loud sounds, it is not necessarily very great and recovery seems to be within 24 hr in most cases (Popper et al., 2005, 2007; Hastings et al., 2008; Hastings and Miskis-Olds, 2011).

The potential effects of TTS are similar to those of masking (see **Section 4.1**). If the hearing ability of an affected fish decreases, then the likelihood of detecting predators, prey, or mates (or a reef) decline, thus decreasing the potential fitness of the receiver until normal hearing returns.

4.3. EFFECTS OF HIGH INTENSITY SOURCES ON HEARING

Several studies have examined the effects of very high intensity sources on hearing and demonstrate little or no effect on a diverse group of species. Popper et al. (2005) and Song et al. (2008) examined the effects of exposure to a seismic airgun array on three species of fishes found in the Mackenzie River Delta near Inuvik, Northwest Territories, Canada. One species, the lake chub (*Couesius plumbeus*), has hearing specializations, whereas the northern pike (*Esox lucius*) and the broad whitefish (*Coregonus nasus*) (a salmonid) do not. Fishes were exposed to 5 or 20 shots from a 730-in^3 (12,000 cc) calibrated airgun array. And unlike earlier studies, the received exposure levels were not only determined for rms sound pressure level, but also for peak sound levels and SELs (e.g., average mean peak SPL 207 dB re 1 µPa RL; mean rms sound level 197 dB e 1 µPa RL; mean SEL 177 dB re 1 µPa^{2}s).

For both the 5 and 20 airgun shots, the results showed a temporary hearing loss for both lake chub and northern pike but not for broad whitefish. Hearing loss was on the order of 20-25 dB at some frequencies for both the northern pike and lake chub; full hearing recovery occurred within 18 hr after sound exposure.

Popper et al. (2007) studied the effect of the Surveillance Towed Array Sensor System (SURTASS) low-frequency active (LFA) sonar on hearing, the structure of the ear, and select non-auditory systems in the rainbow trout and channel catfish (*Ictalurus punctatus*) (also Halvorsen et al., 2006). Fishes were exposed to LFA sonar for 324 or 648 seconds, an exposure duration that is far greater than any fishes in the wild would get since, in the wild, the sound source is on a vessel moving past the far slower swimming fishes. The maximum received level was approximately 193 dB re 1 µPa at 196 Hz. Analysis

[8] Interesting note: The sensory cells in the mammalian and fish ear responsible for hearing are the same. The difference between fishes and mammals is that fishes retain a regenerative mechanism in the ear for when cells are lost, whereas no such capacity is found in mammals.

of hearing showed that channel catfish and some specimens of rainbow trout showed 10-20 dB of hearing loss immediately after exposure to the LFA sonar when compared to baseline and control animals; however, another group of rainbow trout showed no hearing loss. Recovery in trout took at least 48 hr, and channel catfish recovered with 24 hr. Similar studies on several other species, including hybrid sunfish and black perch, showed no TTS to the same signals (Halvorsen et al., 2006).

Finally, Hastings et al. (2008) studied TTS in Indian Ocean reef fishes during a seismic survey with a full airgun array. They found no hearing loss following sound exposures up to 190 dB re 1 μPa^2-s cumulative SEL in a species that hears well, in the pinecone soldierfish (*Myripristis murdjan*), and in three species that do not have hearing specializations: the blue green damselfish (*Chromis viridis*), sabre squirrelfish (*Sargocentron spiniferum*), and bluestripe seaperch (*Lutjanus kasmira*).

In summary, it is clear that if hearing loss occurs after exposure to intense sounds (and it does not always occur), it primarily shows up in fishes with hearing specializations and is not permanent (i.e., there is full recovery). More importantly, TTS is less likely to show up in fishes without hearing specializations. The only time that TTS has been documented as a response to high intensity sources has been when the exposure duration has substantially exceeded the amount of time that an animal would normally be exposed to such sounds in the wild (Popper et al., 2007).

5. EFFECTS OF HIGH INTENSITY SOURCES

Intensive sources are generally short (measured in parts of a second to several seconds) and are highly intensive at the source (attenuation follows normal attenuation characteristics of sound in water). Also, exposure time to the sound for an animal may be rather short. For example, a fish exposed to high intensity sonar may only hear a few sonar sounds since the source, on a boat, is moving. In the case of seismic devices, the source is constantly moving, although the sounds may increase the overall ambient noise for the duration of a 3D seismic study. Sounds from pile driving may last for as long as the pile driving operation, but there frequently are periods of pile driving followed by longer periods of silence as the pile driving equipment is moved to a new pile or other construction activities occur that increase the time between pile driving actions.

The concerns associated with intensive sources range from immediate mortality to delayed mortality to behavioral effects (**Figure J-2**). Behavioral effects are varied and less likely to involve masking or TTS, as found in long-term exposures, because of the short periods of the intense sounds. However, there are concerns, as discussed below, that an extended seismic survey could result in fishes leaving their feeding or spawning areas for extended periods of time, or even permanently, which could impact survival of populations as well as catchability for fishers (e.g., Engås et al., 1996; Slotte et al., 2004; Løkkeborg et al., 2012).

At the same time, while much concern about intensive sources rests on immediate mortality, the limited data suggest that the circumstances under which immediate mortality occurs are very limited. Indeed, there are no data to suggest mortality associated with high intensity sources other than pile driving[9].

The only data on mortality associated with sound (as compared to explosives) come from driving very large piles. For example, the California Department of Transportation (Caltrans, 2001) showed some mortality for several different species of wild fishes exposed to driving of steel pipe piles 2.4 m (8 ft) in diameter. However, no mortality seems to occur at distances of more than approximately 10 m (32.8 ft) from the source. Only recently have data become available to suggest the ranges from a driven pile at which injury may occur (Halvorsen et al., 2011).

5.1. NON-AUDITORY PHYSIOLOGICAL EFFECTS OF EXPOSURE TO INTENSE SOUNDS

Non-auditory physiological effects from exposure to intense sounds generally result from rapid and substantial expansion and contraction of the air bubble walls within fishes (such as the swim bladder or air bubbles in the blood) that strike against nearby tissues or from air bubbles within the blood bursting or expanding and damaging tissues (Stephenson et al., 2010). The actual nature of non-auditory

[9] Note: There is mortality associated with explosive devices, but this is outside the purview of this Appendix. A discussion of the effects of explosives can be found in Hastings and Popper (2005) and Popper and Hastings (2009b).

physiological effects may range from a very small amount of external bleeding to small internal bleeding to substantial hemorrhage of tissues (such as kidney or liver), rupture of the swim bladder, occlusion of gills, and other organ damage (see Stephenson et al. [2010] and Halvorsen et al. [2011, 2012a,b] for a discussion of the range of potential effects).

There are several potential (and overlapping) consequences of non-auditory physiological effects. One possibility is that the effects heal, and there is no lasting consequence. Alternatively, even if the physiological effect has no direct consequences per se, it is possible that it leads to temporary decreased fitness of the animal until the damage is healed. This could result in the animal being subject to predation, less able to find food, or other consequences that result in death.

Secondly, the effect could result in delayed mortality from events such as continuous bleeding or disruption of tissues (e.g., spleen or liver). Or, the tissue damage itself may not be life threatening, but it may become infected and potentially result in death.

There are few quantified and reliable data on effects of exposure to high intensity sound on body tissues. There are a number of studies showing no tissue damage as a result of exposure of several different species to sonar (Kane et al., 2010), seismic devices (Song et al., 2008), and pile driving (Caltrans, 2010a,b). However, in each of these studies, the swim bladder in the fishes may not have been filled with air, and this could have resulted in less likelihood of damage as compared to situations where the swim bladder is filled with its normal mass of air (Halvorsen et al., 2011, 2012a,b; Casper et al., 2012a).

The only quantifiable study documenting a range of physiological effects on fishes comes from exposure of Chinook salmon and several other species to 960 or 1,920 strikes of simulated pile driving sounds (Halvorsen et al., 2011, 2012a,b; Casper et al., 2012a) at a static pressure of 1 atm. These studies demonstrate that effects are graded, with what is likely to be minimal peripheral bleeding at the lowest (but still very intense) sound exposures (207 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum} or higher, depending on the species) to significant bleeding and tissue rupture at the very highest levels presented in the study (219 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum}). Importantly, fish held for a period of time post-exposure showed complete recovery from most of the effects, although the investigators are very careful to point out that recovery took place in a lab tank where fish with slightly lowered fitness would not be subject to predation or disease as may happen in the wild (Casper et al., 2012a).

It is of particular interest that approximately the same sound exposure levels are required for the start of physiological effects (onset of injury) in species that are widely different taxonomically and in morphology (Casper et al., 2012a; Halvorsen et al., 2012a,b). For example, even though there are substantial differences in body shape and overall morphology between Nile tilapia, hybrid striped bass, and lake sturgeon, all three species show the first onset of (revoverable) physiological effects at about 207 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum}. Moreeover, the hogchoker, a flatfish without a swim bladder, showed no effect from exposure to sounds as high as 216 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum}, the sound level that resulted in mortal injuries in the other species (Halvorsen et al., 2012b). Indeed, by showing no effect in a species without a swim bladder, these studies provide evidence that the major effects in fishes from high intensity sound sources is from the presence of air bubbles, such as the swim bladder, as discussed above.

Indeed, the overall impact on fishes in an ecosystem is low, as only a very small fraction of the fish population will likely be close enough to an intense source to be subject to immediate mortality. The open issues may be (a) injury that can lead to delayed mortality and (b) behavioral effects that lower fitness (e.g., move from migratory routes, leave food sites, and masking of biologically important sounds).

5.2. AUDITORY EFFECTS OF EXPOSURE TO INTENSE SOUNDS

Several studies have examined effects of high intensity sounds on the ear. While there was no effect on ear tissue in either the SURTASS LFA study (Popper et al., 2007) or in the study of effects of seismic airguns on hearing (Popper et al., 2005; Song et al., 2008), three earlier studies suggested that there may be some loss of sensory hair cells resulting from exposure to high intensity sources. However, none of these studies concurrently investigated effects on hearing. Enger (1981) showed some loss of sensory cells after exposure to pure tones in the Atlantic cod (*Gadus morhua*). A similar result was shown for the lagena of the oscar (*Astronotus oscellatus*), a cichlid fish, after an hour of continuous exposure (Hastings et al., 1996). In neither study was the hair cell loss more than a relatively small percentage of the total sensory hair cells in the hearing organs. And, in neither case was the sound anything like the high intensity sources of concern today.

Most recently, McCauley et al. (2003) showed loss of a small percentage of sensory hair cells in the saccule (the only end organ studied) of the pink snapper (*Pagrus auratus*), and this loss continued to increase (but never to become a major proportion of sensory cells) for up to at least 58 days post-exposure. This hair cell loss or the ones in the Atlantic cod or oscar would not necessarily have resulted in hearing loss since fishes have tens or even hundreds of thousands of sensory hair cells in each otolithic organ (Popper and Hoxter, 1984; Lombarte and Popper, 1994), and only a small portion were affected by the sound. The question remains as to why McCauley et al. (2003) found damage to sensory hair cells while Popper et al. (2005) did not. The difference in results may very well be associated with differences in species, precise sound source, spectrum of the sound, and sound propagation effects. For example, the Popper et al. (2005) study was in relatively shallow water with poor low-frequency propagation, therefore, the spectrum of sound is likely to have been very different than in the McCauley et al. (2003) study (Hastings, 2009).

One question that arises in the McCauley study is the continued damage to sensory cells after 58 days and whether this would indicate that there was permanent hair cell damage and hearing loss. Since the tissue sampled at each time interval in this study were from different fish, it is impossible to know if the dead cells on Day 58 had been replaced by newly formed cells and what was seen as damage was scar tissue or if the cells that died post-exposure were not replaced. However, based on the considerable data demonstrating hair cell replacement and addition in many fish species, it is likely that even if the cells that were damaged did not get replaced, the high rate of sensory cell proliferation in fishes would have compensated for the small number of lost hair cells (e.g., Corwin, 1981; Popper and Hoxter, 1984; Lombarte and Popper, 1994, 2004).

6. EFFECTS OF ANTHROPOGENIC SOUNDS ON BEHAVIOR

Perhaps the biggest issue with regard to effects of anthropogenic sound is the potential effects on fish behavior. Some potential effects can be suggested based on studies of masking and TTS (see **Section 4**). However, whether TTS or masking actually impacts behavior or whether other behaviors are affected by anthropogenic sound (e.g., leaving a feeding area, changes in migratory paths) is very difficult to study and can only be studied using wild animals in the open water. While investigators have, from time to time, suggested that behavior can be predicted based on responses to sound in tanks, small cages, or larger enclosures, there is always the question as to whether these behaviors are the same as would be encountered in fishes in the wild whose responses were restricted by only their being able to move limited distances. As will be discussed below, there are a few studies that give some suggestion as to the potential responses of wild fishes to sound sources.

However, before discussing those results, it is critical to appreciate the complexities associated with understanding responses of fishes to increased ambient noise and/or the presence of intense sound sources. In fact, fishes may (or may not) show behavioral responses to a sound, and, if a response occurs, the nature of the response may vary widely. It is equally important to note that the nature of a response (or whether there is a response at all) varies depending on the type of signal heard as well as on the motivation of the fishes to respond, the experience of the fishes in the presence of a particular sound or to sounds in general, the age of a fish, and many other factors. Thus, predicting behavior is not simply correlating sound level or type with a behavior and assuming this behavior will show up every time that sound occurs. Instead, a fish may respond to a sound at one time but not at another and the response may be predicated on what the fish is otherwise doing when the sound is presented. Therefore, a fish that is mating may be less likely to respond to an anthropogenic sound than a fish that is simply swimming around, and a fish that has heard the same sound multiple times and does not associate danger with it may not respond, whereas a fish that hears the sound for the first time may respond.

The difficulty of predicting behavior is documented not only in the data on fishes but also from data on hearing for amphibians, birds, and mammals (including humans). These data show, in general, that as sound levels in the environment increase, animals tend to respond in different ways, which often vary depending on the nature of the sound source and sound level as well as on the behavioral state of the animal (e.g., what it is doing) when the sound level changes. Responses of animals vary widely (reviewed in Brumm and Slabbekoorn [2005]). These may include movement from the area of maximum sound level, as shown for several fish species (Engås et al., 1996; Slotte et al., 2004), to changing the intensity of calls so they can be heard over the background sounds (Bee and Swanson, 2007) or changing the spectrum of the emitted sounds so they are no longer masked, as has been shown in a variety of species (Brumm and Slabbekoorn, 2005; Dooling et al., 2009; Parris et al., 2009; Laiolo, 2010; Slabbekoorn et al., 2010).

It is also critical to note that animals (and humans) generally do not respond to sounds when the sounds are just detectable (whether there is background sound or not). Sounds generally have to be well above the minimal detectable level in order to elicit behavioral responses[10]. At the lowest sound levels, the animal may simply ignore the sound since it is deemed "not important" or from too distant of a source. It is only at higher levels where the animal becomes "aware" of the sound and may make a decision that it is important or not to behaviorally respond. To put it into terms of masking, it is possible that the sound has to be sufficiently above the masked threshold of detection for the animal to be able to resolve the signal within the noise and recognize the signal as being of biological relevance.

By way of example, in an experiment on responses of American shad to sounds produced by their predators (dolphins), it was found that if the predator sound is detectable but not very loud the shad will not respond (Plachta and Popper, 2003). But, if the sound level is raised by about 8 or 10 dB, the American shad will turn and move away from the sound source. Finally, if the sound is made even louder, as if a predator were nearby, the American shad go into a frenzied set of motions that probably helps them avoid being caught. It was speculated by the researchers that the lowest sound levels were recognized by the American shad as being from very distant predators and, thus, not worth a response. At somewhat higher levels, the American shad recognized that the predator was closer and started to swim away. Finally, the loudest sound was thought to resemble a very nearby predator, eliciting maximum response to avoid predation.

At the same time, there is evidence from a recent study in Norway (Doksaeter et al., 2009) that fishes will only respond to sounds that are of biological relevance to them. Doksaeter et al. (2009) showed no responses at all from free-swimming herring (*Clupea*) when exposed to sonars produced by naval vessels. Similarly, sounds at the same received level that had been produced by major predators of the herring (killer whales) elicited strong flight responses.

Significantly, the sound levels received by the fishes from the sonar in this experiment were from 197-209 dB (rms) re 1 µPa at 1-2 kHz. In this frequency range, the hearing threshold for herring that are most closely related to those used in the Doksaeter et al. (2009) study is about 125-135 dB re 1 µPa (Mann et al., 2005). This means that the fish showed no reactions to a sound that is biologically irrelevant even though the sound was up to 84 dB above the fish's hearing threshold (209 dB sonar versus 120 dB threshold).

It is likely that responses from fishes to any noise source, including pile driving, will show gradations in responses similar to the American shad. Therefore, fish responses can be seen as being in several sequential steps (see also **Figure J-2**):

- Fishes do not hear the sound (it is too low and/or masked).
- The sound is at a higher level detectable to the fish, but it is sufficiently low that the sound is "dismissed" as not being biologically relevant or important.
- The sound is somewhat higher above threshold, but the fish cannot discriminate it from the ambient sounds and so still does not respond (e.g., informational masking).
- The sound is clearly audible to the fish and recognizable, but the fish does not respond or makes only an initial, small response (e.g., startle) and then returns to whatever it was doing. In addition, after multiple presentations of the sound, the fish may decide that the sound is not biologically important, and the animal habituates and no longer shows a startle response.
- Sound is even louder, and the fish recognizes it as something that may be biologically relevant and may change behavior (e.g., swim away or change swimming course). But, when the sound ends or after the fish habituates to the sound, the animal returns to what it was doing.
- The fish may totally avoid the very loudest signals if they perceive it as being potentially "harmful" and permanently change location or migratory pattern.

[10] Of course, there are exceptions. A parent will respond to the lowest sound produced by their newborn child, and a person walking down a very dark street at night will probably respond to sounds of scraping feet even if they are very quiet.

6.1. FISH CATCH AND ANTHROPOGENIC SOUND

Several studies have demonstrated that human-generated sounds may affect the behavior of at least a few species of fishes. Engås et al. (1996) examined movement of fishes during and after a seismic airgun study by determining catch rate of haddock (*Melanogrammus aeglefinus*) and Atlantic cod as an indicator of fish behavior. These investigators found a significant decline in catch rate of both species that lasted for several days after termination of airgun use. Catch rate subsequently returned to normal. The conclusion was that the decline in catch rate resulted from the fish moving away from the fishing site as a result of the airgun sounds. However, the investigators did not actually observe behavior, and it is possible that the fish just changed depth. Another alternative explanation is that the airguns actually killed the fish in the area, and the return to normal catch rate occurred because of other fishes entering the fishing areas.

More recent work from the same group (Slotte et al., 2004) showed parallel results for several additional pelagic species, including blue whiting and Norwegian spring spawning herring[11]. However, unlike earlier studies from this group, the authors used fishing sonar to observe behavior of the local fish schools. They reported that fishes in the area of the airguns appeared to go to greater depths after the airgun exposure. Moreover, the abundance of animals approximately 30-50 km (18.6-31.1 mi) away from the ensonification increased, suggesting that migrating fish would not enter the zone of seismic activity.

Similarly, Skalski et al. (1992) showed a 52 percent decrease in rockfish (*Sebastes* sp.) catch when the area of catch was exposed to a single airgun emission at 186-191 dB re 1 µPa (mean peak level) (see also Pearson et al. [1987, 1992]). They also demonstrated that fishes would show a startle response to sounds as low as 160 dB, but this level of sound did not appear to elicit a decline in catch.

Culik et al. (2001) conducted a very limited number of experiments to determine catch rate of herring (*Clupea harengus*) in the presence of pingers producing sounds that overlapped with the frequency range of herring hearing (2.7-160 kHz). They found no change in catch rate in gill nets with or without the higher frequency sounds (>20 kHz) present, although there was an increase in catch rate with the signals from 2.7-19 kHz (a different source than that of the higher frequency). The results could mean that the fish did not "pay attention" to the higher frequency sound or that they did not hear it, or that lower frequency sounds may be attractive to fish. There were no behavioral observations to document how the fish actually responded when they detected the sound.

Most recently, Løkkeborg et al. (2012) repeated the earlier study using a somewhat different approach, and the results were different from those found initially. There was some suggestion that the fish in this study did not respond to the seismic sounds in these studies, but comparisons are hard to make because of substantial experimental differences. However, what these results do suggest is that understanding and predicting effects of sound on fishes will not be simple, and that there are many factors that come into play in trying to understand fish behavior.

6.2. OTHER BEHAVIORAL STUDIES

There have been a variety of other behavioral studies, none of which provide conclusive evidence that fishes will or will not respond to a particular sound source. For example, Wardle et al. (2001) used a video system to examine the behaviors of fishes and invertebrates on a coral reef in response to emissions from seismic airguns that were carefully calibrated and measured to have a peak level of 210 dB re 1 µPa at 16 m (164 ft) from the source and 195 dB re 1 µPa at 109 m (357.6 ft) from the source. They found no substantial or permanent changes in the behavior of the fishes or invertebrates on the reef throughout the course of the study, and no animals appeared to leave the reef. There was no indication of any observed damage to the animals.

Mueller-Blenkle et al. (2010) examined responses of several penned Atlantic Ocean species to sounds recorded from pile driving, but results were equivocal and could not be used to predict responses of fishes to pile driving. Indeed, responses levels were low, and fishes showed some acclimation to the sounds, suggesting (though not proving) that fishes might learn to ignore high levels of anthropogenic sound over time.

[11] Scientific names for neither species were given in publication.

A study by Jorgenson and Gyselman (2009) may provide some insight into how fishes would behave in response to intense anthropogenic sounds[12]. The authors exposed fishes in the Mackenzie River (Northwest Territories, Canada) to seismic airguns and using sonar observed the movements of the fishes. The goal was to determine if a seismic survey, using high intensity sounds for long periods of time, could impact behavior by changing migratory patterns of fishes.

The investigators could not determine the species observed by sonar, but based on known river inhabitants, they suggest that there were a variety of species present, including those used by Popper et al. (2005)[13]. While results may be limited to one or two species, the investigators found that free-swimming fishes observed with sonar showed no response to the airguns with respect to changes in swimming direction or speed, even when sound exposure levels (single discharge) were on the order of 175 dB re 1 $\mu Pa^2 \cdot s$ and peak levels of over 200 dB re 1 µPa.

Finally, Sarà et al. (2007) used divers to observe the behavioral responses of bluefin tuna (*Thunnus thynnus*) in large in-ocean cages (approximately 70 m [230 ft] square opening and 30 m [98 ft] deep) to noise from passing boats. The results showed that the tuna schools would change depth and some swimming patterns in the presence of sounds from approaching ferries and hydrofoils (normal transport in the region of the cages) and exhibit various other types of behavior in response to sounds from small boats. While these results are potentially of interest in suggesting that at least bluefin tuna may be disturbed by vessel noise, the authors did not provide sound levels received at the fish. Moreover, the fish used are a large oceanic pelagic schooling species (weight of 40-54 kg [88-119 lb] in this study) and the results may not necessarily apply to other species.

7. PRESSURE VS. PARTICLE MOTION

Of growing interest is the question as to whether the particle motion component of a sound field will affect fishes (including sharks and rays), invertebrates, and possibly even sea turtles in ways similar to that of sound pressure. This issue was raised recently at the BOEM Workshop on Effects of Sound on Fish, Fisheries, and Invertebrates (Normandeau Associates, Inc., 2012[14]). The concern is that many fishes and all invertebrates are likely to detect particle motion. And, since all sound sources produce particle motion as well as sound pressure, it is possible that this component of the sound field needs additional consideration, at least with respect to potential behavioral effects.

It is necessary to consider potential effects of particle motion in terms of both behavioral effects (through hearing) and physiological effects on auditory and non-auditory tissues. In effect, the issues for particle motion are no different than for pressure. For both pressure and particle motion, behavioral effects will occur only if the signals are detected (heard!) by the animal. In contrast, even if an animal cannot detect pressure and/or particle motion, there still could be an effect resulting from the signal producing motion of any air bubbles in the animal body and thereby causing damage to nearby tissues.

Very little is known about sound detection in invertebrates (see Normandeau Asssociates, Inc., 2012). Indeed, while some marine invertebrates have sensory receptors that resemble hearing organs (e.g., cephalopods), others do not (see literature synthesis in Normandeau Associates, Inc., 2012 for a review). It will, therefore, be very important to do studies of detection of particle motion in invertebrates.

While we know that fishes can detect particle motion, there are few data on particle motion detection capabilities. This is because most studies of fish hearing to date have focused on pressure since it is far easier to make these measurements than to measure particle motion. Indeed, even now there are few easily available and usable instruments that enable calibration of particle motion in tanks or in the field. As a consequence, even species that are likely to primarily detect particle motion have only been tested for hearing in terms of sound pressure.

The other issue is whether higher intensity particle motion signals, and accompanying higher magnitude pressures, could have physiological effects on fishes and invertebrates. This can, presumably, occur even if the animals cannot "hear" the signal since effects of high intensity signals may result in changes in the volume of air bubbles in the body cavity, and such changes might affect nearby tissues (**Sections 1.4** and **5.1**).

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[12] It should be noted that this study was done on fish in a river, and it is not clear how applicable results would be to fishes in a marine environment and, thus, in a much larger expanse of water in which they can move around.

[13] The Jorgenson and Gyselman study was conducted just after the Popper et al. (2005) investigation and so it is highly likely that the same species, plus additional species, were in the Mackenzie River at the time.

[14] The literature survey in Normandeau (2012) was written by Drs. Anthony Hawkins and Arthur Popper.

In considering potential effects of the particle motion accompanying high intensity sounds on fishes and invertebrates, it is important to consider one aspect of the physics of sound in water. That is, while both pressure and particle motion are produced by a sound source, the particle motion attenuates more rapidly as it leaves the source than does pressure (e.g., Rogers and Cox, 1988). Thus, after a relatively short distance (within one wavelength of the sound), particle motion has attenuated substantially, and it continues to decline at a rapid rate with distance from the source. This means that any effect as a result of exposure to particle motion (as well as its detection) is very likely to only occur very close to a source. Thus, while particle motion is important to many species for hearing, the distance from a source over which particle motion may potentially be damaging will be substantially smaller than for pressure.

While this means that the potential detection and impacts of particle motion are only likely to occur close to a source, it is also important to understand that the actual effect may take place over much greater distances if the source puts energy into the substrate (e.g., pile driving, seismic airguns). In such cases, significant energy may propagate through the substrate and enter the water column at some distance from the source. Such a signal would radiate from the substrate, which acts as a secondary source, as both pressure and particle motion. While particle motion would again attenuate rapidly as the signal propagates from the substrate, animals living close to (or in) the substrate would likely detect the particle motion signal (even if they cannot detect pressure). There are no data to indicate if and how such a signal could have any effect on animals, but it is clear that the level of energy that would enter the water column from the substrate is very likely to be sufficiently low, both in pressure and particle motion, so it could not result in physiological effects. Moreover, since most particle motion detecting species (including elasmobranchs and invertebrates) have no air chambers, it is highly likely there would be no physiological effect.

The conclusions regarding particle motion are as follows: (a) more data are needed about whether it is detected by marine animals; (b) more needs to be known about behavioral responses to particle motion signals and whether such signals can "mask" detection of biologically relevant signals and/or alter behavior; (c) it is unlikely that particle motion would have the potential to result in physiological effects on any species unless they are very close to a source where accompanying high magnitude pressures would present a greater risk of injury; and (d) any effects from particle motion are likely to decline very rapidly even at short distances from a source. At the same time, it must be realized that as long as an animal has an air bubble, there is the potential for non-auditory tissue effects from high intensity pressure signals even if the animal cannot "hear" the pressure signal.

8. OTHER ISSUES WITH REGARD TO EFFECTS OF ANTHROPOGENIC SOUNDS

8.1. STRESS

Although an increase in background sound may cause stress in humans[15], there have been few studies on fishes (e.g., Smith et al., 2004b; Remage-Healey et al., 2006; Wysocki et al., 2006, 2007). There is some indication of physiological effects on fishes, such as a change in hormone levels and altered behavior, in some (Pickering, 1981; Smith et al., 2004a,b) but not all species tested to date (e.g., Wysocki et al., 2007). Sverdrup et al., 1994 found that Atlantic salmon subjected to up to 10 explosions to simulate seismic airguns released primary stress hormones, adrenaline and cortisol, as a biochemical response. There was no mortality. All experimental subjects returned to their normal physiological levels within 72 hr of exposure. Since stress affects human health, it seems reasonable that stress from loud sound may impact fish health, but available information is too limited to adequately address the issue.

8.2. EGGS AND LARVAE

An additional area of concern is whether high intensity sounds may have an impact on eggs and larvae of fishes. Eggs and larvae do not move very much and so must be considered as a stationary object

[15] The data here are very complex, and there are many variables in understanding how sound may stress humans or any animal. The variables include sound level, duration, frequency spectrum, physiological state of the animal, and innumerable other factors. Thus, extrapolation from human stress effects to other organisms is highly problematic and should be done with only the most extreme caution.

with regard to a moving sound source. Thus, the time for impact of sound is relatively small since there is no movement relative to the vessel.

There have been a few studies on effects of sound on eggs and larvae (reviewed extensively in Popper and Hastings, 2009b), and there are no definitive conclusions to be reached. At the same time, many of the studies have used non-acoustic mechanical signals such as dropping the eggs and larvae or subjecting them to explosions (e.g., Lagardère, 1982; Jensen and Alderdice, 1983, 1989; Dwyer et al., 1993). Other studies have placed the eggs and/or larvae in very small chambers (e.g., Banner and Hyatt, 1973) where the acoustics are not suitable for comparison with what might happen in a free sound field (and even in the small chambers, results are highly equivocal). A few studies of the effects of high energy sounds on eggs and larvae of invertebrates also provided no definitive evidence of damage, but, like for vertebrates, there are insufficient studies to reach firm conclusions as to the effects of sounds on invertebrates (Lagardère and Régnault, 1980).

Several studies did examine effects of sounds on fish eggs and larvae, and, in all cases, there were no observed effects on normal survival or hatching, including with the use of sounds that mimic those produced by seismic airguns (e.g., Kostyuchenko, 1972). In contrast, Booman et al. (1996) investigated the effects of seismic airguns on eggs, larvae, and fry of different larval stages of cod (*Gadus morhua*), saithe (*Pollachius virens*), herring (*Clupea harengus*), turbot (*Psetta maximus*), and plaice (*Pleuronectes platessa*) in field experiments. They exposed fishes to sound source with peak sound pressure levels, 220-242 dB re 1 μPa^2, and found significant mortality, but only when the specimens were within about 5 m (16.4 ft) of the source. The most substantial effects were to fishes that were within 1.4 m (4.6 ft) of the source. While the authors suggested damage to some cells, such as those of the lateral line, few data were reported, and the study is in need of replication. Moreover, it should be noted that the eggs and larvae were very close to the airgun array; at such close distances, the particle velocity of the signal would be exceedingly large. However, the received sound pressure and particle velocity were not measured in this study.

Jørgensen et al. (2005) examined effects of high intensity pure tones from 1.5-6.5 kHz on the survival and behavior of larval and juvenile fishes of several species placed in small plastic bags. The study used herring (*Clupea harengus*) (standard lengths 2-5 cm [0.8-1.9 in]), Atlantic cod (*Gadus morhua*) (standard length 2-6 cm [0.8-2.4 in]), saithe (*Pollachius virens*) (4 cm [1.6 in]), and spotted wolffish (*Anarhichas minor*) (4 cm [1.6 in]) at different developmental stages. Both tissue pathology and survival were studied in response to sounds from 150-189 dB, and the only effects found were 20-30 percent mortality in one group of herring larvae at the highest sound levels, but this was not replicated.

In a follow-up unpublished analysis of these data, Kvadsheim and Sevaldsen (2005) sought to understand whether the mid-frequency continuous wave (CW) signals used by Jørgensen et al. (2005) would have a significant impact on larvae and juveniles exposed to this sonar in the wild. The investigators concluded that the extent of damage/death induced by the sonar would be below the level of loss of larval and juvenile fishes from natural causes, and so no concerns should be raised. The only issue they did suggest that needs to be considered is when the CW signal is at the resonance frequency of the swim bladders of small clupeids. If this is the case, the investigators predict (based on minimal data that are in need of replication) that such sounds might increase the mortality of small clupeids that have swim bladders that would resonate.

Most recently, a group in the Netherlands exposed larvae of common sole (*Solea solea*) to simulated pile driving sounds in an apparatus that is very similar to that used by Halvorsen et al. (2011, 2012a,b) for larger fish (de Jong et al., 2011; Bolle et al., 2012). The larvae of different stages were exposed to sound with SEL_{cum} of up to 206 dB re 1 $\mu Pa^2 \cdot s$ without any effect on fish mortality. In other words, there were no differences in mortality between fish exposed to the simulated pile driving sound and fish that served as controls. The authors did not, however, look at effects on fish tissue or larval growth, and it is possible that either or both of these would have shown an effect of sound exposure.

8.3. INVERTEBRATES

One question that is difficult to answer is the potential effect of high intensity sounds on invertebrates (e.g., crabs and cephalopods). There are almost no data on hearing by aquatic invertebrates, and the few suggestions of hearing indicates that it is for low frequencies and only to the particle motion component of the sound field (e.g., Mooney et al., 2010; also see review in the literature synthesis in Normandeau Associates, Inc., 2012). There are few data indicating if and how invertebrates may use sound in behavior, although a number of species make sounds and so, presumably, use such sounds for communication (e.g., Budelmann, 1992; Popper et al., 2001). However, there are no data that indicate whether masking occurs in invertebrates or suggest whether sounds from construction would have any impact on invertebrate behavior. The one available study on effects of seismic exploration on shrimp suggests no behavioral effects at sound levels with a source level of about 196 dB re 1 µPa rms at 1 m (Andriguetto-Filho et al., 2005).

There are also no substantive data on whether the high sound levels of any anthropogenic sound would have physiological effects on invertebrates. The only potentially relevant data are from a study on the effects of seismic exploration on snow crabs on the east coast of Canada (Boudreau et al., 2009). The preponderance of evidence from this study showed no short-term or long-term effects of seismic exposure in adult or juvenile animals or on eggs. Indeed, as discussed in **Section 5.1**, in order for there to be physiological effects of intense sounds (pressure or particle motion), the animal must have air bubbles (either in the blood or in air chambers) or some other potentially resonate structure that would be set into motion by the signal. Unless such resonating structures are present, the likelihood of physiological effects are probably low (though this has yet to be studied).

Two other studies are important to mention, but only because the results are likely to be referenced. It is important to note that both have substantial problems that make them scientifically unsound. An unpublished study by Guerra et al. (2004) suggested that there was damage to body tissues in squid that had possibly been exposed to high intensity naval sonars. However, there is no evidence that the animals were exposed to sonar (only an inference). Moreover, there were no controls for the tissues, and all of the animals had died well before they were accessed by the investigators. During this time, it is highly likely that the tissue went through normal degenerative processes; therefore, it is impossible to know if the damage suggested was from anything other than normal tissue decay. It is also important to note that this work, while in the news, was never published in the scientific literature and that the histological analysis of the tissue has not been made available for examination by other experts.

The second study by André et al. (2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Illex coindetii*) in a tank to sounds and then, after sacrifice of the animals, examined the statocysts (which are the ears of cephalopods). The authors show that there is some tissue degeneration, and they suggested that the sounds to which the animals were exposed caused the damage. However, there are very substantial problems with this study that open the results, and conclusions, to serious question.

First, the only controls provided were never subject to the same handling as the experimental animals. The only controls should be animals and tissues exposed to precisely the same conditions and procedures as the experimental other than for the variable in question, in this case the sound. However, this was not done in this study, and so it is very reasonable to suggest that the overall treatment of the experimental animals, including handling, being placed and maintained in the test tank, etc. could have been the cause of any effects noted.

Second, cephalopods, even as indicated by the authors, are detectors of particle motion (just like fishes that do not have specializations to couple an air bubble to the ear). The signals to which the cephalopods were exposed were measured in pressure (something that the animals do not detect), and there was no measurement of particle motion. Since the exposure was done in a tank with relatively flexible walls, it is impossible to estimate the particle motion from pressure measurements. Thus, nothing in this experiment can relate the sound levels and any damage to the statocysts, even if the damage seen was related to the sounds.

Third, to generalize about invertebrates, it is important to note that the lack of any air bubbles (such as the fish swim bladder) that would be set in motion by high intensity sounds leads to the suggestion that there would be little or no impact of high intensity sounds on invertebrates (although, like fishes, if the invertebrates are very close to the source, the higher magnitude pressure wave from the source might have a general impact on survival).

Finally, the authors exposed the animals to sound for 2 hr, which is far longer than any exposure in the wild where the anthropogenic sources of concern, such as sonar and seismic airguns. These are generally moving sources, thus they would expose a slower moving (or stationary) animal for just a few minutes (if not less) rather than 2 hr.

8.4. VESSEL NOISE AND FISH

A growing concern with regard to increases in anthropogenic noise comes from the increasing number of commercial ships that are found over large geographic areas as well inshore and the increasing number of small pleasure craft found inshore and in harbors. All vessels produce sound as a by-product of their operation, which is generally below 1 kHz. Source levels of vessels can range from <150 dB re 1 µPa to over 190 dB for the largest commercial vessels (Richardson et al., 1995; Hildebrand, 2009).

Vessel noise produces sounds in the general hearing range of fishes (Amoser et al., 2004). Continuous exposure (30 min) to boat noise has been shown to increase fish cortisol levels (stress response) (Wysocki et al., 2006). Temporary threshold shift has been associated with long-term, continuous exposure (2 hr), and masked hearing thresholds have also been recorded for fishes exposed to noise from small boats and ferries (Scholik and Yan, 2001; Vasconcelos et al., 2007). Additionally, vessels (i.e., trawlers, ferries, small boats) can change fish behavior (e.g., induce avoidance, alter swimming speed and direction, and alter schooling behavior) (Sarà et al., 2007). Studies do not indicate precisely which of these kinds of physical or behavioral effects may result from a single ship or from an aggregation of shipping activity, although it is important to bear in mind that the large number of commercial vessels, their nearly continuous presence in many nearshore areas, and projected increases in shipping trends. One of the most serious implications of this increase in shipping noise is the impact it may have in terms of masking sounds of biological origin and affecting communication between fishes.

The sounds produced by motor-driven ships causes herring to dive and swim away from the vessel (Mitson and Knudsen, 2003). Paradoxically, research vessels specially designed to reduce noise can result in an even greater behavioral reaction (Ona et al., 2007). Sand et al. (2008) have pointed out that passing ships produce high levels of infrasonic and low-frequency noise (>10-1,000 Hz), and that infrasonic frequencies may be responsible for the observed avoidance reactions.

9. GENERAL CONCLUSIONS – EFFECTS

The data obtained to date on effects of sound on fishes are very limited both in terms of the number of well-controlled studies and in the number of species tested. Moreover, there are significant limits in the range of data available for any particular type of sound source. While new data have become available on physiological effects of very intense pile driving (Halvorsen et al., 2011, 2012a,b; Casper et al., 2012a) and these data may be carefully extrapolated to other sound sources and species, the data are still very limited and comparable data are needed for other sources and species.

At the same time, physiological effects are probably not the major issue with regard to anthropogenic sound since most fishes will not be close enough to a sound source, and thereby exposed to high intensity sound, to show such effects. Instead, the biggest issues are related to effects on behavior since anthropogenic sources could, potentially, impact behavior of fishes over broad areas. Consideration of behavioral response to sound is complicated by needing to know more about not only the behavioral response to sound, but also the consequences in terms of the well being of affected fish of any observed behavioral responses. Yet, despite this clear need for understanding of behavioral effects, the extent of data is exceedingly limited and equivocal; it is not yet possible to make clear statements about effects of any particular sound source on the behavior of any species and the consequences of observed behavioral responses.

The following sections briefly review and comment on the effects discussed earlier in this report. At the same time, it should be noted that after examining the complete literature on effects of sound on fishes (and turtles), an international panel of experts reached the conclusion that there are insufficient data to reach conclusions for most any sound source[16].

9.1. PHYSIOLOGICAL EFFECTS

Several general points can be made with reference to effects on fish physiology and mortality of intense sounds.

[16] This panel was co-chaired by Drs. Arthur Popper and Richard Fay, and a report is in preparation. The work was done under the auspices of the Standards Group of the Acoustical Society of America and was funded by several U.S. and international agencies and organizations. The report cannot be provided at this point, but will be provided as soon as possible.

1. There is little evidence for immediate mortality other than when fishes are very close to intense sound sources, such as pile driving for very large piles. There are no data on any other sound source. Substantial study needs to be put into questions of immediate mortality.
2. Physiological effects (injury) that are sufficient to potentially kill fishes over time appear to have some correlation with the total energy of sound exposure. A few non-quantified studies have shown no damage to non-auditory tissues as a result of seismic airgun exposure (Popper et al., 2005; Song et al., 2008) or to any tissue after exposure to high intensity low-frequency and mid-frequency sonars (Halvorsen et al., 2006; Popper et al., 2007). A quantified study of pile driving (Halvorsen et al., 2011, 2012a,b; Casper et al., 2012a) demonstrates a range of effects that increase in likely impact on the animals, but the fishes seem to recover from these effects in a few days (Casper et al., 2011a). There are some data that suggest that some seismic airgun signals, under certain acoustic conditions, may damage sensory cells of the ears (McCauley et al., 2003), but that there is no effect on other species under different acoustic conditions (Song et al., 2008).
3. There are very few data documenting effects of any intense sound source on eggs and larvae in the open ocean. Far more data are needed before any preliminary conclusions can be reached on the effects of sound on eggs and larvae, and studies need to include, in addition to mortality, effects on growth and body tissues.
4. It is possible that exposure to loud sounds or increased background noise can result in increased stress levels and effects on the immune system. However, such effects have never been documented for fishes, and the only long-term study (Wysocki et al., 2007) of increased ambient noise showed no effect. It is critical to note that lack of effect may be more a function of not enough study rather than being the actual result. Future studies are needed to ask questions of such effects.

9.2. EFFECTS ON FISH BEHAVIOR

The more critical issue for effects of anthropogenic sound on fishes, however, is the effect on the behavior of wild animals and whether sound exposure will alter the behavior of a fish in a manner that will affect its way of living – such as where it tries to find food or how well it can find a mate. With the exception of just a few field studies, there are no data on behavioral effects, and most of these studies are very limited in scope and all are related to seismic airguns. Because of the limited ways in which behavior of fishes in these studies were “observed” (often by doing catch rates, which tell nothing about how fishes really react to a sound), there really are no data on the most critical questions regarding behavior.

Indeed, the fundamental questions are how fishes behave during and after exposure to a sound as compared to their “normal” pre-exposure behavior. This requires observations of a great number of animals over a large area for a considerable period of time before and after exposure to sound sources as well as during exposure. Only with such data is it possible to tell how sounds affect overall behavior (including movement) of animals. These experiments are very difficult to do, require a large amount of resources, and are very expensive to conduct.

There is growing interest in the behavioral responses of fish to sound, primarily seismic sources, that may affect their catchability, thereby affecting the finances of commercial fishers.

9.3. INCREASED BACKGROUND SOUND

In addition to questions about how fish movements change in response to sounds, there are also questions as to whether any increase in background sound has an effect on more subtle aspects of behavior, such as the ability of a fish to hear a potential mate or predator or to glean information about its general environment. There is a body of literature that shows that the sound detection ability of fishes can be “masked” by the presence of other sounds within the hearing range of the fishes (reviewed in Fay and Megela-Simmons, 1999; Popper et al., 2003). Just as a human has trouble hearing another person as the room they are in gets noisier, it is likely that the same effect occurs for fishes (as well as all other animals). In effect, acoustic communication and orientation of fishes may potentially be restricted by noise regimes in their environment that are within the hearing range of the fishes. Perhaps this is the single most important area for future study since the masking effects of anthropogenic sounds could have a direct impact on the ability of fishes to hear sounds relevant to survival.

10. CURRENT CRITERIA

There is considerable national and international concern about effects of anthropogenic sound on marine organisms, including fishes (see Popper and Hawkins [2012]). However, despite the concerns, there is actually very little in the way of recommendations for regulatory levels of sound. In fact, the only known criteria, which are clearly labeled “interim,” arose on the U.S. West Coast out of concern about effects of pile driving on fishes (reviewed in Woodbury and Stadler, 2008; Stadler and Woodbury, 2009). These criteria are for the onset of physiological effects and say nothing about behavior.

The current interim criteria are dual in nature. That is, they state that physiological onset may occur if the peak sound level of a pile driving strike is 206 dB re 1 µPa or have an SEL_{cum} of 187 dB re 1µPa^2-s for fishes above 2 g (0.07 oz) or 183 dB re 1 µPa^2-s for fishes below 2 g (0.07 oz) (for explanation of these criteria, see also Popper et al. [2006] and Carlson et al. [2007]).

The levels for the current interim criteria were substantially criticized as not being based on the best available science at the time of their implementation (see Carlson et al. [2007] for detailed recommendations that were not used in setting the current interim criteria). Presently, based on a wide range of data that arose concurrent or subsequent to the current interim criteria, it is clear that the set levels, at least for cumulative exposure, are far too low and unrealistic for onset of physiological effects.

The inadequacy of the interim criteria has now been documented in the recent quantified study on the effects of pile driving on the onset of physiological effects in Chinook salmon (Halvorsen et al., 2011. 2012a; Casper et al., 2012a) and several other species (Halvorsen et al., 2012b). These studies, which demonstrated that an SEL_{cum} below approximately 207 dB re 1 µPa^2·s will not result in the onset of injury and that SEL_{cum} as high as 210 dB re 1 µPa^2·s produces physiological effects that are inconsequential (e.g., minor external bleeding). These data have been shown to be appropriate for five very different species, suggesting that there may be reasonably broad applicability of these values for setting future interim criteria.

At the same time, these results are only for pile driving. It is not clear which aspect(s) of intense sounds result in physiological onset, but it is likely that the rise time (onset time) of the signal may be of consequence. Thus, signals with slower rise times than pile driving may have even higher onset levels whereas sounds with faster rise times (e.g., from explosives) may have somewhat lower criteria. However, since rise time, peak amplitude, and other signal characteristics are correlated, addition investigation will be needed to conduct studies that can estimate the contribution of each factor on injury risk.

One other factor that must be recognized with these criteria, which is built into the West Coast interim criteria (Stadler and Woodbury, 2009), is recovery time. That is, all tissues, when damaged, start to recover as soon as the stimulus is removed. This has been documented in mammals exposed to intense sounds (reviewed in Popper and Hastings, 2009b), and it is more than likely that the same thing happens for fishes. Indeed, Popper et al. (2005) showed recovery of hearing loss resulting from exposure to seismic airguns within 18 hr of the termination of exposure. Thus, if a fish is exposed to pile driving, the accumulation of exposure (the SEL_{cum}) is returned to zero (0) after 12 hr without exposure (Carlson et al., 2007; Stadler and Woodbury, 2009).

This same restart of accumulation is important for any sound exposure condition. Thus, no matter whether a fish is exposed to pile driving, seismic airguns, sonars, etc., accumulated energy returns to zero after some period of non-exposure.

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APPENDIX K

COOPERATING AGENCY

In Reply Refer To: MS 5410

MAR 18 2011

Ms. Patricia A. Kurkul, Regional Administrator
NOAA Fisheries Service
Northeast Regional Office
55 Great Republic Drive
Gloucester, Massachusetts 01930-2276

Dear Ms. Kurkul:

In accordance with Council on Environmental Quality regulations, 40 CFR 1501.6, the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) inquires whether or not the National Oceanographic and Atmospheric Administration wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (PEIS). We have begun the process of preparing a PEIS for the proposed action of approving geological and geophysical (G&G) activities in the Mid- and South Atlantic Planning Areas. This is a result of direction given in the Conference Report for the FY 2010 Department of the Interior, Environment and Related Agencies Appropriations Act.

Our *Federal Register* Notice of Intent to prepare a PEIS on January 21, 2009 (74 FR 3636), contained a scoping period, but it did not contain the scoping meetings schedule. The proposed G&G activities include, but are not limited to, seismic surveys, sidescan sonar surveys, electromagnetic surveys, geological and geochemical sampling, and remote sensing in support of the program areas under BOEMRE's jurisdiction; i.e., oil and natural gas, renewable energy, and marine minerals.

Our *Federal Register* Notice on April 2, 2010 (75 FR 16832), reopened our scoping process and announced public meetings that were held between April 12 and April 23, 2010, in Portland, Maine; Boston, Massachusetts; Newark, New Jersey; Wilmington, North Carolina; Charleston, South Carolina; Savannah, Georgia; Jacksonville and Fort Lauderdale, Florida; and Houston, Texas. Since scoping meetings were held, the area of interest for the environmental evaluation was reduced to just the Mid- and South Atlantic Planning Areas.

Should you affirm an interest, we will provide to your designated contact a draft schedule for our National Environmental Policy Act evaluation and a draft Memorandum of Agreement for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing by April 25, 2011, to Mr. Gary D. Goeke, Bureau of Ocean Energy Management, Regulation and Enforcement, Gulf of Mexico OCS Region (MS 5410), 1201 Elmwood Park Boulevard, New Orleans, Louisiana 70123-2394, telephone (504) 736-3233, to confirm your participation as a cooperating agency in the preparation of our PEIS and provide a point of contact. Mr. Goeke can also be contacted for further information.

Sincerely,

Orig. Sgd. Lars Herbst

Lars Herbst
Regional Director

Enclosure

cc: Dr. Roy Crabtree, Regional Administrator
NOAA Southeast Regional Office
Southeast Regional Office
263 13th Avenue South
Saint Petersburg, Florida 33701

bc: Associate Director for Offshore Energy and Minerals Management (MS 4230)
Chief, Office of Public Affairs (MS 4230)
J. Bennett, w/o encls (MS 4000)
G. Goeke. w/o encls (MS 5410)
C. Rowe, w/o encls (MS 5410)
102-01a (MS 5410)
ORD Reading File w/o encls (MS 5000)

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In Reply Refer To: MS 5410 **MAR 1 8 2011**

Dr. Roy E. Crabtree, Regional Administrator
NOAA Fisheries Service
Southeast Regional Office
263 13th Avenue South
Saint Petersburg, Florida 33701

Dear Dr. Crabtree:

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Sincerely,

Orig. Sgd. Lars Herbst

Lars Herbst
Regional Director

Enclosure

cc: Ms. Patricia A. Kurkul, Regional Administrator
NOAA Northeast Regional Office
Northeast Regional Office
55 Great Republic Drive
Gloucester, Massachusetts 01930-2276

bc: Associate Director for Offshore Energy and Minerals Management (MS 4230)
Chief, Office of Public Affairs (MS 4230)
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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

APR 25 2011

Mr. Gary D. Goeke
Bureau of Ocean Energy Management,
Regulation and Enforcement
Gulf of Mexico OCS Region (MS 5410)
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

Dear Mr. Goeke,

Thank you for the invitation to participate as a cooperating agency in the development of the Programmatic Environmental Impact Statement (PEIS) to be prepared for the upcoming geological and geophysical (G&G) activities in the Mid- and South Atlantic Planning Areas. It is our understanding that the proposed G&G activities include, but are not limited to, seismic surveys, side scan sonar surveys, electromagnetic surveys, geological and geochemical sampling, and remote sensing. These activities are undertaken in support of programs under the Bureau of Ocean Energy Management, Regulation and Enforcement's (BOEMRE) jurisdiction, including oil and natural gas, renewable energy, and marine minerals.

NOAA Fisheries Service is supportive of a collaborative approach to fulfilling obligations under the National Environmental Policy Act (NEPA), and hereby expresses our interest to participate as a cooperating agency in the review of the PEIS within the limits of our existing staff resources. As the agency with special expertise and jurisdiction by law, NMFS supports BOEMRE's decision to prepare a PEIS for these activities, and expresses its desire to participate as a cooperating agency due, in part, to our responsibilities under sections 101(a)(5)(A) and (D) of the Marine Mammal Protection Act and Section 7 of the Endangered Species Act. We offer this commitment with the understanding that we will meet subsequently to outline a more detailed description of the manner of our coordination and that this commitment does not represent an obligation for authoring written sections of the document.

Future coordination regarding the PEIS should be addressed to our designated point of contacts:

For Habitat Conservation issues:
Patricia Kurkul
Northeast Regional Administrator
National Marine Fisheries Service
55 Great Republic Drive
Gloucester, MA 01930
Pat.Kurkul@noaa.gov

For Protected Resources issues:
Jim Lecky, Director
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910
Jim.Lecky@noaa.gov

We appreciate the opportunity to participate in the early planning phases of this important program. We look forward to establishing this relationship with your agency and working together in the near future.

Sincerely,

Samuel Rauch
Deputy Assistant Administrator for
Regulatory Programs
National Marine Fisheries Service

cc:
Patricia A Kurkul, NMFS NE Regional Administrator
Roy Crabtree, NMFS SE Regional Administrator
Jim Lecky, NMFS Director of the Office of Protected Resources
Jennifer Anderson, NMFS NE Regional NEPA Coordinator
David Keys, NMFS SE Regional NEPA Coordinator
Steve Leathery, NMFS National NEPA Coordinator

Memorandum of Agreement
between
Bureau of Ocean Energy Management
and
National Oceanic and Atmospheric Administration
during completion of a
Programmatic Environmental Impact Statement
for Geological and Geophysical Activities
in the Mid- and South Atlantic Planning Areas

INTRODUCTION

The Bureau of Ocean Energy Management (BOEM) is preparing a Programmatic EIS (PEIS), pursuant to the National Environmental Policy Act (NEPA), for geological and geophysical activities in BOEM's Mid- and South Atlantic Planning Areas. A Notice of Intent to prepare an EIS was published in the *Federal Register* on January 28, 2009, for initial scoping, and a subsequent *Federal Register* Notice was published that scheduled scoping meetings held in April 2010.

The National Oceanic and Atmospheric Administration (NOAA) has authority under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) to engage in consultations on protected species and to review and comment on the BOEM's NEPA evaluations. The BOEM could benefit from special and authoritative expertise residing within the NOAA. Section 1501.6 of the Council on Environmental Quality's regulations emphasizes agency cooperation in the NEPA process between federal agencies either having overlapping jurisdiction or special expertise related to a proposed action.

This Memorandum of Agreement (MOA) is designed to establish expectations between the two agencies that apply for the duration of the EIS project, whereupon it terminates. This MOA outlines the responsibilities agreed to by BOEM and NOAA for this EIS project. This MOA does not affect NOAA's role and responsibilities for consultations under the MMPA. This MOA does not affect BOEM's responsibilities under the Outer Continental Shelf (OCS) Lands Act and regulations under 30 CFR 250.

BOEM RESPONSIBILITIES

1) BOEM is the lead agency for preparation of OCS lease sale EISs,

2) BOEM shall designate a primary point of contact (POC) for matters related to the MOA,

3) BOEM shall have the lead in setting up and holding public hearings for the draft PEIS,

4) BOEM shall provide NOAA a summary of all comments received during preparation of the EIS (Scoping Report), if requested, and the comments received during public review of the draft PEIS,

5) BOEM shall place a copy of the MOA in an appendix to the PEIS,

6) BOEM shall provide NOAA with early versions of the PEIS sections as arranged between the BOEM and NOAA POCs,

7) BOEM shall provide NOAA with a preliminary copy of the draft PEIS for review prior to final lead agency approval and distribution of the document, and

8) BOEM shall respond to all comments received from NOAA.

NOAA RESPONSIBILITIES

1) NOAA is a cooperating agency for preparation of the PEIS,

2) NOAA's responsibilities for any environmental consultations required by law are not affected by this MOA,

3) NOAA shall designate a primary POC to represent NOAA in matters related to this MOA,

4) NOAA shall participate, as they deem appropriate, in the public hearing process,

5) NOAA shall provide BOEM a brief description of NOAA's reason(s) for participating as a cooperating agency for the PEIS,

6) NOAA comments on the draft PEIS submitted outside of the formal agency comment submission shall receive full and due consideration, but may not be made a part of the record,

7) NOAA shall comply with the schedule agreed upon between NOAA and BOEM for PEIS preparation and for all solicited inputs and review periods , and

8) NOAA shall be responsible for any expenses incurred by NOAA related to this MOA.

TERMINATION

The MOA may be terminated by written notice by either of the below signatories at any time. This MOA terminates at the conclusion of the PEIS project.

LIMITATIONS

All commitments made in the MOA are subject to the availability of appropriated funds and each agency's budget priorities. Nothing in the MOA obligates BOEM or NOAA to expend appropriations or to enter into any contract, assistance agreement, interagency agreement, or incur other financial obligations. This MOA is neither a fiscal nor a funds obligation document. Any endeavor involving reimbursement or contribution of funds between the parties to this MOA will be handled in accordance with applicable laws, regulations, and procedures, and will be subject to separate subsidiary agreements that will be effected in writing by representatives of both parties. This MOA does not create any right or benefit enforceable against the BOEM or NOAA, their officers or employees, or any other person. This MOA does not apply to any person outside BOEM and NOAA.

PREDECISIONAL MATERIALS

The undersigned hereby agrees to maintain confidentiality of information and documents shared between NOAA and the BOEM during completion of this PEIS. These confidentiality provisions apply to all communications, including: e-mail messages; notes to the file; agendas, pre-meeting materials, presentations, and meeting notes or summaries; letters, reviews, evaluations, and all documents created and shared as part of the collaboration established in this MOA.

Documents generated or shared in furtherance of this MOA shall be maintained as confidential by the parties. The parties have the right to expressly waive any privilege with regard to such documents and may do so by advising the other party in writing of its decision to waive the privilege.

Alan Thornhill, Ph.D.
Chief Environmental Officer
Bureau of Ocean Energy Management

1/3/12
Date

Samuel Rauch
Deputy Assistant Administrator
for Regulatory Programs
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

12/12/11
Date

Memorandum of Agreement
Between the
Bureau of Ocean Energy Management
And the
Bureau of Safety and Environmental Enforcement

Environmental and NEPA

I. Purpose

This Memorandum of Agreement (MOA) establishes the working relationship of the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE) in order to synchronize the agencies' environmental review and environmental enforcement processes for authorizations required to conduct conventional energy and resource activities on the Outer Continental Shelf (OCS). This MOA is intended to help both agencies minimize duplication of efforts, promote consistency in procedures and regulations, and resolve disputes. A separate, overarching Memorandum of Understanding describes the general relationship between the two bureaus. A series of standard operating procedures (SOPs) describes more specific roles and responsibilities of the two Bureaus and are designed to be updated as dictated by changing practices, law, or technology.

A. The purpose of this MOA is to establish a general framework for the necessary coordination between the agencies to ensure requisite environmental oversight for OCS conventional energy and resource activities under the jurisdiction of BOEM or BSEE.

B. Cooperation between the Bureaus will ensure that each agency's responsibilities under the National Environmental Policy Act (NEPA) and other applicable federal laws, including but not limited to, the Coastal Zone Management Act (CZMA), Endangered Species Act (ESA), Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), Marine Mammal Protection Act (MMPA), National Historic Preservation Act (NHPA), Rivers and Harbors Act (RHA), Migratory Bird Treaty Act, Clean Water Act (CWA) and Clean Air Act (CAA) are met in connection with the issuance of authorizations required to conduct conventional energy and resource activities on the OCS.

C. BSEE will serve as a cooperating agency on BOEM NEPA documents. There is a clear expectation that serving as a cooperating agency where practicable will be the standard protocol for any BOEM NEPA analysis that BSEE may adopt for its decisions. Both Bureaus recognize that BSEE may adopt NEPA analyses prepared by BOEM for proposed OCS conventional energy and resource activities under the jurisdiction of BSEE. However, there may be some circumstances where both agencies will be better served by alternate approaches to NEPA compliance. This MOU does not preclude such arrangements.

D. Both Bureaus also anticipate that certain proposed activities on the OCS authorized solely by BSEE would benefit from consultation and coordination with the robust environmental functions in BOEM.

II. Authorities

Both BOEM and BSEE derive authority to regulate certain activities on the OCS through the Secretary of the Interior. Secretarial Order 3299 assigned BOEM conventional and renewable energy-related management functions, including, but not limited to, activities involving leasing, plans, environmental studies, NEPA analyses, economic and reserves analyses, and geologic risk analyses. BSEE's authority includes, but is not limited to, permitting, environmental compliance, conservation compliance, engineering standards and regulations, oil spill response planning, inspections, enforcement, and investigations. Additionally, both agencies have responsibilities derived from Departmental regulations and delegations of authority issued to implement various statutes, including the Outer Continental Shelf Lands Act, the Clean Air Act, the Oil Pollution Act of 1990, the Energy Policy Act of 2005, and the Gulf of Mexico Energy Security Act of 2006.

A. National Environmental Policy Act of 1969 (42 U.S.C. §4321 et seq.)
NEPA requires all agencies of the federal government to use a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in planning and decision making for actions and activities that may have an impact on man's environment. Prior to making any detailed statement, the responsible federal official shall consult with and obtain the comments of any federal agency that has jurisdiction by law or special expertise with respect to any environmental impact involved.

B. Outer Continental Shelf Lands Act (OCS Lands Act), as amended (43 U.S.C. §1331 *et seq.*). Under this authority, and as delegated by the Secretary of the Interior, BOEM and BSEE administer different aspects of the OCS oil and gas program, with BOEM responsible for oil and gas leasing program and approval of plans that describe how leases will be explored, developed and resources produced; BSEE is responsible for decisions implementing the approved plans and ensuring conservation of the resources. Together, the agencies are charged with ensuring safe and environmentally sound operations.

III. Objectives

This MOA and associated SOPs have several objectives. The functional SOPs for this MOA are:

1. NEPA/Environmental Compliance for APDs

BSEE Objective in the Process:

a. To determine if the Categorical-Exclusion Review (CER), Site-Specific Environmental Assessment (SEA), or Environmental Impact Statement (EIS) prepared on the Exploration Plan (EP), Development Operations Coordination

Document (DOCD), or Development/Production Plan (DPP) associated with the subject Application for Permit to Drill (APD) was adequate, whether Extraordinary Circumstance (EC) may exist (in the case of a CER), and/or if supplemental NEPA analysis is required;

b. To conduct NEPA decision making and the preparation of an associated Determination of NEPA Adequacy (DNA) or CER for adoption of BOEM NEPA analyses and approval of associated APD;
c. To oversee any requisite environmental monitoring needs (i.e., related to protected species requirements, water quality checks, anchoring concerns, air quality inventory issues, etc.); and
d. To ensure that Post-Activity environmental compliance needs are identified, met, and documented.

BOEM Objective in the Process:

a. To assist in any Post-Activity environmental compliance reviews; and
b. To improve site-specific impact reviewing/mitigation development and incorporate compliance efforts into BOEM's programmatic analyses using feedback from BSEE.
c. Prepare NEPA documents in regards to BSEE APDs.

2. Environmental Compliance for 30CFR251/280 G&G Permit Applications

BSEE Objective in the Process:

a. To oversee any requisite environmental monitoring needs (i.e., protected species requirements, anchoring concerns, etc.); and
b. To ensure that Post-Activity environmental compliance needs are met and documented.

BOEM Objective in the Process:

a. To assist in any Post-Activity environmental compliance reviewing; and
b. To improve site-specific impact reviewing/mitigation development and incorporate compliance efforts into BOEM's programmatic analyses using feedback from BSEE.

3. NEPA/Environmental Compliance for APMs/RPMs Proposing Explosive Use

BSEE Objective in the Process:

a. To assist in the coordination of the NEPA review of any Application for Permit to Modify/Revised Application for Permit to Modify (APM/RPM) proposing explosive well severance (i.e., initial BOEM assignments, data gathering, eWell coordination, etc.);
b. To determine if an adequate level of NEPA analysis was conducted (i.e., Site-Specific Environmental Assessment (SEA) in GOMR; possibly SEA or Environmental Impact Statement (EIS) in POCS/AKOCS);
c. To prepare NEPA Decision Making/Preparation of Decision Document (i.e., Finding of No Significant Impact (FONSI) for GOMR; possibly FONSI or Record of Decision (ROD) for POCS/AKOCS) for adoption of BOEM NEPA document and approval of associated APM/RPM; and

d. To conduct any requisite environmental monitoring needs (i.e., related to protected species requirements, anchoring concerns, etc.); and
e. To ensure Post-Activity environmental compliance needs are met and documented.

BOEM Objective in the Process:
a. To conduct the site-specific environmental impact analyses and prepare the appropriate NEPA document (i.e., SEA or EIS) for the respective APM/RPM;
b. To assist in any Post-Activity environmental compliance reviewing; and
c. To improve site-specific resource/impact reviewing efforts and incorporate compliance efforts into BOEM's programmatic analyses using feedback from BSEE.

4. **NEPA/Environmental Compliance For Pipeline Permit Applications (Right-of-Way & Lease Term Pipeline Permits for Installation and/or Modification)**

BSEE Objective in the Process:
a. To assist in the coordination of the NEPA review of all Permit Applications for the installation or modification of Right-of-Way (ROW) or Lease-Term (LT) Pipelines (i.e., TIMS assignments [via coordination reviews], data gathering, etc.);
b. To determine if an adequate level of NEPA analysis was conducted (i.e., a Categorical-Exclusion Review (CER) or Site-Specific Environmental Assessment (SEA) in GOMR; possibly a CER, SEA, or Environmental Impact Statement (EIS) in POCS/AKOCS);
c. To prepare NEPA Decision Making/Preparation of Decision Document (i.e., CER Adoption Memo or Finding of No Significant Impact (FONSI) for GOMR; possibly CER Memo, FONSI, or Record of Decision (ROD) for POCS/AKOCS) for adoption of BOEM NEPA document and approval of the associated Pipeline Permit;
d. To conduct any requisite environmental monitoring needs (i.e., anchoring concerns, etc.); and
e. To ensure that Post-Activity environmental compliance needs are met and documented.

BOEM Objective in the Process:
a. To conduct the site-specific environmental impact analyses and prepare the appropriate NEPA document (i.e., CER, SEA, or EIS) for the respective Permit Application;
b. To assist in any Post-Activity environmental compliance reviewing; and
c. To improve site-specific impact reviewing/mitigation development and incorporate compliance efforts into BOEM's programmatic analyses using feedback from BSEE.

5. **Environmental Compliance For Plans (EPs, DOCDs, and DPPs)**

BSEE Objective in the Process:
a. To oversee any requisite environmental monitoring (i.e., protected species requirements, water quality checks, anchoring concerns, air quality inventory issues, etc.); and

b. To ensure that Post-Activity environmental compliance needs are met and documented.

BOEM Objective in the Process:

a. To assist in any Post-Activity environmental compliance reviewing; and
b. To improve site-specific impact reviewing/mitigation development and incorporate compliance efforts into BOEM's programmatic analyses using feedback from BSEE.

6. NEPA/Environmental Compliance Structure-Installation/Modification/Repair Permits

BSEE Objective in the Process:

a. To determine if the Categorical-Exclusion Review (CER), Site-Specific Environmental Assessment (SEA), or Environmental Impact Statement (EIS) prepared on the Exploration Plan (EP), Development Operations Coordination Document (DOCD), or Development/Production Plan (DPP) associated with the subject Structure Installation or Modification Permit Application was adequate, whether Extraordinary Circumstance (EC) may exist (in the case of a CER), and/or if supplemental NEPA analysis is required;
b. To prepare NEPA Decision Making and the Preparation of an associated Determination of NEPA Adequacy (DNA) or CER for adoption of BOEM NEPA document/site-specific impact analyses and approval of associated APD;
c. To conduct any requisite environmental monitoring needs (i.e., related to protected species requirements, water quality checks, anchoring concerns, air quality inventory issues, etc.); and
d. To ensure that Post-Activity environmental compliance needs are met and documented.

BOEM Objective in the Process:

a. To assist in any Post-Activity environmental compliance reviewing; and
b. To improve site-specific impact reviewing and/or mitigation development and incorporate compliance efforts into BOEM's programmatic analyses using feedback from BSEE.

7. NEPA/Environmental Compliance Structure-Removal Permit Applications

BSEE Objective in the Process:

a. To assist in the coordination of the NEPA review of all Structure-Removal Permit Applications (i.e., TIMS assignments [via coordination reviews], data gathering, etc.);
b. To determine if an adequate level of NEPA analysis (this includes all applicable consultations) was conducted (i.e., Site-Specific Environmental Assessment (SEA) in GOMR; possibly SEA or Environmental Impact Statement (EIS) in POCS/AKOCS);
c. To oversee NEPA Decision Making/Preparation of Decision Document (i.e., Finding of No Significant Impact (FONSI) for GOMR; possibly FONSI or Record of Decision (ROD) for POCS/AKOCS) for adoption of BOEM NEPA document and approval of associated Structure-Removal Permit; and

d. To ensure that any environmental monitoring (i.e., related to protected species requirements, anchoring concerns, etc.) and/or Post-Activity environmental compliance needs are met and documented.

BOEM Objective in the Process:

a. To conduct the site-specific environmental impact analyses and prepare the appropriate NEPA document (i.e., SEA or EIS) for the respective Structure-Removal Permit Application;
b. To assist in any Post-Activity environmental compliance reviewing; and
c. To improve site-specific impact reviewing/mitigation development and incorporate compliance efforts into BOEM's programmatic analyses using feedback from BSEE.

8. Procurement of Environmental Studies Program (ESP) Projects

BSEE Objective in the Process:

a. To provide input to the ESP's annual Studies Development Plan (SDP).
b. To attend and participate in meetings of the Outer Continental Shelf Scientific Committee (OCS SC).
c. To participate in the development and conduct of studies as appropriate to the need and discipline.
d. To receive and use products and results of studies in work products as appropriate.

BOEM Objective in the Process:

a. To prepare the ESP's annual SDP.
b. To plan and conduct meetings of the OCS SC.
c. To lead the design and conduct of environmental studies.
d. To solicit and incorporate input from partners into study design and on interim study products.
e. To disseminate products, results and information from completed studies to those using them in their work products.

IV. Contacts

BSEE and BOEM Regional Directors

<u>BSEE AKOCS</u>
Chief, Environmental Enforcement Branch (Regional Environmental Officer)
Regional Supervisor for Field Operations

<u>BOEM AKOCS</u>
Regional Supervisor for Environment
Chief, Environmental Analysis Section I
Chief, Environmental Analysis Section II

Regional Supervisor for Leasing and Plans
    Chief, Plans Section
    Chief, Leasing Section
Regional Supervisor for Resource Evaluation
    Chief, Resource Analysis Section
    Chief, Resource and Economic Analysis Section

BSEE POCS
Regional Environmental Officer
Regional Supervisor for Field Operations

BOEM POCS
Regional Supervisor for Environment
    Chief, Environmental Analysis Section
    Chief, Environmental Sciences Section
Regional Supervisor Strategic Resources
    Chief, Plans Section

BSEE GOMR
Chief, Environmental Enforcement Branch (Regional Environmental Officer)
    Supervisor, Environmental Review Unit
    Supervisor, Environmental Inspection and Enforcement Unit
Regional Supervisor for Regional Field Operations
    Chief, Structural and Technical Support
    Chief, Pipeline Section
    Chief, Office of Safety Management
Regional Supervisor for District Field Operations
    Manager, Houma District Office
    Manager, Lafayette District Office
    Manager, Lake Charles District Office
    Manager, Lake Jackson District Office
    Manager, New Orleans District Office

BOEM GOMR
Regional Supervisor for Environment
    Chief, Operations Assessment Section
    Chief, Environmental Sciences Section

HQ
Chief, Office of Environmental Programs
    Chief, Environmental Sciences Division
        Manager, Environmental Studies Program
    Chief, Environmental Assessment Division

V. Responsibilities

1. **BOEM.** BOEM administers a regulatory program for oil and gas related activities on the OCS and conducts environmental analyses for pre-lease activities; oil and gas leasing decisions; and approval of exploration, development and production plans. Pre-lease activities may include site characterization surveys, which may involve geological and geophysical evaluations. BOEM reviews and approves required plans to authorize oil and gas activities under its jurisdiction pursuant to 30 CFR 550 and 556. BOEM conducts NEPA analyses on all these actions.

   BOEM assists BSEE with environmental consultations under other statutes for activities under BSEE jurisdiction. BOEM, in consultation with BSEE, develops environmental mitigation measures, monitoring protocols, and other environmental requirements for implementation in appropriate BOEM and BSEE authorizations. BOEM provides environmental review and input to BSEE on environmental investigations, compliance efforts, and enforcement actions.

2. **BSEE.** BSEE administers a regulatory environmental enforcement program to ensure that OCS oil and gas exploration, development, and production are conducted in an environmentally sound manner. BSEE confirms NEPA compliance for BSEE authorized activities, preparing documentation for all requisite decisions. BSEE confirms compliance with environmental requirements under NEPA and other statutes. BSEE monitors industry compliance with mitigations and other environmental requirements through office and field inspections. BSEE takes enforcement actions on incidences of non-compliance and BSEE confers with BOEM as appropriate and conducts investigations related to environmental enforcement actions.

VI. Modifications and Interpretations

Modifications to this MOA shall be made by written consent of both Bureaus' Deputy Directors.

Interpretations of this MOA should be consistent with the stated goals and purpose. For specific actions, Bureaus should clarify their roles and responsibilities in SOPs. The SOPs may be modified with the written consent of both Bureaus' appropriate Regional Director or Senior Executive.

VII. Signatures

Walter D. Cruickshank   10/3/11

BOEM Deputy Director   Date

Robert LaBelle   10/3/11

BSEE Deputy Director, Acting   Date

APPENDIX L

PUBLIC COMMENTS ON THE DRAFT PROGRAMMATIC EIS

TABLE OF CONTENTS

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LIST OF TABLES

1. DRAFT PROGRAMMATIC EIS COMMENTS AND RESPONSES OVERVIEW

To initiate the public review and comment period on the Draft Programmatic Environmental Impact Statement (EIS), the Bureau of Ocean Energy Management (BOEM) took the following actions: they (1) published a Notice of Availability in the *Federal Register* (*Federal Register*, 2012a) on March 30, 2012, announcing a 60-day comment period that ended on May 30, 2012; (2) mailed a special public notice that reported availability of the Draft Programmatic EIS and how to comment to all of the groups and agencies identified in Chapter 5.4 of the Draft Programmatic EIS; (3) emailed a group notification that reported availability of the Draft Programmatic EIS and how to comment to all people who had furnished BOEM with their email address during scoping or who had requested to be on such a mailing list; (4) placed multiple notices announcing availability of the Draft Programmatic EIS, all public meeting locations and times, and how to comment on the document in each of the following newspapers that served local media markets; *The Florida Times-Union*, *Savannah Morning News*, *The Post and Courier*, *The Virginian Pilot*, *Wilmington Star News*, *The Capital*, *Dover Post*, and *The Press of Atlantic City*; and (5) posted the Draft Programmatic EIS on the BOEM, Gulf of Mexico OCS Region's Internet website (http://www.boem.gov/Oil-and-Gas-Energy-Program/GOMR/GandG.aspx).

During the comment period BOEM extended the comment period by 30 days, ending the comment period on July 2, 2012 (*Federal Register*, 2012b), per commenter requests. On June 4, 2012, all parties who received initial notification of document availability by email were re-contacted and advised of the comment period extension.

All comments received during the public comment period for the Draft Programmatic EIS have been considered during preparation of this Final Programmatic EIS. Public comments on the Draft Programmatic EIS were received by mail, by email via ggeis@boem.gov, and in oral and written form at the 15 public hearings conducted by BOEM at eight locations along the Atlantic coast adjacent to the Area of Interest. A total of 55,295 individual comment submissions were received during the public comment period and can be found on the BOEM website (http://www.boem.gov/oil-and-gas-energy-program/GOMR/GandG.aspx). The review and response process is intended to ensure that improvements are made to the Final Programmatic EIS for its use as a decision-making document through the inclusion of new or substantive information, or to explain the rationale for how the evaluation was carried out.

1.1. CONSTRUCTION OF COMMENT INDEX

All comments received during the public comment period were placed into a comment index (**Section 2**) to provide accessibility, a full understanding of who provided comments, and how the comments were addressed. A document identification number called the Submission ID was assigned to each comment received (e.g., a letter, an email, or a set of comments given during a public hearing). Submission IDs were assigned to each comment based on their category and manner that the comment was received, and were then consecutively numbered; see **Tables L-1** and **L-2** for a listing of categories and subcategories of the Submission IDs. Once the Submission ID was assigned and entered into the Comment Index, each comment was thoroughly reviewed following the protocol described in **Section 1.2**.

Table L-1

Categories for Submission IDs in the Comment Index

Category Code	Category	Category Definition
EO	Elected Official	Government elected official at any level
FA	Federal Agency	U.S. Federal agency
SA	State Agency	State agency
LA	Local Agency	County, municipality, city, agency
I	Industry	Entity that is involved in the marine or G&G industry
NGO	Non-Governmental Organization	Non-profit, voluntary citizens group
P	General Public	General member of the public

Table L-2

Subcategories for Submission IDs in the Comment Index Indicating the Manner Received

Subcategory Code	Subcategory	Subcategory Definition
E	Email	Email comments received through BOEM website
EF	Emailed Form Letter	Formulaic letters set up as email campaigns on the websites of 10 environmental non-governmental organizations
L	Letter	Letter mailed in to BOEM
PHA	Public Hearings in Annapolis, Maryland	Comment received during Annapolis meeting. Includes testimony or written comment
PHAC	Public Hearings in Atlantic City, New Jersey	Comment received during Atlantic City meeting. Includes testimony or written comment
PHC	Public Hearings in Charleston, South Carolina	Comment received during Charleston meeting. Includes testimony or written comment
PHJ	Public Hearings in Jacksonville, Florida	Comment received during Jacksonville meeting. Includes testimony or written comment
PHN	Public Hearings in Norfolk, Virginia	Comment received during Norfolk meeting. Includes testimony or written comment
PHS	Public Hearings in Savannah, Georgia	Comment received during Savannah meeting. Includes testimony or written comment
PHWDE	Public Hearings in Wilmington, Delaware	Comment received during Wilmington, DE meeting. Includes testimony or written comment
PHWNC	Public Hearings in Wilmington, North Carolina	Comment received during Wilmington, NC meeting. Includes testimony or written comment

1.2. COMMENT REVIEW PROTOCOL

Each comment received was thoroughly reviewed to determine if the comment contained general and similar concerns (including form emails) or if the comment contained specific comments requiring detailed technical responses and/or changes to the Final Programmatic EIS.

If the comment expressed a general concern that was similar in content to other comments, it was assigned a Comment Code (**Table L-3**) to categorize the general topic of the comment and then entered into the Comment Index (**Section 2**, **Table L-4**). The 69 alpha-numeric Comment Codes were developed and defined based on comments received during the scoping period for the Programmatic EIS and were expanded based on specific, common comments received during the comment period for the Draft Programmatic EIS (**Table L-3**). Placing comments into categories allows similar concerns to be addressed with an appropriate common response and avoids repeating the same response numerous times. **Section 3** summarizes the general comments that have been grouped together and responded to in a general and concise manner. **Table L-5** provides the Comment Summary and Response for each Comment Code.

If the comment contained specific comments or recommendations requiring detailed technical responses and/or changes to the Programmatic EIS, subject-matter experts reviewed it and provided a response specifically addressing the comment, and changes, if required, were incorporated into the Programmatic EIS. **Section 4**, **Table L-6** provides a tabular listing of specific comments provided in detailed submissions, the expert response, and changes made in the Programmatic EIS, if any.

Table L-3

Comment Code General Categories

Comment Code	Comment Code Topic
A. Position on Proposed Action	
A-1	In favor of the proposed action (Supports Alternative A)
A-2	Opposed to the proposed action
A-3	Neutral
A-4	Supports Alternative B
A-5	Supports Alternative C
A-6	Opposition to future oil and gas activities, without any specific reference to G&G activities
B. Regulatory Process	
B-1	Fast and efficient regulatory process
B-2	Balanced energy policy
B-3	State permitting
B-4	Request extension of the public comment period for draft Programmatic EIS
B-5	Draft Programmatic EIS is adequate
B-6	Require local/State support
B-7	Lack of availability of Draft Programmatic EIS
B-8	Cooperating agency issues
B-9	Outer Continental Shelf Lands Act
B-10	National Environmental Policy Act
B-11	Executive Order 12114
B-12	Coastal Zone Management Act
B-13	Endangered Species Act
B-14	Marine Mammal Protection Act
B-15	Magnuson-Stevens Fishery Conservation and Management Act
B-16	Clean Air Act
B-17	Clean Water Act
B-18	National Historic Preservation Act
B-19	Migratory Bird Treaty Act
B-20	Executive Order 13547
B-21	Rivers and Harbors Act
B-22	National Marine Sanctuaries Act
B-23	Survey Data Availability
C. Alternatives Analysis	
C-1	Redefine Purpose and Need
C-2	Issues with screening criteria
C-3	Other issues with alternatives
C-4	Include the North Atlantic Planning Area
C-5	Additional information needed for alternatives
C-6	New alternatives
D. Impact Producing Factor	
D-1	Active acoustic sound sources
D-2	Vessel and equipment noise
D-3	Vessel traffic
D-4	Aircraft traffic and noise
D-5	Vessel exclusion zones
D-6	Vessel wastes

Table L-3. Comment Code General Categories (continued).

Comment Code	Comment Code Topic
D-7	Trash and debris
D-8	Seafloor disturbance
D-9	Onshore support activities
D-10	Fuel spills
E. Resource Areas	
E-1	Benthic communities
E-2	Marine mammals
E-3	Sea turtles
E-4	Marine and coastal birds
E-5	Fish resources and essential fish habitat
E-6	Threatened or endangered fish species
E-7	Commercial fisheries
E-8	Recreational fisheries
E-9	Recreational resources
E-10	Archeological resources
E-11	Marine protected areas
E-12	Other marine uses
E-13	Human resources and land use
E-14	General environmental resource
F. Socioeconomics	
F-1	Oil and gas infrastructure
F-2	Military activities
F-3	Regional sand sources
F-4	Socioeconomics (general)
G. Mitigation Measures	
G-1	Avoidance and minimization
G-2	Expanded Time-Area Closure for North Atlantic Right Whales (NARW)
G-3	Time-Area Closure for Nesting Sea Turtles
G-4	Separation between Simultaneous Seismic Airgun Surveys
G-5	Passive Acoustic Monitoring
G-6	General Mitigation

1.3. REVIEWING COMMENT RESPONSES

To review a response provided for a specific comment, readers should first refer to **Table L-4**. Commenters are listed under the heading associated with their category (i.e., elected official, Federal agency, State agency, local agency, industry, non-governmental organization, or general public). The far right column in **Table L-4** provides the Comment Code(s) assigned to each comment if the comment was classified as a general comment. Responses to general comments are provided in **Table L-5**; if the comment required a detailed technical response, the reader is referred to **Table L-6**.

2. COMMENT INDEX

Table L-4

List of Comment Category Codes

Submission ID	Last Name	First Name	Organization	Comment Codes
Elected Officials (sorted by last name)				
EO-L-3	Berger	Phil	North Carolina Senate	See detailed technical response in **Table L-6**
EO-PHC-1	Campbell	Paul G.	State Senator	See detailed technical response in **Table L-6**
EO-PHAC-2	Fuller	Janice	Behalf of Representative Frank Pallone	A-2
EO-PHWNC-2	Goolsby	Thom	Senator, North Carolina Senate	See detailed technical response in **Table L-6**
EO-PHC-2	Horne	Jenny	State Representative	See detailed technical response in **Table L-6**
EO-PHJ-1	Hutton	Marge	County Commission, District 3	See detailed technical response in **Table L-6**
EO-PHC-3	Johnston	Ann	Mayor, Town of St. George	See detailed technical response in **Table L-6**
EO-PHWNC-3	Rabon	Bill	Senator, North Carolina Senate	See detailed technical response in **Table L-6**
EO-L-2	Rigell	Scott	U.S. House of Representatives	See detailed technical response in **Table L-6**
EO-PHAC-1	Shultz (Smoltz)	Frank	Behalf of Senator Menendez	See detailed technical response in **Table L-6**
EO-PHWNC-1	Thompson	Jason	Newer Hanover County Commissioner	See detailed technical response in **Table L-6**
EO-PHN-1	Wagner	Frank	Virginia State Senator (District 7)	See detailed technical response in **Table L-6**
EO-L-1	Warner	Mark	U.S. Senate	See detailed technical response in **Table L-6**
Federal Agency Representatives (sorted by Agency)				
FA-E-4	Herman	Melissa	Marine Mammal Commission, Behalf of Timothy J. Ragen, Ph.D.	See detailed technical response in **Table L-6**
FA-E-3	Barnett	Anita	National Park Service	See detailed technical response in **Table L-6**
FA-L-1	Laws	Ben	NOAA	See detailed technical response in **Table L-6**
FA-E-1	Wilson	Joseph	U.S. Army Corps of Engineers	See detailed technical response in **Table L-6**
FA-L-2	Bromm	Susan	U.S. Environmental Protection Agency	See detailed technical response in **Table L-6**
FA-E-2	Johnson	Tamara	U.S. Fish and Wildlife Service	See detailed technical response in **Table L-6**
State Agency Representatives (sorted by Agency)				
SA-E-6	Kelly	Brian	Delaware Department of Natural Resources	See detailed technical response in **Table L-6**
SA-E-2	Tucker	Debby	Florida Department of Environmental Protection, NE District Clearinghouse Review, Florida Dept. of State, Florida Geological Survey, Florida Bureau of Beaches and Coastal Systems	See detailed technical response in **Table L-6**
SA-L-3	Clark	Chris	Georgia Department of Natural Resources	See detailed technical response in **Table L-6**
SA-E-4	Moore	Kelie	Georgia Department of Natural Resources Coastal Resources Division	See detailed technical response in **Table L-6**
SA-E-7	Bast	Cecilia	Maryland Department of Natural Resources	See detailed technical response in **Table L-6**
SA-PHA-1	Flemming	Matthew	Maryland Department of Natural Resources	See detailed technical response in **Table L-6**
SA-L-4	Moore	Christopher	Mid-Atlantic Fishery Management Council	See detailed technical response in **Table L-6**

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
SA-E-3	Creech	William E. H.	NC Department of Administration, Department of Environment and Natural Resources	See detailed technical response in **Table L-6**
SA-L-2	Neale	Barbara	South Carolina Department of Health and Environmental Control	See detailed technical response in **Table L-6**
SA-E-5	Davies	Jaclyn	State of New Jersey	See detailed technical response in **Table L-6**
SA-E-1	Christopher	Evie	Virginia Department of Mines, Minerals and Energy	See detailed technical response in **Table L-6**
SA-L-1	Weeks	Richard	Virginia Department of Environmental Quality	See detailed technical response in **Table L-6**
SA-PHN-2	Villanueva	Ron	Virginia House of Delegates	See detailed technical response in **Table L-6**
SA-PHN-1	Domenech	Doug	Virginia Secretary of Natural Resources	See detailed technical response in **Table L-6**
Local Agency Representatives (sorted by Agency)				
LA-E-2	Crumpler	Meg	City of Charleston, SC on behalf of the Mayor	See detailed technical response in **Table L-6**
LA-PHN-1	Pennington	Brian	City of Norfolk	See detailed technical response in **Table L-6**
LA-PHN-2	Matthias	Robert	City of Virginia Beach	See detailed technical response in **Table L-6**
LA-E-1	Brewer	Jan	St. Johns County Florida	See detailed technical response in **Table L-6**
Industry Representatives (sorted by Organization)				
I-PHA-1	Hopkins	Holly	American Petroleum Institute (API)	A-1
I-E-12	Radford	Andy	American Petroleum Institute (API)	See detailed technical response in **Table L-6**
I-E-1	Hala	Bob	Brüel & Kjaer - Environment Management Solutions (EMS)	G-6
I-E-14	Graham	Mary	Charleston Metro Chamber of Commerce	A-1, F-4
I-E-10	Suthard	Beau	Coastal Planning & Engineering (CPE)	See detailed technical response in **Table L-6**
I-E-13	Dubey	Paul W.	Conoco Phillips, Behalf of Richard Lunam	A-1
I-PHJ-1	Doyle	Kevin	Consumer Energy Alliance	A-1, F-4
I-PHJ-7	McMinn	Jineane	Corporate Development of Associated Industries of Florida	A-1, F-4
I-PHAC-1	Lovgren	James	Fisherman's Dock Corp; Point Pleasant	E-1, E-2, E-5, E-6, E-7, E-8, E-14, F-4, G-5
I-PHJ-3	Hamilton	Eric	Florida Petroleum Council	A-1, F-4
I-PHN-3	McNeilan	Sally	Fugro Geotechnics and Survey	A-1, G-1
I-E-6	Kaelin	Jeff	Garden State Seafood Assoc.	A-2, D-1, E-2, E-7
I-PHS-2	Hamling	Jeff	Georgia Chamber of Commerce	A-1, A-6
I-PHS-1	Cobb	Richard	Georgia Petroleum Council	A-1, F-4
I-PHAC-5	Neugebauer	Thomas E.	IAGC (TGS-NOPEC Geophysical Company)	A-1, C-4, E-2, E-6, G-4, G-5
I-PHJ-6	Padon	Matthew	International Associations of Geophysical Contractors	A-1, C-4, E-2, G-4, G-5
I-PHJ-5	Kaufman	David	Jacksonville Port Authority	A-1
I-E-4	Kohrn	Bruce	Lockheed Martin MS2	A-1, E-2, E-14
I-PHAC-4	Ross	Scott	New Jersey Petroleum Council	A-1
I-PHAC-3	Drulis	Michael	New Jersey Society of Economic Development	A-1
I-PHAC-2	Egenton	Michael	New Jersey State Chamber of Commerce	A-1
I-PHJ-2	Boe	William	none provided	A-1

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
I-PHJ-4	Hamilton	Bill	none provided	A-2
I-E-8	Findley	Madeleine	North American Submarine Cable Association	See detailed technical response in **Table L-6**
I-E-2	Salley	Frank	North American Submarine Cable Association	See detailed technical response in **Table L-6**
I-PHWNC-2	Witherspoon	Bill	North Carolina Petroleum Institute	A-1
I-E-7	Saydlowski	John	Nucor Steel Berkeley	A-1
I-E-5	Pfeister	Doug	Offshore Wind Development Coalition	See detailed technical response in **Table L-6**
I-PHWDE-1	Pfeister	Doug	Offshore Wind Development Coalition	See detailed technical response in **Table L-6**
I-E-9	Bodge	Kevin	Olsen Associates	See detailed technical response in **Table L-6**
I-PHC-1	Novinger (Norbinger)	Cathy	Palmetto AgriBusiness Council	A-1, F-4
I-E-3	O'Neil	Wanda	Piedmont Natural Gas	A-1
I-PHC-5	Winkles	David	SC Farm Bureau	A-1
I-L-1	Rawl	Otis	South Carolina Chamber of Commerce	A-1
I-PHC-2	Clamp	Kay	South Carolina Petroleum Company	A-1, F-4
I-PHWNC-1	Brown	Mike	Southeast Energy Alliance	A-1
I-PHC-3	Carnevale	Chris	Southern Alliance for Clean Energy	C-6, D-3, E-2, E-3, E-12
I-PHC-4	DeScherer	Chris	Southern Environmental Law Center	A-5, C-3, D-1, E-2, E-7, F-4
I-E-11	Wade	Foster	Statoil	A-1
I-PHN-2	DuVal	Barry	Virginia Chamber of Commerce	A-1, F-4
I-PHN-1	Ward	Mike	Virginia Petroleum Council	A-1, E-2, F-1
Non-Governmental Organization (NGO) Representatives (sorted by Organization)				
NGO-L-7	Brunswig	Norman	Audubon South Carolina	A-5, B-23, E-7, E-8, E-9, F-4
NGO-PHAC-10	Shanley (Shadley)	Georgina (Regina)	C.U.R.E.	A-5
NGO-PHS-1	Grainey	Karen	Center for a Sustainable Coast and Southern Environmental Law Firm	A-5, E-2, E-7
NGO-E-8	Tozzi	Jim	Center for Regulatory Effectiveness	See detailed technical response in **Table L-6**
NGO-EF-8	Numerous (78)	Numerous (78)	Chesapeake Climate Action	A-2, A-5
NGO-PHN-5	Wiegard	Hannah	Chesapeake Climate Action Network	A-2, A-5
NGO-PHAC-5	Grant	Joyce	Citizens for Oceanfront Preservation	D-1
NGO-L-2	Merrill	Denver	Citizens for Sound Conservation	A-1
NGO-PHC-1	Merrill	Denver	Citizens for South Conservation	A-1
NGO-EF-3	Numerous (11)	Numerous (11)	Clean Energy.org, Southern Alliance for Clean Energy	A-5, D-1, E-2, E-3, E-5, E-7, E-8, E-14
NGO-PHAC-1	Zipf	Cindy	Clean Ocean Action	D-1, E-7, E-8, E-9, E-14
NGO-PHAC-9	Stanish	Egan	Clean Ocean Action	A-5, E-2, E-5, E-12
NGO-PHAC-13	McCue	Zach (Jack)	Clean Ocean Action	A-5
NGO-PHAC-15	Stafford (Saffert)	Heather	Clean Ocean Action	See detailed technical response in **Table L-6**
NGO-E-6	Davis	Hamilton	Coastal Conservation League	A-2, B-23, C-3, C-5
NGO-EF-4	Numerous (2,496)	Numerous (2,496)	Consumer Energy Alliance	A-1, F-4
NGO-E-3	Goggin	Brenna	Delaware Nature Society	A-5, D-1, E-2, E-3, E-14, F-1
NGO-EF-2	Numerous (1,174)	Numerous (1,174)	Energy Nation	A-1, F-4

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
NGO-PHJ-2	Paradise	Brian	Florida Chapter Sierra Club	A-5, D-1, E-2, E-5, E-7, E-8, E-9, F-4
NGO-L-5	Owen Gledhill	Sarah	Florida Wildlife Federation	A-5, D-1, E-2, E-7
NGO-EF-9	Numerous (696)	Numerous (696)	Food and Water Watch	A-2
NGO-PHAC-7	Davis	Rachel Dawn	Food and Water Watch	A-2
NGO-PHJ-1	Matthaei	Marcella	Friends of Metenzas	A-5, D-1, E-2, E-5, E-7
NGO-L-6	Allgood	Beth	International Fund for Animal Welfare	A-5, D-1, E-2, G-6
NGO-PHAC-6	Dean	Sheila	Marine Mammal Stranding Center	E-2, E-5, E-14, F-4
NGO-E-15	Hinman	Ken	National Coalition for Marine Conservation	A-5, C-5, D-1, E-2, E-5, E-14, F-4
NGO-E-14	Kane	Austin	National Wildlife Foundation	A-5, D-1, E-2, E-14
NGO-PHAC-14	Chase	Alison	Natural Resources Defense Council (NRDC)	A-5, D-1, E-2, E-7, E-14, F-4
NGO-E-10	Jasny	Michael	Natural Resources Defense Council (NRDC), Center for Biological Diversity, Center for Water Advocacy, Clean Ocean Action, Coastal Conservation League, Earthjustice, Ocean Conservation Research, Oceana, Southern Environmental Law Center, Surfrider Foundation, The Humane Society of the United States, Whale and Dolphin Conservation Society	See detailed technical response in **Table L-6**
NGO-EF-10	Numerous (19,360)	Numerous (19,360)	Natural Resources Defense Council	A-5, D-1, E-2, E-14, G-6
NGO-E-9	Phemister	David	Nature Conservancy	See detailed technical response in **Table L-6**
NGO-E-13	Kraus	Scott	New England Aquarium	See detailed technical response in **Table L-6**
NGO-E-7	Dallara	Nicole	New Jersey Sierra Club	A-2, D-1, E-2, E-7, E-14, F-4
NGO-PHAC-8	Bennekamper	Robert	none provided	A-2
NGO-PHAC-11	Hoffberger (Hoffer)	Jeffrey A.	none provided	A-2, E-2, E-14
NGO-PHAC-12	Weber	John	none provided	A-5
NGO-PHN-2	Bell	Susan	none provided	A-2, D-1, E-2, E-5, E-12, F-4
NGO-PHN-3	James	Ellis W.	none provided	E-2, E-12, E-14
NGO-E-4	Stocker	Michael	Ocean Conservation Research Two Emailed Letters	See detailed technical response in **Table L-6**
NGO-PHAC-2	Jackson	Margit-Meissner	Ocean Sierra Club	D-1, D-8, E-1, E-3, E-7, E-14
NGO-PHAC-3	Auriemman (Orgamba)	D. Gregory	Ocean Sierra Club	A-5
NGO-EF-1	Numerous (720 + 27,382)	Numerous (720 + 27,382)	Oceana	A-2, A-5, D-1, E-2, E-7, E-14, F-4
NGO-PHN-4	Glenn	Becca	Oceana	A-2, A-5, D-1, E-2, E-7, E-14, F-4
NGO-PHWNC-5	Keith	Zachary	Oceana	A-5

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
NGO-E-11	Huelsenbeck	Matthew	Oceana, Natural Resources Defense Council, Center for Biological Diversity, Clean Ocean Action, Earthjustice, Defenders of Wildlife, Surfrider Foundation, Southern Environmental Law Center, and Sierra Club	B-4
NGO-E-1	Armbruster	Thomas	SandyHook SeaLife Foundation	A-2, D-1, E-14
NGO-PHAC-4	Tittel (Fiddle)	Jeff	Sierra Club	A-2, A-5, E-2, E-7, F-4
NGO-PHN-1	Levandoski	Eileen	Sierra Club	A-2, D-1, E-7, E-9, E-12, E-14, F-4
NGO-PHWNC-1	Barnett-Loro	Carina	Sierra Club	A-2, A-5, B-2, E-2, E-3, E-7, E-14, F-4
NGO-PHWNC-2	Montgomery	Mac	Sierra Club	A-5
NGO-L-1	Roe	Amy	Sierra Club, Delaware Chapter	A-2, A-5, D-1, E-2, E-3, E-6, E-14
NGO-L-4	Meissner-Jackson	Margit	Sierra Club, Ocean County Group	See detailed technical response in **Table L-6**
NGO-EF-7	Numerous (1,117)	Numerous (1,117)	Sierra Club, Virginia Chapter	A-5, D-1, E-2, E-5, E-7, E-9, E-14, F-4
NGO-E-12	Hartl	Brett	Society for Conservation Biology	See detailed technical response in **Table L-6**
NGO-PHC-2	Zimmerman	Katie	South Carolina Conservation League	B-23, C-6
NGO-E-2	Mahan	Simon	Southern Alliance for Clean Energy	C-6, D-1, D-3, E-2, E-5, E-14, G-2
NGO-EF-5	Numerous (1,592)	Numerous (1,592)	Surf Rider Foundation-1	A-5, D-1, E-2, E-5, E-7, G-6
NGO-EF-6	Numerous (124)	Numerous (124)	Surf Rider Foundation-2	A-2, D-1, E-2, E-5, E-7, E-14, G-6
NGO-E-5	Stauffer	Peter	Surfrider Foundation	A-2 D-1, E-2, E-5, E-7, E-8, E-9, E-12, E-14, F-4
NGO-L-3	Crouch	Ethan	Surfrider Foundation	A-5, E-2, E-3, E-7, E-8, E-10, F-4
NGO-PHWNC-3	Richardet	Aaron	Surfrider Foundation	A-5, D-1, E-2, E-3, E-5, E-7, E-8, E-9, E-10, E-14, F-4
NGO-PHWNC-4	Meadowcroft	Al	Surfrider Foundation	A-5, E-7, E-8, F-4
N/A	Savitz	Jacqueline	Oceana and International Fund for Animal Welfare	See detailed technical response in **Table L-6**
General Public (sorted by Last Name)				
P-E-103	Abate Cosumano	Lorraine	none provided	A-2, D-1
P-E-24	Albee	Kimberly	none provided	A-6
P-E-59	Allen	Kerri	none provided	A-5
P-PHWNC-32	Altic	Keenan	none provided	A-6
P-E-120	Amendola	Kate	none provided	A-2, E-9, E-14, F-4
P-E-223	Amor	Valerie	none provided	A-2, E-14
P-PHWNC-42	Amoroso	Frank	none provided	A-1
P-E-16	Anderson	William	none provided	A-6
P-L-8	Andrews	Emiko	Friends School Wilmington	A-2, E-2, E-14
P-E-12	Andrews	Lynn	none provided	A-2, E-2
P-E-160	Armstrong	Anne	none provided	A-2, E-2, E-3, E-14
P-PHJ-8	Arpaia	James	none provided	A-6
P-E-226	Ashley	Thomas	none provided	A-5, E-14
P-PHA-2	Aus	Doug	none provided	A-2, E-5, E-7, E-9, E-12, E-13, F-4
P-PHJ-32	Baer	Victoria	none provided	A-1
P-PHWNC-13	Ballantrae	Patrick	none provided	A-1, A-4

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-E-211	Barbar	Kimberly	none provided	A-5
P-PHJ-1	Bardin	Rachel	none provided	A-5
P-L-18	Barrett	Linn	none provided	A-2, D-1, E-2, E-7, E-14
P-PHN-5	Barton	James	none provided	A-3
P-E-172	Baysden	Virginia	none provided	A-2, E-2
P-PHWNC-6	Beck	Ed	none provided	A-5
P-PHJ-15	Bedran	Kyle	none provided	A-1, A-4
P-PHJ-14	Bell	Nathaniel	none provided	A-1
P-E-93	Belon	Susan	none provided	A-2, E-14
P-L-7	Berg	Christopher	none provided	A-5, D-1, E-2, E-3, E-7, E-8, E-9, E-14
P-PHAC-6	Bernstein	Harriann	none provided	A-6
P-E-52	Best	Trish	none provided	A-2
P-E-31	Beyda	Wendy	none provided	A-2, D-1, E-2
P-E-204	Bigger	Lisa	none provided	A-2
P-E-113	Bissinger	Tom	none provided	A-2, E-2
P-E-58	Blazier	Brandi	none provided	A-2, E-14
P-PHN-11	Bloodworth Rowe	Jane	none provided	A-2, E-7, E-8, E-13, E-14, F-4
P-E-221	Boyd	Patty	none provided	A-5
P-E-237	Bozard	Cecil	none provided	A-2
P-PHWNC-21	Bradshaw	Brady	none provided	A-2, A-5, E-2, E-14
P-E-242	Braestrup	Angelica E.	none provided	A-5, D-1, E-2
P-PHN-22	Brelin	Scott	none provided	A-1
P-E-142	Brickman	Christopher	none provided	A-2, E-2
P-E-76	Brinn	Ira M.	none provided	A-5, D-1, E-2, E-5, E-7, G-6
P-PHC-1	Brooks	Tom	none provided	A-1
P-E-239	Brown	David	none provided	A-1
P-E-229	Brown	Ward	none provided	A-2
P-PHA-1	Bruckner	Steven	none provided	A-2, B-14, D-1, E-2, E-7, E-12
P-PHWNC-23	Bustle	Jonathan	none provided	A-5
P-L-19	Byers	Lola	Friends School Wilmington	A-5, E-14
P-E-98	Cafiero	Stephen	none provided	A-2, E-14
P-E-86	Calderon	Sheila	none provided	A-5, D-1, E-2, E-5, E-7, G-6
P-PHWNC-5	Cameron	Dan	none provided	A-6
P-E-20	Campaigne	Alyssondra	none provided	A-2, B-23, E-2, E-5
P-E-39	Campbell	Al	none provided	A-1
P-E-69	Campbell	Grant	South Florida Audubon Society	D-1, E-1, E-2, E-3
P-E-106	Candia	Joe	none provided	A-2
P-E-14	Cantrell	Paul	none provided	A-2, B-23, E-2, E-5, G-1
P-PHC-9	Carmen	Carlene	none provided	A-1
P-PHWNC-14	Carmen	Carlene	none provided	A-1, A-4

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-E-146	Cassidy	Paula	none provided	A-2, E-2, E-14
P-E-183	Chamberlin	Geoff	none provided	A-6
P-PHJ-34	Chastain	Stephen	none provided	A-6
P-E-139	Classen	Matt	none provided	A-2, E-2, E-14
P-E-34	Cochran	Alyssa	none provided	A-2, E-14
P-PHS-2	Collier	Claudia	none provided	A-6
P-E-3	Collins	Kenny	none provided	A-6
P-E-215	Comber	Mary Lou	none provided	A-2
P-E-188	Conner	Spencer	none provided	A-2, D-1, E-2
P-PHWNC-24	Cross	Nancy	none provided	A-2, A-5, E-2, E-14
P-E-154	Cs	Chris	none provided	A-2, E-7, E-8, E-14, F-4
P-E-158	Csatary	Christine M.	none provided	C-5
P-E-180	Curran	Tina	none provided	A-2, E-14
P-E-191	D'Aiuto	Christopher	none provided	A-6
P-E-102	Danch	Nancy	none provided	A-2, D-1, E-14
P-E-135	Daniel Reinitz	Nancy	none provided	A-2
P-E-75	Davidson	Kym	none provided	A-2
P-E-28	Davis	Ken	none provided	A-1, F-4
P-E-174	Davis	Susan	none provided	A-5, D-1, E-2, E-7, E-9, E-14, F-4
P-E-213	Dawson	Betty Anne	none provided	A-2, E-2, E-3, E-14
P-PHWNC-41	Dean	Liza	none provided	A-5, E-2, G-5
P-E-100	DeClementi	Camile	none provided	A-2, E-14
P-E-244	deFur	Peter L.	none provided	See detailed technical response in **Table L-6**
P-E-129	Del Porto	Anthony	none provided	A-2, E-7, E-8, E-9, E-14, F-4
P-E-157	DeVan	D	none provided	A-2, D-1, E-2, E-3, E-14, F-4
P-PHJ-20	deVidal	Steve	none provided	A-1
P-PHN-25	Devine	Carole	none provided	A-6
P-PHAC-7	Diamond	Michael	none provided	A-6
P-PHAC-11	Dickson	Mr.	Behalf of Assemblyman McKeon	A-2, E-7, E-9, E-12, E-13, E-14, F-4
P-E-202	di Grazia	Cathie	none provided	A-2, E-2, E-14
P-PHAC-1	Dixon (Dickson)	Sean (Shawn)	none provided	A-5, D-1, E-2, E-3, E-7, E-8, E-9, F-3, F-4
P-PHJ-4	Dockery	Arlyn	none provided	A-6
P-PHJ-31	Donnelly	Pamela	none provided	A-1
P-E-165	Downey	Jennifer	none provided	A-2, E-2
P-E-178	Doyle-Madsen	Jan-Judy	none provided	A-2, E-2, E-3, E-14
P-E-111	Duckworth	Keith	none provided	A-2, A-5
P-PHWNC-9	Duval	Paul	none provided	A-2
P-E-197	Dziak	John	none provided	A-2
P-E-64	Eckert	Rose Marie	none provided	A-5, D-1, E-2, E-5, E-7, F-4, G-6
P-E-220	Eckles	Casey	none provided	D-1, E-2

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-PHWNC-26	Eisler	Sara	none provided	A-2, A-5, D-1, E-2, E-3, E-7, E-8, E-9, E-14, F-4
P-E-48	Eisler	Sara Sophie	none provided	A-5, C-3, E-2, G-5
P-PHC-5	Ensor	Linda	none provided	A-1
P-PHAC-2	Fagan	Thomas	none provided	A-2, D-1
P-E-57	Fazzino III	Frank T.	none provided	A-1, F-4
P-E-187	Feighner	Liz	none provided	A-2, A-5, D-1, E-2, E-7, E-8, E-9, E-14, F-4
P-E-116	Fellows	George	none provided	A-1
P-E-208	Fink	Harriet	none provided	A-5, E-2, E-14
P-E-133	Fischer	Angela	none provided	A-2, D-1, E-2
P-E-140	Fisher-Golton	Karin	none provided	A-2
P-E-119	Fitton	Jamie	none provided	A-2
P-PHJ-18	Fitzpatrick	James	none provided	A-1, A-4
P-E-109	Flaherty	Carolynn	none provided	A-2, D-1, E-2, E-14
P-PHJ-33	Fleming	Dennis	none provided	A-1
P-PHWDE-2	Fleming	Lorraine	none provided	See detailed technical response in **Table L-6**
P-PHN-8	Fleming	William	none provided	B-23, D-3, E-2
P-E-49	Fleming, PhD	William W.	none provided	A-4, B-23, G-5
P-E-95	Flynn	Joan	none provided	A-2
P-E-50	Fogel	Captain Joel S.	none provided	A-2, A-5, D-1, E-2, E-5, E-7, E-14
P-E-37	Franke	Angela	none provided	E-14
P-E-171	Freas	Carol	none provided	A-2
P-PHWNC-11	Freeman	Paige	none provided	E-2, E-7, E-8, E-14, F-4
P-E-207	Fricke	Lee	none provided	A-2, E-14
P-E-210	Friedman	Meryl	none provided	A-5
P-E-99	Fry	Maureen	none provided	A-2, E-14
P-E-94	Fuller	Richard P.	none provided	A-2
P-PHN-7	Gagnon	Chuck	none provided	A-2, D-1, E-2, G-5
P-E-101	Gaine	Richard	none provided	A-6
P-PHWNC-20	Gale	Tom	none provided	A-5
P-PHWNC-40	Gales	Bev	none provided	A-5
P-E-26	Gallegos	Karen	none provided	A-1, F-4
P-E-138	Gayle	LaToya	none provided	A-5, D-1, E-2, E-3, E-7, E-14
P-E-131	Geer	Eugene	none provided	A-2, D-1, E-2, E-14, G-1, G-6
P-PHAC-10	Geer (Dear)	Eugene	none provided	E-1, E-2, E-14
P-E-200	Gentry	Shannon	none provided	A-2
P-E-130	Gerst	Dan	none provided	A-5, E-2, E-3, E-5, E-7, E-9, E-14, F-4
P-PHWNC-22	Gigliotti	Mary	none provided	A-2, A-5
P-E-61	Giordano	Tony	none provided	A-6
P-PHWNC-35	Gisler	Geoff	none provided	E-2, E-14
P-E-43	Gooding	Suzanne	none provided	A-5, E-9, F-4

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-E-60	Gornik	April	none provided	A-2
P-E-166	Gould	Pamela	none provided	A-5, E-7, E-14, F-4
P-L-15	Grant	Joyce	none provided	A-2
P-PHJ-23	Grant	Shannon	none provided	A-1, A-4
P-E-203	Green	Carol	none provided	A-2
P-PHA-4	Green	Carol	none provided	A-2, D-1, E-2, E-7, E-9, F-4
P-E-177	Green	Jaime	none provided	A-2, D-1, E-2
P-PHWNC-1	Greer	Robert	none provided	A-1
P-E-65	Griffin	Candice B.	none provided	A-6
P-E-22	Griffin	Jacqueline	none provided	A-5, E-9
P-E-70	Griffiths	Bev	none provided	A-2, D-1, E-1, E-2, E-5, E-7, E-14
P-PHS-6	Gross	Ellen	none provided	A-6
P-E-85	Grover	Ravi	none provided	A-2, A-5, E-2, E-5, E-14
P-E-141	Guerra	Javier	none provided	A-2
P-E-82	Guida	Patricia	none provided	A-2, D-1, E-14
P-E-148	Hagan	Teresa	none provided	A-5
P-PHJ-3	Hamilton	Patrick	none provided	A-6, D-1, E-2, E-7
P-PHWNC-10	Hampton	Jean	none provided	A-1
P-E-219	Hankins	Judith	none provided	A-2, D-1, E-2
P-E-121	Hankinson	Gail	none provided	A-2, D-1, E-2, E-7, E-8, F-4
P-PHAC-9	Harper	Mary	none provided	A-2, E-2
P-E-170	Hartwell	Margaret	none provided	A-2, A-5, E-2
P-E-175	Hasney	Ann O.	none provided	A-2
P-PHJ-25	Hasty	Elvira	none provided	A-1, E-7, E-14
P-E-235	Hawkins	Monty	none provided	See detailed technical response in **Table L-6**
P-PHN-16	Hayut	Raven	none provided	D-1, E-2, E-3, E-14
P-PHWNC-30	Hazlett	Michael	none provided	A-5, D-1, E-2, E-6
P-E-169	Healey	Simone	none provided	A-5
P-PHAC-4	Healy	Simone	none provided	A-2, A-5, D-1, E-2, E-12, E-14, F-4
P-PHJ-19	Henry	Chelsi	none provided	A-1
P-E-161	Hibbs	L.	none provided	A-2
P-E-186	Hoffman	Elisabeth	none provided	A-2, E-14
P-E-89	Hofford	Anna	none provided	A-2, B-23, E-2, E-9, E-14, F-4, G-6
P-E-231	Holeve	Barry	none provided	E-2, E-7, E-8, F-4
P-PHS-5	Hollingsworth	Beverly	none provided	B-7, D-1, E-2
P-E-224	Holmes	Judi	none provided	A-1
P-E-11	Hook	Holly	Coastal Conservation League	A-2, E-2, E-5, G-1
P-E-13	Horton	Linda	none provided	A-2, E-2
P-PHAC-13	Huges	James A.	none provided	A-2
P-L-13	Hughes	James	none provided	A-2

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-PHAC-8	Hughes	Peter	Atlantic Capes Fisheries, Inc.	B-4
P-PHWNC-12	Hunt	W. Scott	none provided	A-1
P-PHWNC-38	Hutchings	Brinkley	none provided	A-5
P-E-110	Isakov	Amy	none provided	A-2
P-PHWNC-33	Jackson	Chip	none provided	A-1
P-E-168	Jacobi	Lynden	none provided	A-2, D-1, E-2
P-E-201	Jagiello	Carol	none provided	D-1, E-2, E-14
P-E-125	Jezierski	Ben	none provided	A-6
P-E-35	John	Anthony	none provided	E-14
P-E-96	Johnson	Monica	none provided	A-2, E-14
P-E-42	Johnston	Jenny	none provided	A-2
P-E-55	Karstens	Kendra	none provided	A-2, D-1, E-14
P-PHWNC-36	Khan (Khm)	Mujahid	none provided	A-3, A-6
P-E-136	King	Michael	none provided	D-1, E-2
P-E-71	Kirby	Patricia	none provided	A-2, E-2, E-7
P-E-108	Kline	Kristin	none provided	A-2
P-E-184	Knowlton	Elizabeth	Knowlton	A-5, D-1, E-2, E-3, E-7, E-8, E-14, F-4
P-E-97	Koehl	Lisa	none provided	A-2, D-1, E-2, E-3, E-5, E-7, E-8, E-9, E-12, E-14, F-4
P-PHJ-7	Kolb	LeAnne	Kolb 4 Congress	A-1, F-4
P-E-238	Kopelman	Arthur H. Ph.D.	none provided	A-2, B-14, E-2
P-PHWNC-2	Kopp	Bill	none provided	A-1
P-L-21	Kreh	Marion	none provided	A-2
P-PHS-3	Kreski	Laura	none provided	A-4
P-E-80	Kuiken	Donna	none provided	A-2, E-14
P-E-198	Kurtz	Elizabeth	none provided	A-5
P-E-145	Kuta	Sue	none provided	A-2, E-2
P-PHN-9	Langston	Diane	none provided	A-2, A-5
P-E-46	Lenahan	Mary	none provided	A-2, E-9, E-14, F-4
P-PHN-19	Lewis	Elizabeth	none provided	A-2
P-PHWNC-37	Lewis	Elizabeth	none provided	A-6
P-E-222	Lewis	Lisa	none provided	A-1
P-E-236	Lipman-Stern	Elizabeth	none provided	A-6
P-E-196	Lish	Chris	none provided	A-2, D-1, E-2, E-7, F-4
P-E-151	Litow	Philip	none provided	A-2
P-E-74	Long	Bud	none provided	A-2, E-2, E-5, E-14
P-E-189	Lopez	Josie	none provided	A-2, A-5, D-1, E-2, E-14
P-L-3	Lorie	Camille	Friends School Wilmington	A-5, E-2, E-7, F-4
P-E-206	Luedtke	Jean	none provided	A-2, E-2, E-3, E-7, E-14
P-E-2	Lundy	Chris	none provided	A-6

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-PHN-15	Lundy	Franklin	none provided	A-6
P-E-105	Macdonald	Felicity	none provided	A-2, E-2, E-14
P-PHN-2	Malina	Catherine	none provided	A-2, D-3, E-3, E-7, E-8, F-4
P-E-243	Malley	Tim	none provided	A-2, D-1, E-2
P-PHN-21	Mariner	Susan	none provided	A-2, E-2
P-E-152	Marryat	Kathi	none provided	A-5, E-2
P-E-6	Marsh-Thomas	Nina	none provided	A-2, B-23, E-2, E-5, G-1
P-E-225	Martin	Martha	none provided	A-6
P-PHJ-30	Martz	Nicole	none provided	A-1
P-E-67	Mascioli	Cheryl	none provided	A-2, A-5, E-14, F-4
P-E-40	Mason	Carl	none provided	A-6
P-E-228	Mathis	Kathy	none provided	A-2
P-E-179	McAveney	Donna M.	none provided	A-2, B-13, B-14, B-15, D-1, E-1, E-2, E-7, E-14, F-4
P-E-112	McAveney	Donna M.	none provided	A-2, B-13, B-14, B-15, D-1, E-1, E-2, E-7, E-14, F-4
P-E-227	McCaffity	Chris	none provided	A-2
P-E-247	McCaffity	Chris	Directed Sustainable Fisheries Inc.	A-2, E-1, E-2, E-5, E-14
P-L-26	McCann	Sydney	Friends School Wilmington	A-5, D-1, E-2
P-E-8	McCulloch	Jamie	none provided	A-2, B-23, E-2, E-5, G-1
P-E-73	McEachern	Joel B.	none provided	A-6
P-PHJ-22	Medros	Diana	none provided	A-1
P-E-232	Meehan	Nancy	none provided	A-2
P-PHJ-27	Methoei	Marcelle	none provided	A-2, A-5, E-2, E-3, E-14
P-PHWNC-39	Metzger	Bryan	none provided	A-2
P-E-23	Mikell	David	none provided	A-2, B-23, E-2, E-5, G-1
P-PHJ-16	Miller	Al	none provided	A-1
P-E-18	Miller	Catherine	none provided	A-2, B-23, E-2, E-5, G-1
P-PHJ-6	Miller	Marty	none provided	A-1
P-PHJ-12	Mills	Jake	none provided	A-6
P-E-5	Mitchell	Catherine	none provided	A-6
P-E-114	Montalvo	Stephanie	none provided	A-6
P-E-159	Monteleone	Bonnie	none provided	A-2, D-1, E-2
P-PHWNC-34	Moon	Hunter	none provided	A-5
P-PHS-4	Moore	Sammy	none provided	A-4
P-PHN-6	Morgan	Christine	none provided	A-2, D-8, E-12, E-14
P-E-90	Morley	Adam	none provided	A-5, E-2, F-4
P-E-107	Mortela	Shannon	none provided	A-2
P-PHJ-10	Morton	Karyn	none provided	A-1
P-PHJ-5	Morton	Ray	none provided	A-1

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-PHWNC-19	Moss	Charles Kenneth	none provided	A-2
P-E-21	Murphy	Sally	none provided	A-2, E-2, E-3, E-5, G-1
P-PHN-1	Murray	Deborah	none provided	A-2, A-5, D-1, E-2, E-5, E-7, E-8, F-4
P-PHJ-24	New	Darrell	none provided	A-1
P-PHWDE-1	Nichols	John	none provided	A-1
P-E-217	none provided	Barbagge	none provided	A-2
P-E-245	none provided	Busse	none provided	A-2, D-1, D-3, E-2
P-E-10	none provided	Cabfolds	none provided	A-2
P-L-4	none provided	Carissa	Friends School Wilmington	A-5, E-2
P-L-5	none provided	Carson	Friends School Wilmington	A-5, E-2, E-14
P-L-6	none provided	Charlotte	Friends School Wilmington	A-5, E-14
P-L-11	none provided	Christian	Friends School Wilmington	A-5, E-2, E-14
P-E-181	none provided	Cyrus	none provided	A-2
P-L-9	none provided	Emma	Friends School Wilmington	A-5, D-1, E-14
P-L-10	none provided	Finn	Friends School Wilmington	A-5, E-2
P-L-12	none provided	Griffin	Friends School Wilmington	A-4, E-2
P-E-79	none provided	Jacqueline	none provided	A-2, E-2, E-5, E-7, E-14, F-4
P-L-17	none provided	Lillian	Friends School Wilmington	A-5, E-2, E-14
P-E-164	none provided	Louise	none provided	A-2, E-2
P-L-20	none provided	Maddie	Friends School Wilmington	A-5, E-2
P-E-143	none provided	Matthew	none provided	A-6
P-PHJ-26	none provided	none provided	Tiny Company of 3	A-1
P-L-23	none provided	Olivia	none provided	A-5, E-2, E-14
P-E-173	none provided	Rippo	none provided	A-2
P-E-216	none provided	Rohalkakepoto	none provided	A-2
P-E-81	none provided	Shana	none provided	A-2
P-L-25	none provided	Student	Friends School Wilmington	A-5
P-L-27	none provided	Tucker	none provided	D-1, E-2
P-L-28	none provided	Tyler	none provided	A-5, E-2
P-PHJ-2	Norman	Yvonne	none provided	E-14
P-E-246	Nowacek	Doug	Duke University Marine Laboratory	See detailed technical response in **Table L-6**
P-E-19	Nutter	Robert	none provided	E-2
P-PHWNC-29	O'Dariell	Sherry	none provided	A-5
P-PHN-20	Olson	Jeanne	none provided	A-6
P-E-137	Orr	Carol	none provided	A-2, E-2
P-E-147	Otero	Jennifer	none provided	A-2, E-2
P-PHJ-28	Pascacci	Maria	none provided	A-1
P-E-156	Passarge	Elke	none provided	D-1, E-2, E-14, F-4
P-E-25	Paulk	Kimberly	none provided	A-2
P-PHWNC-28	Perotto	Heidi	none provided	A-5, E-14

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-L-1	Perry	Alisa	none provided	A-5
P-L-16	Pfeifer	Justin	Friends School Wilmington	A-5, D-1, E-2, E-14
P-E-83	Pharis	Linda	none provided	A-5, D-1, E-2, E-5, E-7, E-9, E-14, F-4
P-E-234	Phillips	Stuart	none provided	B-5, B-14, C-3, C-5, C-6, D-1, D-2, E-1, E-2, E-5, E-14, G-1, G-5
P-E-132	Pierce	Ann	none provided	A-6
P-E-128	Pillot	Cooper	Friends Seminary	A-2, A-5, D-1, E-2, E-5, E-7, E-8, E-14, F-4
P-PHC-6	Piscatella	Tony	none provided	A-3
P-E-30	Polfus	Jennifer	none provided	A-2, B-23
P-E-53	Poole	Colleen	none provided	A-6
P-E-124	Popolizio	Carlo	none provided	A-2, A-5, D-1, E-1, E-2, E-3, E-7, E-8, E-14
P-PHA-3	Porter	Carla	none provided	A-2, A-5, E-2, E-12
P-L-24	Powell	Ren	Friends School Wilmington	A-5, E-14
P-E-241	Preskitt	Sid	none provided	A-1
P-PHWNC-18	Prince	Ann	none provided	A-3
P-E-32	Public	Jean	none provided	A-2, E-2
P-PHWDE-3	Purchase	Ruth Ann	none provided	See detailed technical response in **Table L-6**
P-PHN-10	Quartararo	Alan	none provided	A-1
P-E-88	Ramos	Joann	none provided	A-2, A-5, D-1, E-2, E-3, E-5, E-7, E-8, E-9, E-14, F-4, G-6
P-PHC-10	Rapcitick	Maria	none provided	A-1
P-PHC-3	Rapehick	Steve	none provided	A-1
P-PHJ-9	Raube	Ed	none provided	A-1, F-3
P-PHN-13	Redford	Matt	none provided	D-1, E-2
P-L-22	Reed	Michael	none provided	A-2
P-E-63	Reid	Martha	none provided	A-2, E-2, E-14
P-E-182	Reiss	Wayne	none provided	A-2
P-PHC-4	Richter	William J.	none provided	A-3
P-E-155	Riddle	Mary	none provided	A-2, E-2
P-E-199	Riddle	Mary	none provided	A-2, E-2
P-E-195	Rist	Joanne	none provided	A-5
P-E-194	Rist	Mark	none provided	A-5
P-E-209	Rittenmeyer	Pat	none provided	A-5, D-1, E-2, E-3, E-14
P-E-41	Robuck	Anna	none provided	A-2, E-9, E-14, F-4
P-PHN-24	Romano	Sandy	none provided	A-6
P-PHN-14	Rommen	Peggy	none provided	A-2
P-E-72	Ross	Alexa	none provided	A-2, E-2, E-7, E-14, F-4
P-E-118	Rost	Marlene	none provided	A-2
P-E-84	Rue	Candice	none provided	A-5, D-1, E-2, E-3, E-5, E-7, G-6
P-E-150	Ryan	Phyllis	none provided	A-5, E-2

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-PHN-4	Rybak	Sheila	none provided	A-2, E-2
P-E-185	Santoliquido	Geoffrey	Santoliquido	A-2, A-5, E-2, E-14
P-PHN-3	Saunders	Georgia	none provided	A-2
P-E-134	Sauvageau	Monique	none provided	A-2, D-1, E-14
P-E-56	Savia	Susan	none provided	A-2, D-1, E-2, E-14
P-PHN-23	Scalley (Melsgally)	Melody	none provided	A-1
P-E-230	Schuster	Monica	none provided	A-5, D-1, E-2, E-3, E-7, E-8, E-14, F-4
P-E-38	Scott	Amanda	none provided	A-2, D-1, E-2, E-14
P-PHJ-17	Sharp	Craig	none provided	A-1, A-4
P-PHN-18	Shaw	Susan	none provided	A-6, D-1, E-7, F-4
P-E-68	Sheldon	Tricia	none provided	A-5, D-1, E-2, E-5, E-7, G-6
P-E-233	Shelton	Dede	none provided	A-5, D-1, E-2, E-5, E-7, E-14
P-PHJ-29	Shook	Nancy	none provided	A-2, A-5, E-2, E-14
P-L-30	Siegel	Maia	none provided	A-5
P-PHWNC-25	Simonelli	Jeanne	none provided	A-5, E-7, E-8, E-14
P-E-4	Skipper	Norm	none provided	A-6, F-4
P-E-205	Slating	Deborah	none provided	A-2, E-14
P-PHC-2	Smith	Mike	none provided	A-1
P-E-176	Sotis	Tina	none provided	A-2, E-2
P-E-54	Speck	Regina	none provided	A-2, E-14
P-PHWNC-17	Spencer	Janet	none provided	A-1
P-PHWNC-4	Spruill	Jack	Pender Watch & Conservancy	A-5, B-1, B-8, E-2, E-3, E-14
P-E-78	Stanley	Laurel	none provided	A-2, E-2, E-5, E-7
P-E-7	Steadman	Cheryl	none provided	A-2, B-23, E-2, E-5, G-1
P-E-122	Steitz	Jim	none provided	A-2, B-13, B-14, D-1, E-2, E-14
P-E-126	Stephenson	Diane	none provided	A-5, E-5, E-7, E-14
P-PHAC-3	Stimpfel	Teresa	none provided	A-2, D-1, E-2, E-7, E-14
P-E-66	Stokes	Bill	none provided	D-1, E-1, E-2, E-3, E-5, E-7, E-14
P-E-167	Stone	Gwen	none provided	A-2
P-PHWNC-7	Sullivan	Ann	none provided	A-1
P-E-62	Summer	Denise	none provided	A-2, E-9, E-14, F-4
P-E-91	Suruga	Barbara	none provided	A-6
P-E-36	Sweeney	Stephanie	none provided	A-2, E-9
P-PHWNC-15	Swego	Al	none provided	A-1
P-E-190	Swingle	Mark	Virginia Aquarium & Marine Science Center	See detailed technical response in **Table L-6**
P-E-218	Tank	Tamara	none provided	A-2
P-PHC-8	Taylor	Edwin S.	none provided	A-1, E-3
P-E-127	Taylor	Ginger	none provided	A-2, C-5, E-3, E-14
P-PHWNC-43	Taylor	Ginger	none provided	See detailed technical response in **Table L-6**
P-E-123	Taylor	Steven	none provided	A-6

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-PHJ-21	Thompson	Anita	none provided	A-1
P-PHAC-5	Tippins	Colby	none provided	A-6
P-E-193	Trezza	Roseann	none provided	A-5, D-1, E-2, E-7, E-14
P-PHJ-13	Trigueiro	John E.	none provided	A-1, A-6
P-E-153	Tsocanos	Georgia	none provided	A-5, E-2
P-E-214	Tsokanos	Grace	none provided	A-5
P-E-45	Turner	Holly	none provided	A-5
P-E-29	Usery	Stephanie	none provided	A-6
P-E-47	Veale	Stephen	none provided	A-2, E-14
P-PHAC-12	Vizzi (Beasley?)	Gregory F.	none provided	A-2
P-L-14	Voll	Joanne	none provided	A-5, D-1, E-2, E-3, E-14
P-E-17	Wahab	May	none provided	A-3, G-1
P-L-2	Walker	Cameron	Friends School Wilmington	A-5, E-2, E-14
P-E-192	Walker	Jacqueline	none provided	A-3
P-E-115	Wallmeyer	Joseph G.	none provided	A-1
P-E-149	Walsh	Anne	none provided	A-5
P-E-240	Warren	C	none provided	A-1
P-E-117	Watts	Gene	none provided	A-1
P-PHS-1	Weeks	Vicki	Weeks Consulting	See detailed technical response in **Table L-6**
P-E-9	Welch	Jenny	none provided	A-6
P-PHC-7	White	Linda	none provided	A-2, E-3
P-E-144	Whitfield	Kensie	none provided	A-2, E-2
P-E-92	Wilding	Mary	none provided	A-2, D-1, E-2, E-3, E-5, E-14
P-E-1	Wiles	David	none provided	D-1, E-2
P-E-33	Wiles	David K.	none provided	See detailed technical response in **Table L-6**
P-E-15	Williams	James	none provided	A-2, B-23, E-2, E-5, G-1
P-PHWNC-8	Willson	Ken	Coastal Planning & Engineering	D-1, F-3, G-6
P-PHN-12	Wilson	Laura	none provided	A-2, D-1, E-2, E-14
P-PHJ-11	Wing	Thomas	none provided	A-6
P-PHN-17	Winters	Eva	none provided	A-2
P-E-44	Wisner	Lisa	none provided	A-5
P-PHWNC-27	Wisner	Sevi	none provided	A-6
P-E-104	Wolfson	Margo	none provided	A-2, E-2, E-3, E-7, E-8, E-9, E-14
P-PHWNC-3	Woll	Marvin	none provided	D-1, E-2
P-E-87	Wood	Margaret	none provided	A-5, D-1, E-2, E-5, E-7, G-6
P-PHWNC-31	Woodruff	Paige	none provided	A-6
P-E-77	Woods	Susan	none provided	A-5, D-1, E-2, E-5, E-7, G-6
P-E-212	Workman	Jean	none provided	A-6
P-PHWNC-16	Wright	Curtis	none provided	A-1
P-E-27	Wright	Shelia	none provided	A-6

Table L-4. List of Comment Category Codes (continued).

Submission ID	Last Name	First Name	Organization	Comment Codes
P-PHS-7	Wright	Thomas W.	none provided	A-1
P-E-162	Ziecheck	Eric	none provided	A-2
P-E-163	Ziecheck	Leandra	none provided	A-2, F-4
P-E-51	Zoby	Cecilia	none provided	A-2, E-2, E-4, E-5

3. COMMENT SUMMARY AND RESPONSES

The Comment Summary and Responses table (**Table L-5**) is designed to address the general issues for each category of the Comment Code Number list. Each of the comments coded with each Comment Code were read, summarized, and then grouped together and responded to in a general and concise manner to address the general concerns. Placing comments into categories allows similar concerns to be addressed with an appropriate common response and avoids repeating the same response numerous times.

Table L-5

General Comment Summary and Responses

Comment Code	Comment Code Name	Comment Summaries	Response
A-1	In favor of the proposed action (Supports Alternative A)	BOEM received comments expressing support for G&G surveys in the Atlantic, but that did not provide substantive information or questions that could help in improving the Programmatic EIS as a decision-making document. Support for the proposed action was generally connected with support for O&G production.	The Programmatic EIS describes and evaluates potential environmental impacts related to reasonably foreseeable G&G survey activities in the Area of Interest (AOI) for three program areas: oil and gas; renewable energy; and marine minerals. The scope of this Programmatic EIS does not include a National Environmental Policy Act (NEPA) analysis for oil and gas leasing in the AOI and does not authorize an Outer Continental Shelf (OCS) lease sale. The procedures under the OSCLA to set up a lease sale include a specific NEPA evaluation for that proposed action.
A-2	Opposed to the proposed action	BOEM received comments expressing opposition to G&G surveys in the Atlantic, opposed to both alternatives A and B, but that did not provide substantive information or questions that could help in improving the Programmatic EIS as a decision-making document. Opposition to the proposed action was generally directly connected to O&G production.	The Programmatic EIS describes and evaluates potential environmental impacts related to reasonably foreseeable G&G survey activities in the AOI for three program areas: oil and gas, renewable energy, and marine minerals. The scope of this Programmatic EIS does not include a National Environmental Policy Act (NEPA) analysis for oil and gas leasing in the AOI and does not authorize an OCS lease sale. The procedures under the OSCLA to set up a lease sale include a specific NEPA evaluation for that proposed action.
A-3	Neutral	BOEM received numerous comments that did not mention any aspect of the proposed action or the comments indicated they had no preference for a particular Alternative in the Programmatic EIS.	Comments noted.
A-4	Supports Alternative B	BOEM received comments from individuals opposed to Alternative A, but in support of Alternative B. Support for Alternative B was based on agreement with the increased level of mitigative measures in Alternative B compared to those for Alternative A.	Comments noted. This information was considered by BOEM in determining the Preferred Alternative.
A-5	Supports Alternative C	BOEM received many comments expressing a preference for the No Action Alternative, C. The concern was with the perceived incompatibility with various current marine activities including commercial and recreational fishing, and tourism. Concern was also expressed for several resource areas, primarily marine mammals and fishes. The preference for Alternative C was usually combined with a stated opposition to the action alternatives, A and B, which was usually connected to an opposition to future O&G production.	Comments noted. This information was considered by BOEM in determining the Preferred Alternative.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
A-6	Opposition to future oil and gas activities, without any specific reference to G&G activities	BOEM received numerous comments that did not mention any aspect of the proposed action, but instead generally focused on concern for future O&G production off the Atlantic coast. While a few were in favor of O&G, a preference for alternative energy was more frequently mentioned.	The Programmatic EIS describes and evaluates potential environmental impacts related to reasonably foreseeable G&G survey activities in the Area of Interest (AOI) for three program areas: oil and gas; renewable energy; and marine minerals. The scope of this Programmatic EIS does not include a National Environmental Policy Act (NEPA) analysis for oil and gas leasing in the AOI and does not authorize an Outer Continental Shelf (OCS) lease sale. The procedures under the OCSLA to set up a lease sale include a specific NEPA evaluation for that proposed action.
B-1	Fast and efficient regulatory process	BOEM only received comments regarding the regulatory process that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding the regulatory process.
B-2	Balanced energy policy	BOEM received comments suggesting a balanced energy policy that emphasized a full array of domestic energy sources with particular focus on renewable energy. The comments generally expressed support for alternative energy sources as a substitute for oil and gas.	The Programmatic EIS has been developed to analyze the impacts that might result from G&G activities within the Area of Interest (AOI) associated with the three program areas: oil and gas; renewable energy; and marine minerals. The focus of the Programmatic EIS is a result of Congressional directive (2010 USDOI, Environment, and Related Agencies Appropriation Act [P.L. 111-88]) and, therefore, it does not address topics beyond the stated proposed action, purpose, and need, such as the Nation's energy policy.
B-3	State permitting	BOEM only received comments regarding State permitting coordination that required detailed technical responses.	**Table L-6** provides detailed technical responses to State Agencies' comments.
B-4	Request extension of the public comment period for draft Programmatic EIS	BOEM received comments requesting the public comment period be extended to ensure the public had sufficient time to review the Draft Programmatic EIS and provide comments.	In response to the comments, BOEM extended the 60-day comment period an additional 33 days.
B-5	Draft Programmatic EIS is adequate	BOEM only received comments regarding the adequacy of the Draft Programmatic EIS that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding adequacy of the Draft Programmatic EIS.
B-6	Require local/state support	BOEM only received comments regarding local and State permitting coordination that required detailed technical responses.	See **Table L-6** for responses to local and State Agencies' comments.
B-7	Lack of availability of Draft Programmatic EIS	BOEM received comments regarding inadequate advertisement of public hearings and the need for transparency in the NEPA process by making public hearing transcripts available.	The public hearings were advertised through postings on websites, advertisements in newspapers of the cities hearings were held in, and notices mailed directly to parties that had shown a prior interest in the document. The transcripts for the public hearings will be posted on BOEM's website at http://www.boem.gov/oil-and-gas-energy-program/GOMR/GandG.aspx.
B-8	Cooperating agency issues	BOEM only received comments regarding cooperating agency coordination that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding cooperating agency coordination.
B-9	Outer Continental Shelf Lands Act	No comments were received for this category.	No response necessary.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
B-10	National Environmental Policy Act	BOEM only received comments regarding the National Environmental Policy Act (NEPA) that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding NEPA.
B-11	Executive Order 12114	No comments were received for this category.	No response necessary.
B-12	Coastal Zone Management Act	BOEM only received comments regarding the Coastal Zone Management Act (CZMA), primarily from State Agencies that required detailed technical responses.	**Table L-6** provides detailed technical responses to State Agencies' comments regarding CZMA.
B-13	Endangered Species Act	BOEM received comments expressing the view that the proposed action would violate the Endangered Species Act (ESA).	BOEM requested formal consultation under the ESA with FWS on June 11, 2012. On August 7, 2012, FWS concurred that the proposed G&G activities would have no effect on, or would not be likely to adversely affect, the federally listed species or designated critical habitats. On May 24, 2012, BOEM requested formal consultation under the ESA with NMFS. On May 24, 2013, NMFS issued a Final Biological opinion (BO) BOEM requested NMFS reissue the Final BO to include BOEM's clarifications provided on May 9, 2013. On July 19, 2013, NMFS issued a revised Final BO. NMFS concluded in the BO that the proposed G&G activities are not likely to jeopardize the continued existence of the listed species found in the AOI. NMFS also concluded the proposed action is not likely to destroy or adversely modify NARW critical habitat. The BO included terms and conditions that BOEM has incorporated into the mitigations and protocols outlined in the Final EIS. The ITS issued under the ESA by NMFS as a part of the BO must first be authorized by Section 101(a)(5)(a) of the MMPA. The terms of the ITS and the exemption from Section 9 of the ESA become effective only upon the issuance of MMPA authorization to take marine mammals as stipulated in an ITA.
B-14	Marine Mammal Protection Act	BOEM received comments regarding the potential for violation of the Marine Mammal Protection Act (MMPA) as a result of receiving a permit for implementation of the proposed action.	BOEM is working with NMFS to ensure that all requirements of the Marine Mammal Protection Act are met. While this document contains extensive information about the study area relevant to an application for an incidental take authorization (ITA), including estimates of incidental take of marine mammals, its review of G&G activities is programmatic in nature and therefore will not result in an application for an ITA under Section 101(a)(5) of the MMPA. Operators will be required to obtain ITAs when necessary in conjunction with BOEM authorization at the permit/site-specific level. This document shall serve as a reference for environmental documentation regarding future site-specific actions.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
B-15	Magnuson-Stevens Fishery Conservation and Management Act	BOEM received comments expressing the view that the Magnuson-Stevens Fishery Conservation and Management Act (FCMA) would not protect species from negative impacts resulting from the proposed action.	On April 12, 2012, BOEM requested a Programmatic EFH consultation from NMFS. On June 1, 2012, NMFS made the determination that a Programmatic EFH Consultation was not an appropriate mechanism to evaluate EFH impacts of BOEM G&G Activities in the Atlantic based on available information. The agencies have continued to coordinate on this matter and BOEM has proposed to conduct site/permit-specific review and, if necessary, consultation for site/permit-specific activities.
B-16	Clean Air Act	No comments were received for this category.	No response necessary.
B-17	Clean Water Act	No comments were received for this category.	No response necessary.
B-18	National Historic Preservation Act	BOEM only received comments regarding the National Historic Preservation Act that required detailed technical responses, primarily from State Agencies.	**Table L-6** provides detailed technical responses to State agencies' comments.
B-19	Migratory Bird Treaty Act	BOEM only received comments regarding the Migratory Bird Treaty Act that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding the Migratory Bird Treaty Act.
B-20	Executive Order 13547	No comments were received for this category.	No response necessary.
B-21	Rivers and Harbors Act	BOEM only received comments regarding the Rivers and Harbors Act that required detailed technical responses, primarily from Federal Agencies.	**Table L-6** provides detailed technical responses to Federal agencies' comments.
B-22	National Marine Sanctuaries Act	BOEM only received comments regarding the National Marine Sanctuaries Act that required detailed technical responses, primarily from Federal agencies.	**Table L-6** provides detailed technical responses to Federal agencies' comments.
B-23	Survey data availability	BOEM received comments about the data generated during G&G surveys. Many felt this data should be made available to the public to allow for informed decisions regarding future activities.	G&G surveys are conducted by publicly or privately owned companies. These companies usually carry out surveys on a speculative basis, in order to sell the data generated by those surveys on the market. Making the data publicly available would eliminate any market for its sale which would eliminate the incentive for its collection.
C-1	Redefine Purpose and Need	BOEM only received comments regarding the purpose and need that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding purpose and need.
C-2	Issues with screening criteria	BOEM only received comments regarding screening criteria that required detailed technical responses	**Table L-6** provides detailed technical responses to comments regarding screening criteria.
C-3	Other issues with alternatives	BOEM received comments addressing other issues with the alternatives. These included a desire to avoid duplicative surveys that is, multiple surveys of the same area, and a desire to see other less intrusive technologies used in place of airguns.	While the permit applications BOEM has received to date show an overlapping of surveys, it is unlikely that particular areas will be surveyed multiple times. Because surveys are usually done on a speculative basis multiple surveys of the same data would reduce the market for each survey. The Programmatic EIS does evaluate alternative technologies to airguns (see **Chapter 2.5.6**). Although some airgun alternative technologies are available now or in the next 1-5 years, none are at the stage that they can replace airgun arrays.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
C-4	Include the North Atlantic Planning Area	BOEM received comments indicating the area of interest for the proposed action should be expanded to include the North Atlantic Planning Area to tie production from offshore of Nova Scotia to U.S. Atlantic basins.	The suggested expansion was considered as an alternative in the Programmatic EIS, but eliminated from further analysis (see **Chapter 2.5.2**).
C-5	Additional information needed for alternatives	BOEM received comments suggesting additional information was needed by the public and to help evaluate alternatives. Topics mentioned included: establishing a dataset for public planning of future uses of the Atlantic OCS; gathering information to determine if G&G surveys are appropriate on the Atlantic OCS; and, making G&G survey data available to the public to ensure an informed dialogue.	BOEM was directed by the 2010 U.S. Department of Interior, Environment, and Related Agencies Appropriation Act (P.L. 111-88) to conduct a Programmatic EIS to evaluate potential significant environmental effects of multiple G&G activities in the Atlantic OCS. That direction is the basis for the focus on G&G surveys. Release of G&G survey data has been addressed in the response to Comment Code B-23.
C-6	New alternatives	BOEM received comments suggesting additional alternatives. Suggested alternatives included: limiting G&G surveys to the area in which renewable energy activities would occur; developing a comprehensive plan to evaluate all kinds of future uses of the Atlantic OCS.	As noted in the response to comment code C-5, BOEM was directed to carry out the NEPA process and produce a Programmatic EIS that evaluates multiple G&G activities. To restrict the scope of this document and not address all three program areas would fail to meet the agency mandate. Developing a comprehensive plan that evaluates all kinds of future uses of the Atlantic OCS is beyond the scope of BOEM's mandate for this document.
D-1	Active acoustic sound sources	BOEM received numerous comments regarding sound introduced into the water by G&G survey equipment, most concerns centered on airguns, and the impacts on marine resources, primarily marine mammals. Concerns generally viewed the levels of introduced sound, both the intensity and area over which it would be projected, as unacceptable. The estimated take numbers were also viewed as unacceptable, and mitigation measures were considered insufficient.	Incidental take estimates associated with proposed seismic survey activities indicate it is likely that seismic airgun survey-related noise from G&G activities may impact individual and groups of marine mammals within the AOI, including listed and nonlisted cetacean species on the continental shelf, shelf edge, and slope. Based on the results of this analysis and proposed mitigation measures, the effects of project-related seismic airgun survey noise on marine mammals within the AOI would be moderate. Most impacts would be limited to short-term disruption of behavioral patterns or displacement of individual marine mammals from discrete areas within the AOI, including both critical and preferred habitats.
D-2	Vessel and equipment noise	BOEM only received comments regarding vessel and equipment noise that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding vessel equipment and noise.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
D-3	Vessel traffic	BOEM received comments expressing concern about the level of activity resulting from the proposed action, particularly about increased levels of traffic with the potential for increased ship strikes, the right whale was identified as being especially vulnerable, and potential space/use conflicts between seismic ships and commercial fishermen.	The Programmatic EIS analyzed impacts that might result from a number of impact-producing factors including vessel traffic. It is expected that the likelihood of a collision between a project-related vessel and a marine mammal within the AOI is very low, considering the low number of survey vessels (relative to overall vessel traffic) and their relatively low speed of travel, the presence of protected species observers (PSOs) on board certain survey vessels, and adherence to vessel operations guidelines for avoidance of vessel strikes with listed species. Vessel exclusion zones resulting from proposed G&G seismic activity under Alternatives A and B have the potential to directly affect a limited amount of commercial fishing activity within the AOI. Based on the predicted activity levels, G&G vessel traffic and vessel exclusion zones would be intermittent, temporary, and short-term, producing minor impacts, with no population level or regional effects.
D-4	Aircraft traffic and noise	No comments were received for this category.	No response necessary.
D-5	Vessel exclusion zones	BOEM only received comments regarding vessel exclusion zones that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding vessel exclusion zones.
D-6	Vessel wastes	No comments were received for this category.	No response necessary.
D-7	Trash and debris	No comments were received for this category.	No response necessary.
D-8	Seafloor disturbance	BOEM received comments indicating a concern that seismic (G&G) surveys could trigger submarine landslides and negatively impact plant life on the bottom.	As a programmatic document the Programmatic EIS provides a broad level discussion of mitigation measures. Site-specific environmental documentation will provide mitigation measures designed to address the particular circumstances that will be encountered within the physical bounds of a particular project. Further discussion of this topic can be found in **Table L-6**.
D-9	Onshore support activities	No comments were received for this category.	No response necessary.
D-10	Fuel spills	BOEM only received comments regarding fuel spills that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding fuel spills.
E-1	Benthic communities	Comments expressed a concern regarding the impact of seismic surveys on seafloor canyons, corals, the habitat of bottom dwellers, lobsters, and scallop beds. Concern was also expressed regarding proximity of G&G surveys to marine protected areas and coral habitat areas of concern.	**Chapter 4.2.1.2.2** of the Programmatic EIS explains that each survey that would include bottom-disturbing activities would be required to perform clearance surveys to identify sensitive benthic habitats in the survey area which would then be avoided.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
E-2	Marine mammals	BOEM received many comments expressing concern for marine mammals. The comments generally focused on the importance of hearing to marine mammals and the potential impacts sound from seismic survey equipment, airguns in particular, would have on their ability to rest, forage, migrate, avoid predators, and mate. Specific concerns were also stated regarding hearing loss resulting in disorientation, migratory disruptions, and possible death. Comments noted the estimated number of take seemed high. Many comments asked what studies had been done to assess the impacts of airguns. Many comments focused specifically on the northern right whale. Comments also noted a lack of information on which to base the assessment of impacts.	BOEM has utilized the acoustic criteria provided by the National Marine Fisheries Service (NMFS). The Programmatic EIS uses these NMFS thresholds and discusses the Southall criteria as a way of comparison in the document. Other thresholds are not peer reviewed and until the established thresholds are changed, BOEM needs to follow existing thresholds. BOEM recognizes that literature suggests a need for a change to the current standard and that a new standard may be provided, when it is provided, BOEM will be responsive to those changes at that time and each individual survey would utilize the new thresholds. Until then, the existing thresholds must be used.
E-3	Sea turtles	Critical migration and feeding areas current time restrictions would put sea turtles at risk. Comments expressed a concern that the focus of the Draft Programmatic EIS was primarily on nesting turtles in Florida while ignoring turtles in the other states adjacent to the AOI. Comments also noted a lack of information on which to base the assessment of impacts.	A detailed description of all five sea turtle species found in the AOI is presented in **Chapter 4.2.3.1**.. A more detailed description of sea turtle hearing is provided in **Appendix I**. Potential effects of anthropogenic sound on sea turtles are discussed in **Chapter 4.2.3.2.2**.
E-4	Marine and coastal birds	BOEM only received comments regarding marine and coastal birds that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding marine and coastal birds.
E-5	Fish resources and essential fish habitat	BOEM received comments expressing concern about the impact of G&G surveys on fish resources or EFH, specifically that airguns will affect fish's ability to hear which is used to find mates, locate prey, and avoid predators, and which may seriously compromise their ability to survive. Comments also expressed concern with the assessment that impacts would be primarily behavioral and therefore transient in nature. Many comments asked what studies had been done to assess the impacts of airguns. Potential for damage to swim bladders was also mentioned.	**Appendix J** provides a complete discussion of the effects of sound on fish.
E-6	Threatened or endangered fish species	BOEM received comments expressing concern about the impact of G&G surveys on listed species, the Atlantic sturgeon, in particular, was mentioned. Comments also noted a lack of information on which to base the assessment of impacts.	**Chapters 4.2.6**, **4.3.6**, and **4.4.6** include discussion of the Atlantic sturgeon.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
E-7	Commercial fisheries	BOEM received numerous comments expressing concern about the impact of G&G surveys on fish catches. The concerns were both about direct impacts to fish and limitations of access to fishing areas. Concerns also focused on the effect of G&G surveys on fish behavior, impacts to hearing, and the displacement of commercial fisheries. All comments were ultimately tied together with a concern for the potential loss of jobs and revenues that could result from G&G surveys.	As indicated in **Chapter 3.5.1.5**, prior to conducting a seismic survey, operators would submit information to the local U.S. Coast Guard office and the local harbormaster for issuance of a Local Notice to Mariners. The Local Notice to Mariners would specify the survey dates and locations and the recommended avoidance requirements. Experience in the Gulf of Mexico indicates that seismic surveys can be conducted safely without causing significant interruption of fishing activities or economic hardship to the fishing industry. Regarding displacement of commercial fisheries, clarifying text has been added to **Chapters 4.2.5.2.2**, **4.2.7.2.2**, and **4.2.8.2.2**. **Appendix J** provides a complete discussion of the effects of sound on fish.
E-8	Recreational fisheries	BOEM received comments expressing concern about the potential impacts of G&G surveys on fishes and the resultant impact to recreational fisheries. Concerns and comments were largely the same as those for commercial fisheries.	Please see response above to E-7.
E-9	Recreational resources	BOEM received comments expressing concern about the impact of G&G surveys on recreational activities. Comments focused on impacts to the tourism and travel industry along the coastline adjacent to the AOI which accounts for billions of dollars of revenue and hundreds of thousands of jobs.	**Chapter 4.2.9.2** of the Programmatic EIS provides an analysis of potential impacts to recreational resources from vessel exclusion zones and trash and debris associated with G&G activities.
E-10	Archeological resources	BOEM received comments expressing concern about the potential impact of G&G surveys on archeological resources.	As discussed in **Chapter 3.5.1.8**, BOEM would require site-specific information regarding potential archeological resources prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom-founded equipment or structures in the Area of Interest.
E-11	Marine protected areas	BOEM only received comments regarding marine protected areas that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding marine protected areas.
E-12	Other marine uses	BOEM only received comments regarding other marine uses that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding other marine uses.
E-13	Human resources and land use	BOEM only received comments regarding human resources and land use that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding human resources and land use.
E-14	General environmental resource	BOEM received comments expressing concern in general terms (e.g., ocean, sea, sealife, ecosystem, and environment) that did not contain resource-specific comments.	These comments can be addressed by responses provided for the resource-specific comment categories, particularly E-1 through E-13.
F-1	Oil and gas infrastructure	No comments were received for this category.	No response necessary.
F-2	Military activities	No comments were received for this category.	No response necessary.
F-3	Regional sand sources	BOEM received comments expressing concern about any additional requirements that would be placed on G&G surveys for marine minerals in the Atlantic above and beyond current requirements in the Gulf of Mexico.	**Table L-6** provides detailed technical responses to comments regarding sand sources.

Table L-5. General Comment Summary and Response Table (continued).

Comment Code	Comment Code Name	Comment Summaries	Response
F-4	Socioeconomics (general)	Many socioeconomic-related comments were received, some related to negative impacts to commercial or recreational fishing, tourism, and coastal economies. Some comments noted the economic benefits in the form of job creation as a result of G&G surveys.	For comments related to negative impacts, see responses to comment codes E-7, E-8, and E-9. For comments, regarding economic benefits, see **Chapter 4.2.13.2.2** regarding job creation.
G-1	Avoidance and minimization	BOEM received comments encouraging minimization of impacts from the proposed action to fisheries, marine mammals, habitat, and other marine species such as the Right whale.	**Table L-6** provides detailed technical responses to comments regarding avoidance and minimization.
G-2	Expanded Time-Area Closure for NARWs	Comments for this category called for prohibiting G&G activities during November through April, in essence, expanding the closure area to cover the Mid and South Atlantic Planning Areas over the time period specified in the Programmatic EIS.	**Table L-6** provides detailed technical responses to comments regarding closures.
G-3	Time-Area Closure for Nesting Sea Turtles	BOEM only received comments regarding Time-Area Closure for nesting sea turtles that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding closures.
G-4	Separation between Simultaneous Seismic Airgun Surveys	BOEM received comments indicating opposition to the separation distance between surveys.	BOEM has considered the reduction of duplication of effort as a mitigation measure to reduce the overall sound input, for this Programmatic EIS. The idea of eliminating duplicative surveys would require a degree of coordination and direction of the private sector by BOEM that is not part of the operating relationship between this Agency and industry.
G-5	Passive Acoustic Monitoring	BOEM primarily received comments regarding Passive Acoustic Monitoring (PAM) that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding PAM.
G-6	General Mitigation	BOEM primarily received comments regarding General Mitigation that required detailed technical responses.	**Table L-6** provides detailed technical responses to comments regarding mitigation.

4. COMMENTS REQUIRING A DETAILED TECHNICAL RESPONSE

Table L-6

Comment Summary and Responses for Comments Requiring Detailed Technical Responses

Name, Organization	ID	No.	Comment	Response
Elected Officials (sorted by last name)				
Phil Berger, North Carolina Senate	EO-L-3	0.01	While I support the U.S. Department of the Interior's (DOI's) efforts to move forward with G&G data acquisition outlined in the Bureau of Ocean Energy Management's (BOEM) Draft Programmatic Environmental Impact Statement (PEIS) entitled "Atlantic OCS Proposed Geological and Geophysical Activities," I must first express my disappointment with the final Five-Year Program for Outer Continental Shelf (OCS) Oil and Gas Leasing for 2012-2017.	Comment noted.
Phil Berger, North Carolina Senate	EO-L-3	0.02	While additional G&G data can further quantify our nation's OCS resources, they should be viewed as an enhancement of existing data and not a requirement to move forward with responsible leasing, exploration, and development activities. However, in light of the fact that BOEM and DOI continue to not include the Atlantic OCS in their leasing strategies, I urge BOEM and the DOI to complete the PEIS process quickly. This will ensure that pending G&G permit applications before BOEM are approved in a timely and efficient manner so that additional hydrocarbon potential can be quantified and the federal government can be persuaded to re-open North Carolina's OCS for leasing, exploration, and development.	Comment noted.
Phil Berger, North Carolina Senate	EO-L-3	0.03	I support Alternative A (the proposed action). If additional mitigation is deemed necessary, a combination of Alternatives A & B (additional time-area closures and separation of simultaneous seismic airgun surveys) might also be an acceptable solution. I am concerned that Alternative B as a standalone plan will delay acquisition of critical G&G data and, therefore, do not recommend this approach.	Comment noted.
Phil Berger, North Carolina Senate	EO-L-3	0.04	I strongly urge the DOI and BOEM to increase the permitting pace of existing leases in order to expedite job creation and energy delivery to the domestic market.	Comment noted.
Paul G. Campbell, South Carolina State Senator	EO-PHC-1	0.01	Based on the oil and natural gas industry will do everything to make sure that our marine life is protected as much as possible I think we can do this exploration safely.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Paul G. Campbell, South Carolina State Senator	EO-PHC-1	0.02	And, most certainly, if we find natural gas off the coast of South Carolina, that definitely benefits our state.	Comment noted.
Paul G. Campbell, South Carolina State Senator	EO-PHC-1	0.03	Well, it will certainly be able to support more jobs.	Comment noted.
Paul G. Campbell, South Carolina State Senator	EO-PHC-1	0.04	We are satisfied that we are doing things appropriately and safely so we don't hurt our tourism industry.	Comment noted.
Paul G. Campbell, South Carolina State Senator	EO-PHC-1	0.05	I would urge the Bureau of Ocean and Energy Management to consider the pro-development of this part of the region of the continental shelf, the east coast continental shelf, because I do think we can do it safely.	Comment noted.
Paul G. Campbell, South Carolina State Senator	EO-PHC-1	0.06	I do encourage you to go forward with this and allow them to do exploration tests in our areas.	Comment noted.
Thom Goolsby, Senator, North Carolina	EO-PHWNC-2	0.01	One of our concerns was the fact that we may have potential significant natural gas offshore, and as we convert our power plants here in North Carolina from coal to clean burning natural gas, just as we have done in the Sutton plant over here – we're in the process of spending a lot of money to do -- it would be nice to know if we do have significant natural gas reserves.	Comment noted.
Thom Goolsby, Senator, North Carolina	EO-PHWNC-2	0.02	Having our own supply of that right offshore is something we would like to at least know we have and then investigate over the next two years whether or not that can be harvested safely and without environmental degradation and destroying any of our beautiful natural coast that I represent all of New Hanover County.	Comment noted.
Thom Goolsby, Senator, North Carolina	EO-PHWNC-2	0.03	I would ask that you seriously consider Alternative A and move ahead.	Comment noted.
Jenny Horne, State Representative	EO-PHC-2	0.01	We need these studies because the last surveys of this region were conducted more than 25 years ago, especially since recent technological developments have given us much more sophisticated tools to analyze the data from these surveys and to recover oil and natural gas resources discovered through the use of this data.	Comment noted.
Jenny Horne, State Representative	EO-PHC-2	0.02	A recent Wood-Mackenzie study estimates that increasing development would create approximately 5,000 jobs in South Carolina.· These include jobs involved indirectly in developing	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			new energy as well other related jobs in construction, manufacturing and other sectors that affected indirectly by new development.	
Jenny Horne, State Representative	EO-PHC-2	0.03	I urge you to deliver the South Carolina message of supporting the testing that must be done to let us know if there is oil and/or natural gas off the coast of South Carolina.·	Comment noted.
Jenny Horne, State Representative	EO-PHC-2	0.04	If oil and natural gas is found off our coast, we will have the opportunity, along with other states in the South Atlantic region and across the country, to produce American energy for Americans.	Comment noted.
Marge Hutton, County Commission, District 3	EO-PHJ-1	0.01	I ask you to move forward with the seismic surveys in the Atlantic outer Continental Shelf for the sake of Clay County, for the sake of Florida, and our nation's businesses.	Comment noted.
Ann Johnston, Mayor, Town of St. George	EO-PHC-3	0.01	I urge the Bureau of Ocean Energy Management to move forward with 2012 levels to determine what may be out there in the outer continental shelf.	Comment noted.
Ann Johnston, Mayor, Town of St. George	EO-PHC-3	0.02	I find it difficult to name one reason why this state and other coastal states would not pursue the benefits of new industry for the sake of job and capital investments that come from it.	Comment noted.
Ann Johnston, Mayor, Town of St. George	EO-PHC-3	0.03	For each new job created by off shore exploration and production, there will be substantial creation of other jobs to support these efforts.	Comment noted.
Ann Johnston, Mayor, Town of St. George	EO-PHC-3	0.04	The attraction of the coast and drilling for oil for natural gas does not need to be mutually exclusive.	Comment noted.
Bill Rabon, Senator, North Carolina	EO-PHWNC-3	0.01	We have some things offshore. We don't know what we have, but I'm not afraid to look at it to see what we have and to see what we can do with it and see if we can utilize that resource or if we can't. And when we have data, we can use data driven statistics to tell us whether we need to be out there or whether we don't, but we -- we face a conundrum, and we need to get to the bottom of it, and when we do, we'll make a decision, and hopefully we'll make well-informed and proper decisions.	Comment noted.
Bill Rabon, Senator, North Carolina	EO-PHWNC-3	0.02	We need to be out there looking, which leads me to the conclusion and the only conclusion is the option ·that I would support and I'm sure my colleagues in the Senate are going to support very, very shortly -- come out with a statement that we support Option A, and we support it very strongly.	Comment noted.
Scott Rigell, U.S. House of	EO-L-2	0.01	While I am encouraged that the Administration is giving consideration to the vast energy potential waiting to be	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Representatives			developed off our shores, I am disappointed in the slow, tedious, and dismissive approach that has been taken thus far.	
Scott Rigell, U.S. House of Representatives	EO-L-2	0.02	Leaving Virginia's Lease Sale 220 out of the 2012-2017 five year Outer Continental Shelf (OCS) energy plan was a clear indicator that this Administration has no intention of seeing offshore energy production in the Mid-Atlantic region any time soon.	Lease Sale 220 is not part of the activities evaluated in this Programmatic EIS.
Scott Rigell, U.S. House of Representatives	EO-L-2	0.03	I welcome the opportunity for seismic studies to supplement our understanding of the offshore energy resources, but I do not see a legitimate market for that data when there is no plan to allow the energy potential to be developed. Energy producers will only be willing to purchase the data when there is clear evidence they will be able to recover their investments by harvesting the energy resource.	The projected survey levels analyzed in the Programmatic EIS were based on survey applications submitted by geophysical companies. BOEM has contacted the applicants to verify that they are still interested in conducting the proposed surveys. Whether or not there is a market for the seismic survey data would be part of the business decision made by individual geophysical companies, as most large-scale seismic surveys are conducted on a speculative basis.
Frank Shultz on behalf of Senator Menendez	EO-PHAC-1	0.01	I write in opposition to the draft Environmental Impact Statement to allow seismic testing in the Mid Atlantic.· The only reason to allow seismic testing is to later allow oil drilling and we do not need oil spills on the Jersey Shore.	Comment noted.
Frank Shultz on behalf of Senator Menendez	EO-PHAC-1	0.02	I find it interesting that part of the supposed justification to allow this testing is for renewable energy.· Doing seismic testing to site a wind turbine certainly seems like overkill to me unless the Department of Interior is aware of a wind turbine so large that it needs to be anchored miles under the ocean floor.	As described in **Chapter 3.3** of the Programmatic EIS, high-resolution geophysical surveys of the seafloor would be needed for renewable energy site characterization and assessment. These surveys are conducted to obtain information about subsea floor conditions, shallow hazards, archaeological resources, and sensitive benthic habitats. Typical equipment is expected to include single beam or multibeam depth sounders, magnetometers, side-scan sonars, and shallow and medium penetration subbottom profilers. BOEM does not anticipate that deep penetration seismic surveys using airguns would be necessary for renewable energy site characterization and assessment.
Frank Shultz on behalf of Senator Menendez	EO-PHAC-1	0.03	Seismic testing in and of itself is problematic. Not only can it have significant impacts on marine mammals, but it has also been shown to negatively affect nearby fisheries.	Potential impacts of seismic surveys on fish and fisheries are evaluated in **Chapters 4.2.5** (Fisheries Resources and Essential Fish Habitat), **4.2.6** (Threatened and Endangered Fish Species), and **4.2.7** (Commercial Fisheries).
Jason Thompson, NHC Commissioner	EO-PHWNC-1	0.01	Publicly support the proposal to conduct seismic studies of the Atlantic Continental Shelf.	Comment noted.
Jason Thompson, NHC Commissioner	EO-PHWNC-1	0.02	New technology to analyze, explore and produce oil and natural gas will increase the amount that we can recover, and, therefore, the energy to supply our growing demands will improve.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Jason Thompson, NHC Commissioner	EO-PHWNC-1	0.03	According to a recent -- study, opening up Atlantic offshore areas that are currently unavailable could bring more than 35,000 jobs to North Carolina. These jobs would not be limited to oil and natural gas production -- oil and natural gas development but jobs created indirectly by those companies that supply equipment and other support services both offshore and onshore as well as to construct the infrastructure required to drill offshore.	Comment noted.
Jason Thompson, NHC Commissioner	EO-PHWNC-1	0.04	In addition, offshore development could generate much needed revenue to fund critical services, including roads, environmental conservation and education --according to a --study, nearly four billion dollars in revenue -- four billion dollars in revenue could be generated for North Carolina for 2012 -- 2030 if offshore development were allowed to take place in areas that are currently off limits.	Comment noted.
Jason Thompson, NHC Commissioner	EO-PHWNC-1	0.05	The Federal government is currently indicating that leasing in the Atlantic OCS will not be possible until we have more data on potential resources. This will be a major roadblock to the entire process, because without leases, companies -- companies would not be able to explore -- for and develop these valuable offshore resources, stymieing the benefits additional energy, jobs and revenue that offshore oil and natural gas developments will bring.	Comment noted.
Jason Thompson, NHC Commissioner	EO-PHWNC-1	0.06	Please allow the seismic studies to move forward as soon as possible and advance the leasing process on the Atlantic Outer Continental Shelf so our nation can strengthen our energy and economic security.	Comment noted.
Frank Wagner, Virginia State Senator (District 7)	EO-PHN-1	0.01	We have a saying in the General Assembly up there that a vote against a study is a vote for ignorance, and I really want to commend you for moving forward with this study and moving forward with the opportunity to do these seismic surveys in the Mid-Atlantic and South Atlantic areas because this will give us the opportunity to come to grips with what is out there, what quantities are out there, where are the locations, all of those things that we need to know to formulate and debate a strategy.	Comment noted.
Frank Wagner, Virginia State Senator (District 7)	EO-PHN-1	0.02	Once we know these things, then we can analyze whether it's safe, prudent to go after these resources or whether it makes economic sense to go after these resources.	Comment noted.
Frank Wagner, Virginia	EO-PHN-1	0.03	I can't overemphasize the need to have the accurate information for the citizens that we all represent, particularly in the Mid-	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
State Senator (District 7)			Atlantic and South Atlantic area to know what's out there, with a reasonable expectation of what's out there, not data based on technology that's 25 years old and somewhat suspect, to have that actual information to be able to formulate and base decisions on whether or not we should move forward with this, in what manner we should move forward with this and what expectation we can have and results out there.· And for all those reasons, I think this study is altogether appropriate, and we need to move forward with the study.	
Mark Warner, U.S. Senate	EO-L-1	0.01	One of the most important pieces of information we can gain from this process of exploration is to get a clear, detailed accounting of how much oil and gas is present in the Atlantic Outer Continental Shelf areas.	Comment noted.
Mark Warner, U.S. Senate	EO-L-1	0.02	I also urge the Administration to revise the map of the mid-Atlantic OCS to more accurately reflect Virginia's resources as outlined in legislation that I introduced along with Senator Jim Webb, the Virginia Outer Continental Shelf Energy Production Act of 2011. That legislation also provides for revenue sharing with the Commonwealth of Virginia that would pay for transportation infrastructure improvements as well as land and water conservation, as well as alternative energy advancement.	Comment noted.
Federal Agency Representatives (sorted by Agency)				
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.01	Supports Alternative B as Preferred Alternative.	Alternative B has been identified as the Preferred Alternative.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.02	Amend alternative B to 1) expand the geographic boundary of the time-area restriction on airgun seismic surveys to all coastal waters out to 55 km from shore and 2) require passive acoustic monitoring to detect nearby vocalizing marine mammals for all active acoustic surveys that have the potential to take marine mammals by harassment, including high resolution geophysical surveys.	The time-area closures in Alternative B were based on specific areas that are either protected by laws and regulations (right whale critical habitat and Seasonal Management Areas [SMAs]) or documented as high use areas (sea turtle nesting in Brevard County, Florida). BOEM considered expanding the time-area closures based on the best available information at the time this EIS was drafted, areas likely to be of interest to industry and information made available since the release of the Draft Programmatic EIS which included BOEM's 2012 Atlantic resource assessment (USDOI, BOEM, 2012) and NOAA's cetacean stock assessment. Due to this review, BOEM determined that the extent of the closure will remain at 20 nmi from shore for Alternative B, the Preferred Alternative. BOEM will reconsider the value of this measure at the site-specific NEPA level as well as any new information available

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				at that time. In addition, BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat or SMAs (e.g., if they are expanded farther offshore) and will consider new information about NARW distribution. Alternative B, which has been identified as the Agency's Preferred Alternative, includes the required use of PAM at all times for airgun surveys. If BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility for non-airgun high resolution geophysical (HRG) surveys using sources at or below 200 kHz, effective monitoring technologies which could include PAM would be required.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.03	Add an analysis of the direct and indirect economic costs of implementing each alternative, describe the criteria the Bureau will use to select a preferred alternative, and add an additional comment period so that the public is able to review and judge that material and comment on it.	A cost-benefit analysis is not required to satisfy NEPA analysis requirements, particularly if there are important qualitative considerations (40 CFR § 1502.23). However, an EIS should indicate considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision (40 CFR § 1502.23). Therefore, a cost analysis for inclusion of the proposed mitigation measures has been performed and is included in **Chapter 2.7**. This Agency's Preferred Alternative was not identified in the Draft Programmatic EIS because BOEM wished to examine the aggregate comment record before making that judgment. We have presented a rationale for how we chose our Agency's Preferred Alternative in the Final Programmatic EIS in revised **Chapter 2.7**. There is no requirement in the NEPA regulations 40 CFR 1502.14(e) for an Agency's Preferred Alternative to be identified in a Draft Programmatic EIS, only the Final Programmatic EIS. We do not believe the Draft Programmatic EIS needs to be reissued for public comment with a Preferred Alternative identified in it.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.04	Increase BOEM's efforts to maximize the utility of seismic data while minimizing the number and impacts of new seismic studies.	BOEM has considered the reduction of duplication of effort as a mitigation measure to reduce the overall sound input, for this Atlantic G&G Programmatic EIS, as well as in other forums such as the Mitigation and Monitoring Workshop BOEM hosted in November 2012, which was aimed at measures for the GOM, but could also be applied in other regions. At this phase there are few surveys currently occurring on the Atlantic OCS (only those related to marine minerals or renewable energy).

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.05	Include in the final environmental impact statement an alternative that, as part of the permitting process, would promote the further development, testing, and use of alternative, less harmful technologies to collect the required geophysical information.	Please see the response to comment FA-E-4:0.22.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.06	Suggest that BOEM work with other agencies with related responsibilities, the oil and gas industry, scientists, conservation organizations, and other stakeholders to develop standards for baseline data collection and ensure the availability of adequate baseline information before moving forward with the proposed geological and geophysical surveys.	BOEM is working with NOAA and other agencies to develop better baseline information and standards for collecting such data (see the response to the next comment, FA-E-4:0.07). BOEM acknowledges that there is incomplete or unavailable information for marine mammals. However, the information identified as incomplete or unavailable is not "essential to a reasoned choice among alternatives" (40 CFR § 1502.22) as described in **Chapter 4.2.2.1**, and we do not believe it is necessary to wait for new data collection before moving forward with the proposed action.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.07	The data used to estimate takes of marine mammals in the area of interest is based on incomplete or outdated stock assessment surveys. To better convey the uncertainty or reliability of the density and take estimates used in the draft environmental impact statement, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management provide confidence limits and sources of potential bias associated with the density and take estimates that were calculated for each species.	The U.S. Navy's Operating Area Density Estimates (NODE) data are currently the best available data for estimating marine mammal densities in the Mid/South Atlantic Planning Areas. BOEM has used these data within the analyses contained within this Programmatic EIS. The data are also used as part of the marine mammal take estimations via the Acoustic Integration Model (AIM). BOEM does agree and recognize that there are data gaps in marine mammal density information for these areas. We have revised **Appendix E** to better explain any limitations to the density inputs used in the AIM. To help improve density information, BOEM has partnered with the National Oceanic and Atmospheric Administration (NOAA) and other organizations to fund projects to improve biological information on protected species in the U.S. Atlantic. Two notable programs include: • Atlantic Marine Assessment Program for Protected Species (AMAPPS) – This is an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters. The project will also collect similar data at finer scales at several sites of particular interest to NMFS and BOEM. Importantly, AMAPPS also seeks to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics (see http://www.nefsc.noaa.gov/read/protspp/mainpage /AMAPPS/

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				index.html and http://boem.gov/uploadedFiles/BOEM/ Environmental_ Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_ Studies/AT-10-x11.pdf). • Also, BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre, an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/ Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). Ultimately, NEPA requires that Federal agencies use the best available information in environmental impact statements, which BOEM has done. BOEM will continue to monitor the results of AMAPPS and other relevant studies (i.e., NOAA Sound and Cetacean Density Mapping) to ensure any updated data are considered as they become available to support future, site/permit-specific evaluations of individual survey applications and to inform an adaptive management plan. BOEM does not believe it is realistic to develop confidence limits for incidental take estimates at this time for several reasons. First, incidental take applications and authorizations generally do not contain this information. Second, we do not believe it is appropriate to calculate confidence limits for Level A takes because we expect them to be avoided to the extent practicable through mitigation. As noted in **Appendix E**, we estimated Level A takes without mitigation (other than time-area closures), which is the typical method used in incidental take requests and IHAs. Finally, with respect to Level B harassment takes, we note that the current NMFS criterion for pulsed sources (160 dB re 1 µPa) is widely recognized as a very simplistic predictor of behavioral responses and there is much ongoing research and discussion to develop refined behavioral criteria. Therefore, we believe that calculating confidence limits for numbers of Level B harassment takes would imply a level of quantification and statistical certainty that does not currently exist.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.08	The Bureau used 160 dB re 1 µPa (rms) as the behavioral disturbance criteria for the calculation of Level B incidental takes from all sound sources, pulse and non-pulse. Although 160 dB re 1 µPa (rms) is appropriate for pulse signals, such as airguns, it is not appropriate for nonimpulsive sound sources, such as chirp (shallow penetration) sub-bottom profilers. The National Marine Fisheries Service recently clarified that for non-impulsive sound sources, whether continuous or intermittent, Level B harassment is presumed to begin at	The sound sources analyzed in the cited *Federal Register* document (76 FR 43639) are associated with the operation of a liquefied natural gas facility. They are not similar to the non-pulse sources, such as chirp (shallow penetration) subbottom profilers, proposed for this action. In the case of sub-bottom profilers operating in conjunction with seismic surveys, NMFS has used 160 dB re 1 µPa (rms) as the behavioral disturbance criteria for the calculation of Level B incidental takes (e.g., 78 FR 12720, 12730, February 25, 2013). NMFS uses 160 dB as the exposure level for calculating Level B harassment takes for most species

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			received levels of 120 dB re 1 µPa (76 Fed. Reg. 43639). Consistent with that guidance, the Level B harassment zone should be calculated based on that threshold rather than 160 dB re 1 µPa. To address this concern, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management use the 120-dB re 1 µPa threshold to recalculate the Level B harassment zone and associate takes for the use of shallow penetration sub-bottom profilers and other non-impulsive sound sources.	in most cases. This threshold was established for underwater sound sources (except explosives and tactical active sonar) based on measured avoidance responses observed in whales in the wild. NOAA is developing relatively sophisticated new draft guidelines for determining acoustic impacts, including information for determining Level B harassment thresholds (70 FR 1871). The draft guidelines will undergo a rigorous review that includes internal agency review, public notice and comment, and peer review before any final product is published. At that time, BOEM will incorporate the new acoustic criteria into analyses.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.09	The Bureau also noted that certain activities (e.g., drilling of deep stratigraphic or shallow test wells, geotechnical bottom sampling for renewable energy site characterization) would generate continuous sounds associated with the drilling rig or the support vessel's dynamic positioning thrusters. However, the Bureau did not include those sound sources in its modeling or calculation of take estimates. To address this shortcoming, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management include in its calculation of estimated takes an assessment of all potential sound sources associated with geological and geophysical surveys, including exploratory drilling and vessel sounds.	The amount of drilling activity expected as part of the scenario in **Chapter 3.0** is very modest. The need for the type of sound modeling recommended in the comment is not really necessary at the programmatic level based on the level of activity anticipated. Impulse sound from airguns remains the impacting factor of most concern and our modeling has focused on that. Potential impacts of continuous sound from vessels and equipment (including drilling) are addressed qualitatively in **Chapter 4.2.2.2.2**. In those project-specific cases where drilling operations are proposed and the sound source and propagation may be of concern, BOEM will consider the acoustic effects from these activities in site/permit-specific evaluations of individual survey applications.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.10	Require, as a term and condition for issuing a geological and geophysical permit, that applicants obtain authorization under section 101(a)(5)(A) or (D) of the Marine Mammal Protection Act to take small numbers of marine mammals incidental to those activities; such approval should also stipulate minimum requirements for mitigation, monitoring, and reporting, as outlined in Appendix C of the draft document.	**Chapter 5.7.3** has been revised to state that because Incidental Take under the ESA is only issued for ESA-listed marine mammals once the requirements of Section (101)(a)(5) of the MMPA have been met, seismic surveys that could affect ESA-listed marine mammals shall not commence until such time that FWS and/or NMFS have issued, when warranted, the appropriate MMPA ITA and coordinated its requirements with those in any existing or new ESA Incidental Take Statement. BOEM has noted that operators will be required to satisfy the requirements of all other agencies before a permit will be issued. Operators will be required to abide by any mitigation requirements stated in this Programmatic EIS, in addition to those included in an issued MMPA Incidental Take Authorization or ESA Incidental Take Statement.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.11	Use the mitigation measures proposed for seismic airgun surveys (i.e., the seismic airgun survey protocol) as minimal mitigation measures for all high-resolution geophysical surveys and other sounds that have the potential to take marine mammals by Level A or Level B harassment	Please see the response to comment FA-E-4:0.26.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.12	Develop comprehensive, standardized monitoring protocols for assessing the effects of geological and geophysical surveys and associated activities on marine mammals	Through the Adaptive Management process, mitigation requirements could be revised or new protocols developed if new information indicates that they are infeasible or could be made more effective. A discussion regarding adaptive management has been added to **Chapter 1.7.6** and **Appendix C**, **Section 7** of the Final Programmatic EIS to better address how adaptive management will be incorporated in the program. In November 2012, BOEM and NMFS sponsored a Mitigation and Monitoring Workshop for the Gulf of Mexico (GOM) in Herndon, Virginia. This workshop involved multiple stakeholders, including other Federal agencies, industry, academia and NGOs. While the workshop focused on the Marine Mammal Protection Act (MMPA) and the incidental take authorization process specific to geological and geophysical (G&G) activities in the GOM the goal of the workshop was to seek individual expert input from stakeholders to develop "an appropriate suite of effective and practicable mitigations" and to develop "a comprehensive monitoring plan that [would] enable stakeholders to answer questions regarding marine mammals, the effects of industry activities, and the effectiveness of mitigation measures." While this workshop focused on the GOM region, the discussion could also be applied to the Atlantic OCS.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.13	The Bureau proposes to require that ramp-up and shut-down procedures be used to protect all marine mammals. The one situation where this may not be feasible is when dolphins approach a vessel or towed equipment to bow-ride or draft off the equipment. The frequency of such interactions and the best ways to manage them are not clear. To provide that information, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management prepare annual summaries of marine mammal observer reports, including an analysis of the frequency and outcome of all marine mammal-vessel interactions.	The survey protocols described in the Programmatic EIS in **Chapter 2.0**, and in greater detail in **Appendix C**, include the provision that the exclusion zone be kept clear of all marine mammals and sea turtles. The protocols are based on NTL 2012-JOINT-G02 ("Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program") (USDOI, BOEM and BSEE, 2012a), used for all G&G survey activity in the Gulf of Mexico. The protocols in the Programmatic EIS, airgun and HRG surveys, also include the provision that shutdown would not be required for delphinids approaching the vessel or towed equipment at a speed and vector that indicates a purposeful approach to bow-ride or chase towed equipment. In addition, an adaptive management approach will be taken with these protocols. BOEM and NMFS will use the PSO data collection results and annual reports to later determine if shutdowns are warranted. As part of the Reasonable and Prudent Measures outlined in the Biological Opinion issued by NMFS, BOEM will monitor the effectiveness of mitigation measures and analyze data for both stationary and continuous sound sources. This information will be reported to NMFS as part of the requirements under the BO.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.14	Require that all operators report immediately to the National Marine Fisheries Service and the local marine mammal stranding network all injured and dead marine mammals in the vicinity of the proposed surveys, and suspend those activities if a marine mammal is seriously injured or killed and the injury or death could have been caused by those activities (e.g., a fresh dead carcass is found).	The Programmatic EIS identifies the need for these reporting requirements and the development of future guidance similar to BOEM NTL 2012-G01 "Vessel Strike Avoidance and Injured/Dead Protected Species Reporting." The NTL requires that vessel crews must report to NMFS and stranding hotline sightings of any injured or dead protected species (marine mammals and sea turtles) immediately, regardless of whether the injury or death is caused by the vessel. In addition, as discussed in **Appendix C**, the PSOs are required to provide reporting of all sightings.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.15	Revise its cumulative effects analysis to provide a more rigorous and comprehensive assessment of the full impacts of sound and other human-caused and natural activities that affect marine resources in the proposed action area.	The impact analyses included in **Chapter 4.0** have been revised to address this comment.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.16	The continuous time-area restrictions along the east coast would protect breeding and migrating right whales as well as other cetaceans in near-coastal waters (e.g., bottlenose dolphins, common dolphins, white-sided dolphins, spotted dolphins, harbor porpoise, and humpback whales). However, the Commission believes that the proposed corridor is too narrow and should be expanded from 37 km (20 nmi) to 55 km (30 nmi) offshore. Prior to issuing its 2008 regulations to reduce whale-vessel collisions (73 Fed. Reg. 60173), the National Marine Fisheries Service had proposed a protective corridor out to 55.6 km (71 Fed. Reg. 36299). The width of the area was reduced based on potential economic impacts on shipping, even though it reduced protection for right whales. Since then, Schick et al. (2009) have confirmed that migrating right whales occur at least 55 km and as far as 200 km offshore in the mid-Atlantic. Hence, in the Commission's view, the area that would be restricted under alternative B likely would not provide adequate protection for migrating whales.	BOEM considered expanding the closure, but will keep the 20 nmi time-area closure as proposed in the Draft Programmatic EIS. We believe that a 20-nmi time-area closure provides a credible protective measure for NARWs and other marine mammal species transiting through to critical habitats at either end of their north-south seasonal migration. BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat, SMAs (e.g., if they are expanded farther offshore), or Dynamic Management Areas (DMAs) and will consider new information about NARW distribution. Further, this EIS utilizes Adaptive Management, which is discussed in **Chapter 1.7.6**, and **Appendix C**, **Section 7**, allowing BOEM to require monitoring and mitigation measures based on the nature of the activity and the usefulness and costs of the measures.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.17	The 40-km spacing requirement for vessels conducting simultaneous deep penetration airgun surveys is intended to prevent the merger of two ensonified areas to create a single, much larger obstacle to migration. The use of passive acoustic monitoring would provide additional assurance that marine mammals in the area would be detected and shut-down procedures implemented as appropriate. It also would provide a more accurate estimate of the number of animals exposed to	PAM is a required part of the airgun mitigation protocol for Alternative B, which has been identified as the Preferred Alternative. In addition, in some specific instances PAM would be required for non airgun HRG surveys. BOEM agrees that PAM technology can be a useful tool for implementing mitigation, detecting impacts and even providing basic presence/absence information. **Appendix C** has been revised to provide additional discussion of PAM. With regard to requiring PAM during non airgun HRG surveys, please see the response to comment

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			airgun noise. This technology already is required for certain seismic surveys in the Gulf of Mexico and the Arctic, and recent advances have improved its use for detecting, classifying, and localizing marine mammals using open-source software (e.g., PAMGUARD). The Commission has commented often on the limited effectiveness of visual observations and believes that passive acoustic monitoring should be used during all surveys with active sound sources that may take marine mammals, including high resolution geophysical surveys.	FA-E-4:0.26.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.18	The Commission further recommends that the Bureau amend Alternative B to 1) expand the geographic boundary of the time-area restriction on airgun seismic surveys to all coastal waters out to 55 km from shore and 2) require passive acoustic monitoring to detect nearby vocalizing marine mammals for all active acoustic surveys that have the potential to take marine mammals by harassment, including high resolution geophysical surveys.	The time-area closures in Alternative B were based on specific areas that are either protected by laws and regulations (right whale critical habitat and Seasonal Management Areas [SMAs]) or documented as high use areas (sea turtle nesting in Brevard County, Florida). BOEM considered expanding the time-area closures based on the best available information at the time this EIS was drafted, areas likely to be of interest to industry, and information made available since the release of the Draft Programmatic EIS, which included BOEM's 2012 Atlantic resource assessment (USDOI, BOEM, 2012) and NOAA's cetacean stock assessment. Due to this review, BOEM determined that the extent of the closure will remain at 20 nmi from shore for Alternative B, the Preferred Alternative. BOEM will reconsider the value of this measure at the site-specific NEPA level, as well as any new information available at that time. In addition, BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat or SMAs (e.g., if they are expanded farther offshore) and will consider new information about NARW distributionn. Alternative B, which has been identified as the Agency's Preferred Alternative, includes the required use of PAM at all times for airgun surveys. If BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility for non-airgun high-resolution geophysical (HRG) surveys using sources at or below 200 kHz, effective monitoring technologies that could include PAM would be required.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.19	If seismic activities proceed as projected, the potential for multiple surveys of the same areas by different applicants is considerable (Figure E-19, page E-59)—especially during 2013 and 2014, the two years of highest projected seismic survey activity. Conducting multiple seismic surveys of the same area will increase risks to marine mammals and marine ecosystems unnecessarily with no meaningful gain in information.	BOEM has considered the reduction of duplication of effort as a mitigation measure to reduce the overall sound input, for this Atlantic G&G Programmatic EIS, as well as in other forums such as the Mitigation and Monitoring Workshop BOEM hosted in November 2012, which was aimed at measures for the GOM, but could also be applied in other regions. At this phase there are few surveys currently occurring on the Atlantic OCS (only those related to marine minerals or renewable

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			Permitting unnecessarily duplicative surveys is contrary to the charge of balancing orderly resource development with protection of the human, marine, and coastal environments, as directed by the Outer Continental Shelf Lands Act of 1953 (43 U.S.C. 1331 et seq.), as amended. The Bureau stated that they considered coordinating and consolidating seismic surveys to eliminate duplication of survey effort but rejected this approach because the vessel spacing requirements of alternative B would limit concurrent surveys. The Commission agrees that alternative B would prohibit concurrent overlapping or immediately adjacent surveys, but it would not prevent two or more operators from conducting multiple, unnecessarily redundant seismic surveys of the same area at a different time of year or in subsequent years. Rather than re-survey large areas of the Atlantic for which two-dimensional seismic surveys already exist, or conduct multiple overlapping surveys of the same areas, the Bureau should require the oil and gas industry to make the most use of existing, publicly available seismic data. The Bureau also should provide broader access to seismic data that has been collected but that may not yet be in the public domain. This could help to focus and restrict the scope of future surveys to areas that show the most promise for oil and gas development, especially considering that oil and gas resources in the south and mid-Atlantic are expected to be relatively small (Bureau of Ocean Energy Management 2011, Post et al. 2012). The Bureau also should encourage companies that are engaged in or interested in acquiring seismic data in the same areas to collaborate on data collection to limit the number of surveys that are required.	energy). Further, at this time. BOEM projected a level of activity to construct a scenario for this NEPA evaluation. The actual level of activity that results may differ. A site-specific evaluation under NEPA is necessary before this Agency issues any G&G authorization for oil and gas G&G activity. Once issued, a permit is valid for up to one year. The applicant would need to carefully plan the proposed work to ensure that it can be accomplished within the year. Geological and geophysical surveys are conducted by publicly or privately owned companies. These companies usually carry out surveys on a speculative basis in order to sell the data generated by those surveys on the market. Making the data publicly available would eliminate any market for its sale, which would eliminate the incentive for its collection. Eliminating "duplication of survey effort" (i.e., reducing the cumulative survey activity expended by pre- or post-lease operators) is not as straightforward as indicated in this comment. The business models for prelease geophysical operators typically call for joint licensing of an acquired data set by oil and gas operators. That business model, in effect, is a market driven rationing of survey activity. If a geophysical operator does not have industry operators lined-up and accepting the particular parameters for a proposed survey the deployment would not move ahead because the geophysical operator would not make an adequate profit. Geophysical operators will not deploy a survey unless they are comfortable their expenses and profit are covered. The existing prelease business model has a certain self-regulating aspect. The idea of eliminating duplicative surveys would require a degree of coordination and direction of the private sector by BOEM that is not part of the operating relationship between this Agency and industry. The limitations of existing seismic data in the AOI were explained in **Chapter 2.5.3**. Briefly, reliance on existing data, or digitally reprocessed data, does not meet the stated purpose and need as it does not provide accurate data on which to base regulatory and industry decisions. BOEM cannot compel the public release of proprietary data.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.20	The Commission has emphasized the need to minimize redundant seismic surveys in the Gulf of Mexico and the Arctic. The Bureau has considered methods to achieve that objective under the current regulatory framework, but the Commission believes more could be done. To that end, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management increase its efforts to maximize the utility of seismic data while minimizing the number and impacts of new seismic studies. Steps that could be taken	Please see the response to the preceding comment FA-E-4:0.19. Also, **Chapter 2.5.5** of the Programmatic EIS addresses the issue of consolidating or coordinating surveys. As noted **Chapter 2.5.5**, it is not within BOEM's mission to directly undertake G&G activities, except in the rare circumstance BOEM is part of a joint industry project. **Chapter 2.5.5** also notes that consolidating and coordinating surveys would require the creation of another untested series of regulatory controls and reviews and does not clearly fall under the mandates of this Agency or the USDOE or USGS.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			include: analyzing fully all existing, publicly available seismic data; encouraging industry to release seismic data that is not yet in the public domain; collaborating on seismic surveys in areas of common interest; limiting the geographic scope, frequency, sound output, and/or duration of surveys that occur in any given year, especially in preferred marine mammal habitat areas; having the Bureau conduct seismic surveys and making them available to the industry for a fee; auctioning the right to conduct seismic surveys in certain planning areas or blocks; and providing tax or other incentives to companies that use alternative, less harmful technologies for the collection of seismic data.	
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.21	The Bureau rejected an alternative that would have prohibited the use of seismic airguns. Rather than immediately prohibiting airguns, the Bureau should seek an orderly transition by industry from airguns to alternative technologies. In addition to time, such a transition undoubtedly will require permitting incentives and additional research investments. But unless the Bureau steps forward and facilitates a transition to new, less harmful technologies, the development and use of those technologies will be stalled.	BOEM has considered the use of alternative technologies to airguns as a mitigation measure to reduce the overall sound input, for this Atlantic G&G Programmatic EIS, as well as in other forums such as the Mitigation and Monitoring Workshop BOEM hosted in November 2012, which was aimed at measures for the GOM, but could also be applied in other regions. Through our Environmental Studies Program, we recently sponsored a workshop on “Quieting Technologies for Reducing Noise during Seismic Surveying and Pile Driving” (February 25-27, 2013, in Silver Spring, Maryland), to discuss this very topic. BOEM continues to be engaged in the development of new technologies. At this phase there are few surveys currently occurring on the Atlantic OCS (only those related to marine minerals or renewable energy). Further, at this time, BOEM believes that the mitigation measures in Alternative B provide adequate protections to the environment. The construction of our alternatives followed the simple premise that to be a valid alternative it would have to be economically feasible, technically viable, and fulfill the purpose and need for the proposed action. We found that we could not fashion a NEPA alternative based on one or many of alternative acoustic sources to impulse seismic airguns that are described in **Appendix C**, **Section 6** because none of them were economically feasible or technically viable for commercial deployment; all of them being in various stages of development. We do seek an orderly transition by industry toward alternatives to the impulse airgun. BOEM also believes that permitting incentives are worthy of consideration. Incentives may take the form of selective lifting of certain mitigation measures in the seismic protocol, or operating in an area at a time that airguns are not permitted. The ability of BOEM, however, to compel an applicant to deploy a specific technology the applicant may not consider as adequate to their purpose has not been tested.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.22	Recommends that the Bureau of Ocean Energy Management include in its final environmental impact statement an alternative that, as part of the permitting process, would promote the further development, testing, and use of alternative, less harmful technologies to collect the required geophysical information.	BOEM does seek to promote the further development, testing and use of alternative technologies. Through our Environmental Studies Program, we recently sponsored a workshop on "Quieting Technologies for Reducing Noise during Seismic Surveying and Pile Driving" (February 25-27, 2013, in Silver Spring, Maryland), and we will continue to work cooperatively with a variety of interested stakeholders to evaluate the development of new and alternative technologies. BOEM has revised and updated the discussion of non airgun alternatives in **Chapter 2.5.6** and **Appendix C**, **Section 6**. However, we do not believe that constructing a NEPA alternative is the appropriate mechanism to accomplish this objective. NEPA alternatives must be developed to meet the agency's purpose and need. We evaluated a non airgun alternative in **Chapter 2.5.6.8**, and found that it would not meet the agency's purpose and need because currently, none of the non airgun alternatives are economically feasible or technically viable for commercial deployment; all of them being in various stages of development. We do seek an orderly transition by industry toward the use of alternatives to the impulse airgun. BOEM also believes permitting incentives are worthy of consideration. Incentives may take the form of selective lifting of certain mitigation measures in the seismic protocol, or operating in an area or at a time that airguns are not permitted. The ability of BOEM to compel an applicant to deploy a specific technology they may not consider as adequate to their purpose has not been tested.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.23	The Bureau has acknowledged that baseline information is lacking for many marine mammals in the area of interest. However, the Bureau has concluded that the cost of acquiring such information would be exorbitant and such information could not be collected in time to evaluate the impacts of the proposed action. The Commission agrees that the collection of comprehensive baseline information requires a long-term and consistent commitment of effort and resources, and that federal funding for such studies has been limited. Nevertheless, such information is needed to inform decision-makers regarding whether, where, and under what conditions to conduct activities that could have acute or long-term adverse effects on marine mammals and other marine species. In addition, the Commission does not consider the cost of collecting such information to be exorbitant. Furthermore, the failure to invest in the necessary studies undermines our professed intent to manage our marine resources on the basis of sound science.	BOEM acknowledges that there is incomplete or unavailable information for marine mammals; however, the information identified as incomplete or unavailable is not "essential to a reasoned choice among alternatives" (40 CFR § 1502.22), as described in **Chapter 4.2.2.1**. We agree with the comment that "the collection of comprehensive baseline information requires a long-term and consistent commitment of effort and resources, and that Federal funding for such studies has been limited." At the time this Agency's predecessor was engaged in an active Atlantic oil and gas leasing program in the late 1970s and early to mid-1980s, environmental studies were conducted at a level and intensity that paralleled the incipient opening of this OCS region to that activity. Because of the substantial hiatus in the oil and gas leasing program, BOEM's emphasis on conducting baseline studies has been reduced. Yet, BOEM is charged with making a determination in light of imperfect knowledge. To help improve density information for future decision-making, BOEM has partnered with NOAA and other organizations to fund projects to improve biological information on protected species in the U.S. Atlantic. Two notable programs include:

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				• Atlantic Marine Assessment Program for Protected Species (AMAPPS) – This is an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters. The project will also collect similar data at finer scales at several sites of particular interest to NMFS and BOEM. Importantly, AMAPPS also seeks to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics (see http://www.nefsc.noaa.gov/read/protspp/mainpage/AMAPPS/index.html and http://boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_Studies/AT-10-x11.pdf). • Multipurpose Marine Cadastre – BOEM, working with NOAA, has developed an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). Ultimately, NEPA requires that Federal agencies use the best available information in environmental impact statements, which BOEM has done. BOEM will continue to monitor the results of AMAPPS and other relevant studies (i.e., NOAA Sound and Cetacean Density Mapping) to ensure any updated data are considered as they become available to support future, site/permit-specific evaluations of individual survey applications.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.24	The Bureau has not been consistent in its guidance to applicants regarding compliance with the Marine Mammal Protection Act, and this has led to confusion and litigation. To avoid confusion for applicants seeking permits to conduct geological and geophysical surveys in the south and mid-Atlantic, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management require, as a term and condition for issuing a geological and geophysical permit, that applicants obtain authorization under section 101(a)(5)(A) or (D) of the Marine Mammal Protection Act to take small numbers of marine mammals incidental to those activities; such approval should also stipulate minimum requirements for mitigation, monitoring, and reporting, as outlined in Appendix C of the draft document.	**Chapter 5.7.3** has been revised to state that because Incidental Take under the ESA is only issued for ESA-listed marine mammals once the requirements of Section 101(a)(5) of the MMPA have been met, seismic surveys that could affect ESA-listed marine mammals shall not commence until such time that FWS and/or NMFS have issued, when warranted, the appropriate MMPA ITA and have coordinated its requirements with those in any existing or new ESA Incidental Take Statement. To comply with the MMPA, BOEM-issued approval for G&G activities will be conditional on the operator obtaining MMPA authorization (LOA or IHA), if necessary, from NMFS and/or FWS. BOEM cannot proceed with the processing of a permit application for G&G activities until a NEPA analysis is complete and the applicant/operator has secured all necessary approvals, including an LOA or IHA from NMFS and/or FWS. Operators will be required to

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				abide by any mitigation requirements stated in this Programmatic EIS, in addition to those included in an issued MMPA Incidental Take Authorization or ESA Incidental Take Statement.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.25	The Bureau has proposed that the exclusion zone for each survey would be determined on a survey-specific basis, but in any case would not be less than 500 m for airgun seismic surveys and 200 m for high-resolution geophysical surveys. The Commission has previously commented on the need to obtain in-situ sound propagation measurements to calculate survey-specific exclusion zones, and commends the Bureau for including that provision in its proposed mitigation measures for both airgun surveys and high-resolution geophysical surveys.	Comment noted.
Melissa Herman on behalf of Timothy J. Ragen, Ph.D., Marine Mammal Commission	FA-E-4	0.26	As seismic airgun and high-resolution geophysical surveys both use active sound sources that have the potential to take marine mammals by Level A or Level B harassment, it is unclear why the Bureau has proposed different mitigation measures for the two types of surveys. The survey protocols proposed for high resolution geophysical surveys are inconsistent with those proposed by Cape Wind Associates for geophysical surveys, which included the use of ramp-up procedures, multiple observers, and a minimum 500-m exclusion zone. The Commission believes that the mitigation measures proposed for airgun surveys, including the use of passive acoustic monitoring as identified under alternative B and expanded to include also monitoring of high-resolution geophysical surveys, are minimal requirements for all surveys involving active sound sources. Therefore, the Marine Mammal Commission recommends that the Bureau of Ocean Energy Management use the mitigation measures proposed for seismic airgun surveys (i.e., the seismic airgun survey protocol) as minimal mitigation measures for all high-resolution geophysical surveys and other sounds that have the potential to take marine mammals by Level A or Level B harassment.	The rationale for the different protocols is provided in **Appendix C** (**Section 3.2.2** for the airgun survey protocol and **Section 3.3.2** for the HRG Survey Protocol). Considerations that require separate protocols include differences in acoustic sources, estimated Level A and B harassment ranges, activity locations, and vessel size and operating characteristics. Non-airgun HRG surveys typically only involve the use boomer and/or chirp subbottom profiler, side scan sonar, and multibeam/ interferometric /single beam fathometers. The acoustic characteristics of these electromechanical sources are quite different from airguns as explained in **Appendix D**, and the corresponding exclusion zones are smaller. Lower-frequency HRG sources (e.g., boomer, chirp) are often operated at partial power settings, operated at filtered frequency bandwidth, and towed closer to the bottom, reducing the intensity and zone of ensonification and corresponding likelihood of animal exposure and potential impacts. In addition, comparatively small vessels are typically deployed for these small-footprint and short-duration surveys, where sound-producing equipment is vessel-mounted or towed a short distance behind the vessel. Based on the Programmatic EIS analysis, we recognize that there are potential acoustic impacts from the electromechanical sources and we have developed a fit-for-use HRG protocol for that type of survey, supported by the rationale provided in **Appendix C**, **Section 3.3.1**. If BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility for non-airgun HRG surveys using sources operating at or below 200 kHz, effective monitoring technologies which could include PAM would be required.
Anita Barnett, National Park Service	FA-E-3	0.01	No comments	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Ben Laws, NOAA	FA-L-1	0.01	NMFS' Level A harassment criteria are for both pulsed and continuous sounds. There are numerous locations where the PEIS states that Level A criteria are specific to pulsed sounds, with the first example found in the summary on page xiii. Please revise accordingly	Text has been revised to indicate Level A harassment refers to both continuous and impulsive sounds.
Ben Laws, NOAA	FA-L-1	0.02	The additional language regarding jurisdictional authority included in the PEIS is helpful (notably, additions to Sections 2.3, 3.3.1, 3.4.1). However, it remains unclear what jurisdictional relationship may exist between BOEM and COE authorities as relates to survey activities in State waters. Our concern is that consultations required by law for protected species be conducted as appropriate, whether by BOEM, COE, or individual operators. The PEIS should include sufficient information to clarify for the reader what entity would be responsible for requesting required consultations under various scenarios (e.g., site characterization surveys for renewable energy projects in state waters). Example questions for clarification: Section 3.3.1 states that BOEM does not permit site characterization surveys but requires the results of these surveys to be made available before a COP may be approved. Are these surveys permitted by COE in state waters? What if they occur outside of state waters – is there any permitting authority there? These surveys could potentially be non-compliant with the MMPA unless consultation regarding incidental take were conducted, but there is no apparent mechanism by which operators are made aware of this requirement. How and when do results of COE-permitted prospecting surveys, as described in Section 3.4.1, come into BOEM's permitting process?	Text has been added to **Chapters 1.6.2**, **1.6.10**, and **3.3.1** of the Final Programmatic EIS to address and clarify the jurisdictional issues. In addition, **Chapter 1.7.5** has been added to identify future actions required by various laws and statutes that must be completed before G&G surveys under BOEM's jurisdiction may begin.
Ben Laws, NOAA	FA-L-1	0.03	The PEIS references degrees of take avoidance that may be accomplished through permutations of time-area closure for right whales (e.g., Section 2.1.2.1, "avoid about two-thirds of incidental takes"). Location in the document where details of these analyses may be found should be referenced.	**Chapter 2.1.3.1.1** (and other places where similar statement are made) has been revised to refer to supporting information in **Appendix E**. Incidental take was modeled under the scenario of no time-area closures for NARWs. Comparing that estimate with the estimated number of incidental takes with the time-area closures in place (Alternative A), there would be about a 67% reduction in the number of right whale incidental takes with the implementation of the time-area closures. Although incidental take was not modeled for Alternative B, it is estimated that the expanded time-area closure would avoid approximately 80% of the incidental takes of NARWs over the period of the Programmatic EIS (as compared with no closures) based on the geographic and seasonal distribution of right whale densities.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Ben Laws, NOAA	FA-L-1	0.04	Regarding time-area closures, the PEIS contains a notable departure from language provided for NOAA's review during the preliminary draft phase. That document specified that no G&G surveys would occur in critical habitat during the breeding and calving period for right whales (11/15-4/15), while allowing non-airgun surveys within Seasonal Management Areas during the period of effectiveness (11/1-4/30) in support of the renewable energy and marine minerals program areas. The PEIS has been changed to allow these types of surveys (i.e., non-airgun HRG surveys for renewables/marine minerals) in right whale critical habitat. We recommend that the original requirements be restored (i.e., no surveys at all within critical habitat during the specified time period) or, if not, request that BOEM describe explicitly what mechanism exists in the jurisdictional relationship between BOEM and COE that would ensure these "case-by-case" surveys are subject to interagency consultation under section 7 of the ESA. Note that figures 2-1 and 2-3 reflect preliminary draft language (i.e., they show that critical habitat is a 'no-survey' zone rather than a 'non-airgun HRG survey on case-by-case basis' zone).	We acknowledge that there was a change between preliminary draft phase and Draft Programmatic EIS. In addition, the Airgun and HRG Survey Protocols have been clarified since the release of the Draft Programmatic EIS and have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**. BOEM has noted that operators will be required to satisfy the requirements of all other agencies before a permit will be issued. Prior to conducting any G&G activities, operators must submit MMPA authorizations to BOEM. Operators will be required to abide by any mitigation requirements stated in this Programmatic EIS, in addition to those included in an issued MMPA ITA or ESA ITS. Generally, the COE has no regulatory interest in OCS activities, unless a bottom-founded structure is proposed. In those rare circumstances, COE may prepare a separate Statement of Findings/EA or adopt BOEM's NEPA evaluation prior to issuing a Rivers and Harbors Act Section 10 permit. The COE or another Federal agency may also undertake G&G prospecting activities on the OCS in support of Civil Works project authorized by Congress. In those circumstances, such G&G operations are specifically exempt from BOEM's authorization process. In instances when an entity besides a Federal agency or a Federal contractor is undertaking G&G prospecting on the OCS, BOEM may authorize those activities. BOEM may also require and regulate geophysical monitoring pursuant to the use of OCS sand resources in beach nourishment and coastal restoration projects, including those undertaken by the COE under a specific Congressional authorization. In State waters, the COE may permit or undertake G&G activities pursuant to their direct Congressional authorizations, and or Clean Water Act Section 404 and Rivers and Harbors Act Section 10 authorities, including those related to renewable energy and marine minerals development. Pursuant to their regulatory authority and their Nationwide Permit Program, the COE and BOEM may become cooperating agencies to address the environmental compliance requirements for OCS renewable site characterization activities, in instances where there are connected actions that span both the OCS and State waters. Under the renewable energy regulation at 30 CFR part 585 BOEM will not approve SAPs, COPs, or GAPs without adequate G&G surveys for which guidance on their conduct is available from BOEM. See **Chapters 3.3** and **3.4** for additional details.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Ben Laws, NOAA	FA-L-1	0.05	The options for time-area closures are based upon right whale critical habitat and SMAs. As such, we request that BOEM note these would be responsive to any future revisions of critical habitat or changes to SMAs.	See **Chapter 2.1.3.1.1**. Text has been revised to address this comment.
Ben Laws, NOAA	FA-L-1	0.06	New language describing HRG survey protocols (Section 2.1.2.3; Appendix C, Section 3.3.1.4) is problematic, as it implies prior agreement with NMFS that use of these measures would preclude possibility of incidental harassment and eliminate need for ITA under the MMPA. We suggest BOEM describe the required measure using different language that simply describes the measure and why it is proposed (i.e., why it would be effective in mitigating impacts to marine mammals) without suggesting that the inclusion of such a measure indicates any regulatory decision or course of action on NMFS' part. Specific example, Measure 3a: We would not suggest rejecting these measures, but you should be very clear that this does not infer compliance with the MMPA. It is unlikely that we would concur with a determination that recurring action of this nature would absolutely not result in incidental harassment due to the fact that not all marine mammals are likely to be detected. The language used – "BOEM will consult with NMFS about additional requirements" - implies that NMFS has agreed that use of these measures eliminates potential for harassment. Further, use of the word "authorize" may be confused with take authorizations that may be issued by NMFS.	The HRG Survey Protocol has been reworded as suggested to remove the implication that adoption of the particular mitigation measure would result in a particular NMFS regulatory decision or course of action.
Ben Laws, NOAA	FA-L-1	0.07	In addition, it is unclear how an applicant could "demonstrate" that a zone of any given size could be effectively monitored. There is a distinction between "effectively monitored" and being able to detect 100% of animals that may occur within a zone ensonified to 160 dB. The follow-on passage does not draw that distinction. Example language: "The BOEM anticipates that if an operator can effectively monitor the 160-dB zone to prevent both Level A and B harassment of marine mammals, then it would be reasonable to assume that an ITA under the MMPA may not be necessary for that particular survey. Therefore, the protocol would allow an operator to monitor a radius larger than 200 m (656 ft) if the operator demonstrates that it can be effectively monitored." BOEM is explicitly drawing conclusions about future regulatory decisions to be made by NMFS and is equating "effective	The HRG Survey Protocol has been reworded as suggested to remove the implication that effective monitoring implies 100% detection and that adoption of a particular mitigation measure would result in a particular NMFS regulatory decision or course of action.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			monitoring" with 100% detection of marine mammals, which is likely impossible.	
Ben Laws, NOAA	FA-L-1	0.08	In the draft seismic airgun survey protocol, there are a number of instances where BOEM proposes specific time periods (e.g., time period for ramp-up, time period not requiring new ramp-up, requirements relating to borehole surveys) without explaining the rationale for the specific measures. We reiterate our recommendation, provided during the preliminary draft phase, to justify the specifics of the draft protocol.	**Appendix C** has been revised to explain the rationale for the specifics of the Seismic Airgun Survey Protocol.
Ben Laws, NOAA	FA-L-1	0.09	BOEM indicates that as a result of many years of oil and gas development activity in the Gulf of Mexico Region (GOMR), extensive surveys have identified known areas of sensitive biological resources that are avoided through the implementation of Notices to Lessees (NTLs). BOEM indicates mitigative measures similar to the GOMR NTLs are expected to provide protective buffers to the benthic resources of the South Atlantic; however, specific measures have not been developed. Because oceanic features, such as the Gulf Stream, and the extent of important and valuable benthic habitats (e.g., corals, live bottoms, hard bottoms) in the South Atlantic differ from those in the Gulf of Mexico the mitigative measures contained in GOMR NTLs may not be directly transferable for application in the South Atlantic. BOEM should indicate that specific avoidance measures (e.g., buffer zones) will be established through required consultations such as the EFH Consultation with NMFS.	BOEM has initiated an Essential Fish Habitat (EFH) consultation with NMFS for the Programmatic EIS. NMFS has requested that BOEM conduct further EFH assessments for site/permit-specific G&G applications or permitting activities. Buffer zones and mitigation measures for impacts will be identified during site/permit-specific reviews and assessments. When Notices to Lessees (NTLs) are written for the Atlantic, buffer zones will be included in those NTLs. In addition, BOEM Studies program is working to fill in information gaps concerning sensitive biological resources in the Atlantic through ongoing and planned studies. Another source of information for sensitive habitats in the Atlantic is the EcoSpatial Information Database (ESID), which is a BOEM funded database for the Atlantic that includes scientific studies with geospatial data. See http://boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_Studies/GM-08-x13.pdf. Future actions relative to EFH are discussed in **Chapter 1.7.5**.
Ben Laws, NOAA	FA-L-1	0.10	BOEM indicates site-specific information will be required, to include mapping and pre-deployment photographic surveys, to effectively avoid impacting important and valuable benthic communities. Minimum standards for benthic mapping and surveys should be described and defined. As an example, the Florida Department of Environmental Protection's Guidelines for Conducting Offshore Benthic Surveys provides guidelines for developing appropriate protocols for deep water habitat mapping and biological resource surveys.	The Programmatic EIS has been revised to include additional information on this issue. BOEM's Renewable Energy Program is in the process of developing benthic survey guidance (see http://www.boem.gov/uploadedFiles/BOEM/Renewable_Energy_Program/Regulatory_Information/Habitat%20Guidelines.pdf. BOEM's Marine Minerals Program specifies that a survey to map hard-bottom, coral reef, outcrops, and other environmentally sensitive benthic habitat in the proposed borrow area and affected nearshore may be required for areas that have not been characterized or have outdated characterization (defined by BOEM). In addition, for the renewable energy program, BOEM has issued Guidelines for Providing Geological and Geophysical, Hazards, and Archaeological Information Pursuant to 30 CFR part 585.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Ben Laws, NOAA	FA-L-1	0.11	BOEM should also consider adoption of a classification scheme to standardize habitat definitions and descriptions for benthic survey reporting requirements. As demonstrated in BOEM's analysis (Section 4.2.5.; pages 4-106 to 4-115), over time a wide variety of terms and descriptors have been used to characterize similar habitats. The Department of the Interior and NOAA have representatives on the Federal Geographic Data Committee developing the Coastal and Marine Ecological Classification Standard Version 4.0 (CMECS). CMCES is an ecological classification system applicable for coastal and marine systems, which, facilitates integration of existing data into a single framework.	BOEM contributed to the development of CMECS and is working to ensure that all future BOEM funded coastal and marine habitat mapping projects are consistent with this new classification framework.
Ben Laws, NOAA	FA-L-1	0.12	Red Drum is no longer managed by the SAFMC and therefore does not have EFH designated in accordance with the Magnuson-Stevens Fishery Conservation and Management Act.	**Tables 4-19** and **4-21** have been revised to address this comment.
Ben Laws, NOAA	FA-L-1	0.13	BOEM focuses on sound pressure levels in Appendix D and its analysis of fish impacts from seismic surveys (Appendix J). However, many fish and invertebrates are sensitive to particle motion (both otoliths in fish and statocysts in invertebrates act as accelerometers) and to gain a full understanding of the effects of sound on these animals it may be necessary to measure or estimate particle motion. Based on outcomes from a recent BOEM-hosted hydroacoustic workshop for fish and invertebrates, and other efforts (e.g., CEF 2011, Worchester 2006), particle motion may be a more appropriate measure of potential impact for many species. BOEM should consider including discussion of particle motion changes due to seismic surveys.	Revisions have been made to **Appendix J** to address the issue of particle motion.
Ben Laws, NOAA	FA-L-1	0.14	Additionally, modeling increased particle motion throughout various portions of the water column to determine affects (i.e., potential exposure conditions) to habitat quality and species should be considered, identified as incomplete or unavailable information, or identified as a future research need.	Revisions have been made to **Appendix J** to address the issue of particle motion.
Ben Laws, NOAA	FA-L-1	0.15	ONMS supports Alternative B as the preferred alternative because this alternative reduces peak cumulative ensonification potential from multiple simultaneous surveys through the use of separation distances between surveys and reduces the risk of injury to right whales in and around Monitor and Gray's Reef National Marine Sanctuaries through both more conservative time-area restrictions for airgun surveys and the use of passive	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			acoustic monitoring during surveys, which could enhance detection of vocally active species like right whales and thus trigger mitigation to reduce their ensonification within sanctuaries.	
Ben Laws, NOAA	FA-L-1	0.16	Any activity prohibited by ONMS regulations (15 CFR part 922) occurring inside a national marine sanctuary requires an ONMS permit. BOEM described activities under this category include: drilling, coring, exploratory sampling, and placing sensors on the seafloor. The DPEIS states that these activities will not be permitted in national marine sanctuaries, thus this category of impacts is not commented on further here.	Comment noted.
Ben Laws, NOAA	FA-L-1	0.17	ONMS recommends that National Marine Sanctuaries Act (NMSA) section 304(d) consultation requirements be clarified. Federal actions occurring inside a national marine sanctuary that are likely to injure a sanctuary resource require consultation with ONMS. The action does not have to be a prohibited activity to trigger sanctuary consultation. BOEM proposed activities under this category could include use of airgun and other sources during full-scale and HRG surveys conducted inside sanctuaries and vessel traffic associated with survey activities. Generation of noise by these activities is not prohibited and does not require a permit, but is likely to injure sanctuary resources and therefore triggers the sanctuary consultation requirement. Increased risk of vessel-whale collisions within sanctuaries may also be addressed through consultation. Federal actions that occur outside national marine sanctuaries and are likely to injure sanctuary resources within the boundaries of the sanctuary also trigger sanctuary consultation. BOEM proposed activities in this category could include such impacts as turbidity from drilling activities occurring adjacent to sanctuary boundaries or noise from airgun or HRG surveys conducted outside a sanctuary that ensonify sanctuary waters and are likely to impact resources within the sanctuary.	**Chapter 5.7.6** has been revised to address the fact that non-prohibited activities within a NMS may trigger consultation.
Ben Laws, NOAA	FA-L-1	0.18	ONMS suggests that, where appropriate, BOEM should identify that BOEM and ONMS are working on the procedures and specific stipulations that will conservatively indicate when sanctuary consultation is likely to be required associated with BOEM permitting of individual surveys. ONMS is providing notice of the need for NMSA consultation by separate letter.	BOEM has personnel dedicated to ensuring required compliance with regulatory statutes, including the National Marine Sanctuaries Act. These personnel will ensure required compliance at the programmatic as well as site-specific levels of G&G activities. BOEM and BSEE have begun this process through the November 2, 2012, letter to Mr. Daniel Basta the Director of the ONMS and a subsequent teleconference with ONMS staff on May 20, 2013, and October 22, 2013.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Ben Laws, NOAA	FA-L-1	0.19	Additionally, ONMS believes that additional mitigation measures should be considered for the Gray's Reef and Monitor National Marine Sanctuaries that are recognized as important areas for recreational and scientific diving. Ensonification levels in either sanctuary should be no greater than 145dB. Scientific and recreational diving takes place year round in Gray's Reef NMS. ONMS also asserts that notification through "Local Notice to Mariners" is not an adequate strategy to inform the affected public of G&G activities as it is not widely distributed or recognized as a source of information by recreational boaters and/or divers. A well-advertised central source such as a website could be established to provide divers with up-to-date information on G&G activities, in particular those involving air-gun surveys that might impact divers. BOEM should consider conditioning their permits with specific stipulations that require that the operators comply with a communications plan that would include better notification strategies to reach recreational and scientific divers.	As part of the process for site/permit-specific activities BOEM and BSEE's Environmental Enforcement Division will conduct future coordination with NOAA's Office of National Marine Sanctuaries (ONMS). These coordination activities will include the discussion of notification to divers and boaters in the region, beyond the Notice to Mariners, discussion of set-back from the Monitor and Gray's Reef National and Marine Sanctuaries and environmental monitoring and enforcement efforts. BOEM and BSEE have begun this process through the November 2, 2012, letter to Mr. Daniel Basta the Director of the ONMS and a subsequent teleconference with ONMS staff on May 20, 2013, and October 22, 2013. Text has been added to **Chapter 4.2.11.1** and **Appendix C**, **Section 3.1.4** to include this coordination.
Ben Laws, NOAA	FA-L-1	0.20	Page 1-17, Line # or Figure # Section 1.6.15 National Marine Sanctuaries Act; Thank you for including the authorities of the National Marine Sanctuaries Act (NMSA) in Section 1.6 on Regulatory Framework. In the last paragraph, revise as follows: "Because the review under this document is programmatic in nature and does not address project-specific information regarding potential impacts to sanctuaries, it will not result in ~~a~~ site-specific permit applications and review under ONMS regulations at this time. Future, site-specific proposals will be reviewed by BOEM to ensure NMSA consultation and permit requirements are met and that agreed-upon measures will avoid, minimize, or mitigate potential adverse effects. Specifically, BOEM is working with ONMS to develop specific stipulations for sanctuaries that inform applicants for BOEM exploration permits when sanctuary consultation or permits are required and what information is needed about the project at that time."	Text has been revised in **Chapter 1.6.15** to address this comment.
Ben Laws, NOAA	FA-L-1	0.21	Page 2-9, Line # or Figure # Section 2.1.2.7 Guidance for Activities in or Near National Marine Sanctuaries; ONMS suggests the following changes to clarify between ONMS permitting and sanctuary consultation requirements. In the first and second paragraphs, revise as follows: "There are two	Text has been revised in **Chapter 2.1.2.4** to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			NMSs within the AOI: Monitor and Gray's Reef (see Chapter 4.2.11.1.1 for brief descriptions). The BOEM cannot authorize seafloor-disturbing activities within the boundaries of an NMS. Any activity (such as seafloor disturbance or placement of buoys) that is prohibited by sanctuary regulations would require a separate permit issued by ONMS under 15CFR part 922. Operators should contact the relevant sanctuary superintendent for permit application and procedures. Sound-producing activities (such as seismic surveys) proposed in or near the boundaries of an NMS would be assigned a setback distance as a condition of BOEM permit approval to be determined at the time the action is before BOEM and in consultation with the Sanctuary Superintendent pursuant to section 304(d) of the NMSA. Chapter 1.6.15 provides information about the NMSA consultation process. All BOEM authorizations for G&G activities would include instructions to minimize impacts on NMS resources. Additionally, operators proposing to conduct activities within or near the boundaries of Monitor NMS or Gray's Reef NMS would be instructed to exercise caution to ensure that such activities do not endanger any other users of the sanctuaries."	
Ben Laws, NOAA	FA-L-1	0.22	Page 3-16, Line # or Figure # 3.3.2.1. High-Resolution Geophysical Surveys; This proposal stipulates a 30 m minimum resolution for geophysical surveys pertaining to archaeological resources for wide area assessment. ONMS asserts that this is too low of resolution to determine the presence of archaeological material, particularly older shipwrecks which may have a lower profile on the seabed and especially this is too low for potential pre-historic sites. ONMS recommends that BOEM use higher resolution surveys to the greatest extent practical and to ensure that site-specific actions comply with the National Historic Preservation Act section 110 and interagency compliance procedures at section 106. Second bullet under last paragraph: line spacing for all geophysical data for archaeological resources assessments (on magnetometer, side-scan sonar, chirp subbottom profiler) should not exceed 30 m (98 ft) throughout the area. The BOEM may require higher resolution surveys where necessary to ensure that site-specific actions comply with the NHPA.	Text has been added to **Chapter 3.2.2.1** to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Ben Laws, NOAA	FA-L-1	0.23	Page 4-107, Line # or Figure # Section 4.2.5.1.1 Fish Resources/Demersal Resources/Demersal Hardbottom Fishes; Update the estimate of fish species in Gray's Reef NMS and refer to the proper citation. In the fourth paragraph, second sentence, revise as follows: "A conspicuous hard/live bottom feature on the SAB shelf is Gray's Reef NMS offshore Georgia; this site supports an estimated 200 species of fish and is a popular site for recreational fishing and diving (USDOC, ONMS, 2011)."	Text has been revised in **Chapter 4.2.5.1.1** to address this comment.
Ben Laws, NOAA	FA-L-1	0.24	Page 4-162, Line # or Figure # Section 4.2.9.2.2 Evaluation/Vessel Exclusion Zones; BOEM acknowledges that GRNMS and other sites in the AOI are popular dive locations. Notification through "Local Notice to Mariners" is not an adequate notification strategy as it is not recognized as a source of information for recreational boaters and/or divers. A well-advertised central location – on line, list serves, message boards, etc – could be established to provide divers with up-to-date information on G&G activities, in particular those involving air-gun surveys that might impact divers. BOEM should consider conditioning their permits to require a communications plan that would include better notification strategies to reach recreational and scientific divers. Gray's Reef and Monitor NMS staff could assist in conducting the outreach, if appropriate. In first paragraph, last sentence revise as follows: "However, a Local Notice to Mariners would be issued that would specify the survey dates and locations and the recommended avoidance requirements for both vessels and divers. In addition, BOEM would require that the operators would also use other communication strategies to notify other affected public, such as recreational divers."	As part of the process for site/permit-specific activities BOEM and BSEE's Environmental Enforcement Division will conduct future coordination with NOAA's Office of National Marine Sanctuaries (ONMS). These coordination activities will include the discussion of notification to divers and boaters in the region, beyond the Notice to Mariners, discussion of set-back from the Monitor and Gray's Reef National and Marine Sanctuaries and environmental monitoring and enforcement efforts. BOEM and BSEE have begun this process through the November 2, 2012, letter to Mr. Daniel Basta, Director of the Office of National Marine Sanctuaries, and a subsequent teleconference with ONMS staff on May 20, 2013, and October 22, 2013. Text has been revised in **Chapters 4.2.9.2.2**, **4.2.11.2.2**, and **2.1.2.4** to address this consultation.
Ben Laws, NOAA	FA-L-1	0.25	Page 4-172; 4-173, Line # or Figure # Section 4.2.11.1.1 Description of the Affected Environment – National Marine Sanctuaries; Under subsection Monitor National Marine Sanctuary, revise as follows: "Federal regulations (15 CFR 922, subpart F) prohibit certain activities in the Monitor NMS, including (but not limited to) anchoring, diving (except as authorized), cable laying, coring, dredging…" Under subsection Gray's Reef National Marine Sanctuary, revise as follows: "Federal regulations (15 CFR 922, subpart I) prohibit certain activities in Gray's Reef NMS, including (but not limited to) anchoring; dredging,…"	Text has been revised in **Chapter 4.2.11.1.1** to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Ben Laws, NOAA	FA-L-1	0.26	Page 4-177, Line # or Figure # 4.2.11.2.2. Evaluation - Active Acoustic Sound Sources – National Marine Sanctuaries; ONMS and BOEM will initiate discussions about specific stipulations that would identify when sanctuary consultation would be required. It should be clarified here that the NMSA and the ONMS regulations have a broad definition of the terms “sanctuary resource” and “injury”. Of importance is that “injury” includes behavioral disturbance discussed within the section on National Marine Sanctuaries.	Text has been revised in **Chapter 4.2.11.2.2** to address this comment.
Ben Laws, NOAA	FA-L-1	0.27	Page 4-178, Line # or Figure # Evaluation - Active Acoustic Sound Sources – National Marine Sanctuaries - Recreational Resources; In other environmental analyses conducted by the US Navy, it has been acknowledged that divers may be affected by sound levels above 145 dB. It is not clear that an exclusion zone would adequately protect sanctuary users from adverse effects of noise. ONMS does not agree that impacts are negligible and minor given the lack of mitigation measures. Ensonification levels should be no greater than 145dB during time periods and within areas when and where diving is taking place. ONMS asserts that notification through “Local Notice to Mariners” is not an adequate strategy to inform the affected public of G&G activities as it is not widely distributed or recognized as a source of information for recreational boaters and/or divers. A well-advertised central source such as a website could be established to provide divers with up-to-date information on G&G activities, in particular those involving air-gun surveys that might impact divers. BOEM should consider conditioning their permits with specific stipulations that require that the operators comply with a communications plan that would include better notification strategies to reach recreational and scientific divers.	As part of the process for site/permit-specific activities BOEM and BSEE’s Environmental Enforcement Division will conduct future coordination with NOAA’s Office of National Marine Sanctuaries (ONMS). These coordination activities will include the discussion of notification to divers and boaters in the region, beyond the Notice to Mariners, discussion of set-back from the Monitor and Gray’s Reef National and Marine Sanctuaries and environmental monitoring and enforcement efforts. BOEM and BSEE have begun this process through the November 2, 2012, letter to Mr. Daniel Basta, Director of the Office of National Marine Sanctuaries, and a subsequent teleconference with ONMS staff on May 20, 2013, and October 22, 2013. Text has revised in **Chapter 4.2.11.2.2** to address this comment.
Ben Laws, NOAA	FA-L-1	0.28	Page 4-180, Line # or Figure # 4.2.11.2.2. Evaluation – Seafloor Disturbance – National Marine Sanctuaries; As previously noted, site-specific bottom disturbing activities in sanctuaries requires an ONMS permit. Revise first paragraph under National Marine Sanctuaries as follows: Insert new second sentence: “In addition, federal regulations (15 CFR 922, subpart F) prohibit certain activities in the Monitor NMS, including drilling or coring the seabed.” Revise the following sentence: “Bottom-disturbing activities proposed within the boundaries of an NMS would not be permitted by BOEM,	Text has been revised in **Chapter 4.2.11.2.2** to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			whereas bottom-disturbing activities proposed near the boundaries of an NMS would be assigned a setback distance (to be determined at the time the action is before BOEM and in consultation with the Sanctuary Superintendent Manager) as a condition of permit approval. Given these restrictions, no seafloor-disturbing G&G activities including placement of materials would occur within NMS waters without ONMS approval."	
Ben Laws, NOAA	FA-L-1	0.29	Page 5-5, Line # or Figure # Section 5.4 Distribution of DPEIS for Review and Comment; Edit to indicate that the Office of National Marine Sanctuaries (Monitor and Gray's Reef NMSs) is in NOAA line office National Ocean Service instead of the line office of the National Marine Fisheries Service. *Federal Agencies* Department of Commerce National Oceanic and Atmospheric Administration Silver Spring, Maryland National Marine Fisheries Service Silver Spring, Maryland St. Petersburg, Florida Miami, Florida National Ocean Service Office of National Marine Sanctuaries Silver Spring, Maryland Monitor NMS – Newport News, VA Gray's Reef NMS - Savannah, GA Office of Ocean and Coastal Resource Management, Silver Spring, Maryland.	Text has been revised in **Chapter 5.4** to address this comment.
Ben Laws, NOAA	FA-L-1	0.30	Figures-13, Line # or Figure # Figure 4.4; Figure 4.4 shows "Charleston Bump complex" and the box shown encompasses oceanographic features of the Bump complex (and some additional area), but the boxed area does not include the actual bottom features known as the Charleston Bump, which are off SC and GA. For maps of the actual bottom feature, contact: NOAA's Ocean Exploration & Research http:// explore.noaa.gov/". The map is still unpublished and unavailable elsewhere.	**Figure 4-4** shows Habitat Areas of Particular Concern, not seafloor features. The Charleston Bump feature is already shown on **Figure 4-2**.
Ben Laws, NOAA	FA-L-1	0.31	Appendix; Consider including the frequently referred to "BOEM Guidelines for Providing Geological and Geophysical Hazards and Archaeological Information Pursuant to 30CFR 285, BOEM 2011" in the appendices. It seems that this document may be relevant to the substantive provisions in this DPEIS.	In order to avoid making the Programmatic EIS encyclopedic in nature, BOEM prefers to reference such documents and the document is readily available on the internet.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Susan Bromm, U.S. Environmental Protection Agency	FA-L-2	0.01	EPA believes that the draft PEIS provides an adequate discussion of the potential environmental impacts and we have not identified any potential environmental impacts requiring substantive changes. Since a preferred alternative was not identified in the draft PEIS, we are rating both alternatives as LO - "Lack of Objections."	Comment noted.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.01	In general, we concur that many G&G do not constitute a discharge of dredged or fill material and therefore do not require a Corps Section 404 permit. However, the draft PEIS makes a significant omission regarding permits that may be required by Section 10 of the Rivers and Harbors Act (RHA). While the Clean Water Act (CWA) is defined with a somewhat limited glossary statement, the Rivers and Harbors Act (RHA) is omitted in the glossary.	The EIS has been revised in **Chapters 1.6.10** and **1.6.14** to ensure that CWA and RHA requirements are fully and accurately described.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.02	In the regulatory citation section the Marine Protection, Research and Sanctuaries Act of 1972 was omitted even though the regulatory aspects of that legislation were included in the text on pages 3-41 and 4-190.	**Chapter 1.6.16** of the EIS has been revised to ensure that MPRSA requirements are cited where appropriate.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.03	Importantly, while referencing the specific ocean dredged material disposal areas on page 4-190 the PEIS failed to mention that G&G exploration activities at those sites would not likely be approved by the Corps.	Text has been revised in **Chapter 4.2.12.1.5** to note this.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.04	There are numerous comments regarding pipelines. If such pipelines are a part of G&G activities and those pipelines are on the bottom of the OCS or navigable state waters, those pipelines would constitute work in or affecting navigable waters and therefore require a Section 10 permit.	Pipelines are not part of G&G activities. Each individual survey applicant will be required to apply for the required permits for the specific survey activities.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.05	The draft PEIS specifically notes that anchoring (monitoring buoys and cables), pipeline installation, and structure placement (emplacement of wind turbines, buoys, other items) on the seafloor could be expected from G&G actions. There is also a discussion of, "...or placement of bottom-founded equipment or structure". Such activities, that is installations and other devices on the OCS seabed will require Section 10 permits.	**Chapter 1.6.14** of the EIS has been revised to reflect this information.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.06	We recommend that the CWA glossary statement include, "and Corps permits for the discharge of dredged or fill material."	The Clean Water Act entry in the Glossary has been revised to include this wording.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.07	We recommend that the glossary include the Rivers and Harbors Act (RHA), and this statement: An act that requires Corps permits for work or structures, including structures (installations and other devices) on the OCS seabed, in or affecting navigable waters. The Corps evaluates permits for OCS structures with respect to national security and navigational interests.	The RHA has been added to the Glossary with wording as suggested.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.08	Page viii: Add note that Corps permits are also required for structures on the OCS. Also state that Nationwide Permits (NWP) can only be used for activities with minimal adverse environmental impacts, meet the terms and conditions of the NWP, and comply with any Corps District specific regional conditions.	Text has been reworded as suggested.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.09	Page 1-6: Add "including OCS seabed structures" for COE jurisdiction.	Text has been reworded as suggested.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.10	Page 1-15: Add "and OCS seabed structures" for COE approval	Text has been reworded as suggested.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.11	On page 1-15 the draft PEIS discusses the NWP program, also called general permit. NWPs were reissued in 2012, as published in the Federal Register on February 21, 2012. Corps districts added regional conditions as may have been needed to insure that the activity authorized has only minimal adverse environmental impacts. States also reviewed the NWPs and as appropriate provided Coastal Zone Management (CZM) and Section 401 CWA water quality certifications. Any applicant that intends to use a NWP should insure that their proposed activity meets the terms, conditions, and any regional conditions of the NWP, and any additional CZM or Section 401 water quality requirements. Projects that cannot use a general permit will require a standard permit.	Text has been revised in **Chapter 1.6.10** to incorporate this information.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.12	On page 1-17 the draft PEIS appears to confuse Section 10 permit authority with Section 404 actions. There is a discussion regarding the discharge of excavated material that is more related to Section 404 than Section 10. The draft PEIS should simply note that NWP-5 for "Scientific Measurement Devices" and NWP-6 for "Survey Activities" are both appropriate for Section 10 and Section 404 actions. It would be good to add that Section 10 is applicable for structures, installations, and other devices on the OCS seabed. There is a	Text has been revised in **Chapters 1.6.10** and **1.6.14** to address this comment and ensure that the Clean Water Act and Nationwide Permit requirements are accurately described.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			statement regarding "avoid, minimize, or mitigate". In general those terms are only associated with CWA Section 404 discharges, and specifically the 404(b)(1) Guidelines. With regard to Section 10 permits, the Corps is the only agency that has the authority to make a decision to issue a Section 10 permit, based on an applicant's submission of a Corps permit application and Corps decision that the proposed activity is not contrary to the public interest.	
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.13	On page 2-38 there is a statement that G&G surveys are permitted by NWP. That statement should be qualified that the activity is authorized only if it meets the terms, conditions, and any regional conditions of the NWP, and any additional CZM or Section 401 water quality requirements.	Text has been revised in **Chapter 2.3.1** to address this comment.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.14	On page 3-13 there is a statement that surveys are permitted by NWP. That statement should be qualified that the activity is authorized only if it meets the terms, conditions, and any regional conditions of the NWP, and any additional CZM or Section 401 water quality requirements.	Text has been revised in **Chapter 3.2.3.1** to address this comment.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.15	On page 3-22 there is a statement that the use of sand and gravel is permitted by NWP. That statement should be qualified that the activity is authorized only if it meets the terms, conditions, and any regional	Text has been revised in **Chapter 3.4.1** to address this comment.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.16	On page 3-41 (3.6.9) our ocean dredged material disposal areas are used only for dredged material disposal, not "mainly."	Text has been revised to address this comment.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.17	On the top of page 3-42 in reference to sea turtles there are no documented cases of sea turtles being impacted by disposal operations and there are no effluent discharge criteria at ocean sites.	Text has been revised in **Chapter 3.6.9** to address this comment.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.18	On page 4-70 restrictions on hopper dredges related to sea turtles occurs at the hopper dredge where the dredge head meets the sand surface not at or on the beach. Typically dredge material placement operations which occur on the beach are restricted from times of sea turtle nesting.	Text has been revised in **Chapter 4.2.3.1.2** to address this comment.
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.19	On page 4-74 there is reference to the threat to Kemp's ridley sea turtle threats from dredging in the same vein as commercial fishing. As a matter of reference NOAA Fisheries authorizes the legal take of over 10,000 seat turtles annually while the Corps is authorized the legal take of fewer than fifty and of those only a few are Kemp's.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Joseph Wilson, U.S. Army Corps of Engineers	FA-E-1	0.20	On page 4-138 while referring to the threat of dredging to Atlantic Sturgeon we would point out that the primary dredging threat is inland of the coastline and not in ocean waters. Moreover, since coastal channels are frequently dredged they are no longer considered important habitat for Atlantic Sturgeon.	Comment noted.
Tamara Johnson, U.S. Fish and Wildlife Service	FA-E-2	0.01	The Service recommends that BOEM: Utilizes the Memorandum of Understanding (MOU) that they and the FWS entered into on June 4, 2009. The MOU addresses the effects of agency actions on migratory birds, and outlines appropriate MBTA standards and permit requirements to address in NEPA mandated environmental reviews. We expect this MOU will prompt any site-specific coordination necessary if you anticipate adverse impacts on migratory birds as a result of the proposed activities.	Text regarding this recommendation was included in **Chapter 1.6.12**.
Tamara Johnson, U.S. Fish and Wildlife Service	FA-E-2	0.02	Create an inventory of all migratory birds within the area of interest. This would serve as an important resource for assessing impacts if the need arises. The inventory could include migratory birds found on coastal beaches and marshes that could be affected by oil and gas mapping, exploration, and development.	A bird inventory is available for the migratory birds within the area of interest and **Chapter 4.2.4** has been updated to reflect this database which is a dynamic database and includes maps. This compendium will be used in future analysis (O'Connell et al., 2011). Text has been revised in **Chapter 4.2.4.1.3** to reflect this inventory.
Tamara Johnson, U.S. Fish and Wildlife Service	FA-E-2	0.03	Coordinate with the National Wildlife Refuges within the area of interest as survey activities are further refined. Knowledge of the G&G survey activities within Refuge boundaries should help with coordination between the Service and BOEM. Depending on the activity, special use permits or other authorizations may be needed when a Refuge may be affected.	Each survey applicant will be required to coordinate with FWS regarding NWRs as well as all other requisite Federal and State agencies. See text in **Chapter 1.7.5**.
Tamara Johnson, U.S. Fish and Wildlife Service	FA-E-2	0.04	Coordinates with the National Marine Fisheries Service (NMFS) regarding offshore impacts related to marine species.	NOAA is a cooperating agency for the development of this Programmatic EIS. In addition, BOEM has initiated Section 7 consultation with NOAA for the programmatic document and each individual survey applicant will be required to obtain an Incidental Harassment Authorization for each specific survey as applicable.
State Agency Representatives (sorted by Agency)				
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.01	The Department of Natural Resources and Environmental Control (the Department) previously sent comments on the Notice of Intent to prepare a PEIS in a letter dated March 19, 2009 and on the Reopening of the Comment Period for the PEIS in a letter dated May 17, 2010. Those comments remain relevant and should be considered throughout the PEIS process.	The referenced letters have been considered in the development and revision of the Programmatic EIS.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.02	The Department is committed to development of clean domestic sources of energy and the development of sand and mineral resource areas and is concerned with the potential adverse environmental and economic effects of G&G activities supporting oil and gas exploration (particularly the deep penetration seismic airgun surveys). For these reasons, the Department is supportive of Alternative C analyzed in the PEIS; the no action alternative for oil and gas activities in the Mid-Atlantic Region and the status quo for renewable energy and marine mineral G&G activity.	Comment noted.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.03	...as stated in previous letters, we see no documented scientific justification why the unknown and unlikely benefits of oil and gas exploration in the Mid-Atlantic warrant further risks to the environment and public health. Further ocean related tourism remains one of Delaware's largest initiatives and the consequences of a drilling accident as experienced recently in the Gulf of Mexico would be catastrophic for our state economy. For this reason the Department continues to have significant concerns about oil and gas leasing in the Mid-Atlantic OCS Planning Region.	BOEM was directed by Congress to conduct a Programmatic EIS to evaluate potential impacts from G&G activities in the Atlantic OCS. The scope of this Programmatic EIS does not evaluate oil and gas leasing nor does it authorize an OCS lease sale. Further NEPA evaluation would be required if and when a lease sale program is established for the Atlantic OCS.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.04	In addition to long term concerns about our coastal resources, the Department is concerned about the impact of large-scale seismic surveys on the safety of migratory cetaceous mammals, sea turtles, and other listed and important species and habitats offshore of Delaware's coast. Small-scale and site specific (shallow test drilling and deep stratigraphic test wells) activities would also focus the potential negative impacts upon smaller regions; through focused seismic noise, electromagnetic emissions, operational wastes, and seabed disturbance due to seabed-impacting equipment (e.g. anchors, cable lines, sensors, and drilling).	The impact analysis in **Chapter 4.0** of the Programmatic EIS addresses potential impacts on migratory species including marine mammals, sea turtles, and fishes. Site-specific impacts would be evaluated through the NEPA process for individual applications. Operators will be required to abide by any mitigation requirements stated in this Programmatic EIS, in addition to those included in an issued MMPA Incidental Take Authorization or ESA Incidental Take Statement.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.05	**i. Biological Assessment / Biological Opinion** The draft PEIS is not complete without the Biological Assessment that is to be included as Appendix A. The public should be afforded the opportunity to review and comment on this important part of the draft PEIS before the final PEIS and Record of Decision. The Biological Opinion should also be a part of the Final PEIS.	The Biological Assessment was provided on the BOEM website during the comment period. Both the Biological Assessment and Biological Opinion are included in the Final Programmatic EIS.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.06	**ii. 'Take',** Cumulative Impacts, & Potential Biological Removal Individual estimates of Level A (and Level B) 'takes' of some marine mammals are given separately for seismic airgun surveys and non-airgun HRG surveys. For some species, 100s to nearly 1,500 individuals per year were listed as potential 'take' by these activities. Cumulative impacts of estimated 'take' levels should be compiled and presented for all of the proposed activities (seismic airgun surveys, non-airgun surveys, vessel strikes, COST and test well drilling etc.). In addition, because there are other sources of 'take' not associated with the proposed activities (fisheries interactions, vessel strikes, pollution, etc.) additive 'take' caused by the proposed activities should be evaluated. Further, there is no assessment of how the proposed activities could impact the potential biological removal (PBR) for each species. It should be noted that population estimates are not known for many of these species and the impact of 'take' from the proposed activities on the sustainability of those species may not be predictable or credibly determined.	**Chapter 4.2.2** has been revised to address the cumulative impacts of incidental takes on marine mammal species, including a consideration of PBR. Incidental take estimates were developed for airguns and other active acoustic sources. BOEM expects that incidental takes from vessel strikes would be avoided through the mitigation included in the proposed action, and no incidental takes are expected from other sources such as Continental Offshore Stratigraphic Test (COST) well drilling. The cumulative impact analysis has been expanded to consider incidental takes from other reasonably foreseeable activities.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.07	**iii. Data Gaps** It is acknowledged in the draft PEIS that '*there is incomplete or unavailable information (40 CFR 1502.22) for all marine mammals with respect to: (1) seasonal abundances; (2) stock or population size; (3) population trends, whether they are increasing, stable, or decreasing; (4) the hearing range for mysticetes; and (5) the basic biology of specific species and their physiology for underwater hearing*' (pp. 4-43). Yet very specific conclusions are drawn regarding the potential level of impact to an 'adequate degree of certainty'. Inferences are drawn for those species for which there is little information based on known information for unrelated species. The PEIS should be clear about what is considered an adequate degree of certainty and if it is the same for all species or just those for which a certain level of information is available.	As explained in **Chapter 4.2.2.1**, BOEM acknowledges that there is incomplete or unavailable information for all marine mammals with respect to seasonal abundances, stock or population size, population trends, hearing range, and biology and hearing physiology; however, the information identified as incomplete or unavailable is not essential to a reasoned choice among the alternatives. Under NEPA it is the task of the implementing agency to make this determination, subject to the additional consultations that are required by law. **Chapter 4.2.2** reports what we know about the marine mammals that use the AOI and further supporting information is provided in **Appendix H**. **Appendix H**, **Section 6** summarizes the overall state of knowledge with respect to marine mammal species and groups within the AOI. The subject-matter experts for each resource used what scientifically credible information was publicly available at the time this EIS was prepared, and acquired, when possible, new information between the Draft Programmatic EIS and Final Programmatic EIS. Where necessary, the subject-matter experts extrapolated from existing or new information, using accepted methodologies, to make reasoned estimates and developed conclusions regarding the current understanding of resources within the AOI and expected impacts from G&G proposed activities. BOEM's assessment of impacts is not based on conjecture, media reports, or public perception, rather it is based on theoretical approaches, research

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				methods, and modeling applications generally accepted in the scientific community and that are even in the vanguard for assessing these types of impacts. The Draft and Final Programmatic EIS have thoroughly examined the existing credible scientific evidence that is relevant to evaluating the reasonably foreseeable significant adverse impacts of G&G proposed activities on the physical, biological, and human environments. The subject-matter experts that prepared this EIS conducted a diligent search for pertinent information, and BOEM's evaluation of such impacts is based upon current theoretical approaches or research methods generally accepted in the scientific community. All reasonably foreseeable impacts were considered, including impacts that could have catastrophic consequences, even if their probability of occurrence is low.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.08	**iv. Sea Turtles** There are no 'take' estimates for sea turtles such as presented for marine mammals. All the sea turtle species that occur within the Area of Interest are listed as threatened or endangered under the Endangered Species Act (ESA) and take is defined in the ESA. The PEIS also states that sea turtle hatchlings will be insulated from the most harmful components of the propagated sound field because of their location at or near the sea surface. The PEIS should explain how they are not impacted by the source signal which, although directed downward, also travels upward hitting the surface (which acts as a mirror reflecting another signal downward with opposite polarity-called a source ghost?)[2]. [2]http://www.geoexpro.com/article/Marine_Seismic_Sources_Part_I/5db4dd34.aspx. From Geo Expro-Marine Seismic Sources Part 1. Accessed May 16, 2012.	There are no estimates for taking by acoustic harassment because there are no take thresholds for turtles upon which to base such estimates. Potential effects of anthropogenic sound on sea turtles are discussed in **Chapter 4.2.3.2.2**. In order of decreasing severity, these could include death, physical injury, hearing threshold shift, auditory masking, and behavioral responses. In addition, density estimates for sea turtle species offshore of the eastern U.S. are not sufficient to generate take estimates as presented for marine mammals. The appropriate acoustic terminology for source ghost is Lloyd's mirror effect, where a source or receiver close to the surface receives surface reflections of the sound that make it appear as if another source exists above the surface (what the comment is terming "source ghosting"). Since G&G signals are downward directed, they will first travel down to the seafloor and be reflected and/or refracted from the seafloor before they will return to the sea surface to potentially be reflected, creating a Lloyd's mirror effect. During that propagation, the sound will lose energy and be scattered, so it will not act as a point source that can reflect off the sea surface for "source ghosting." In addition, Lloyd's mirror is strongest with low-frequency tones (narrow-band signals) and calm sea conditions (when the surface is glass-like and can act as a good reflector). Since G&G signals are broadband and sea conditions are often not calm, there is very little likelihood that Lloyd's mirror effect could be a factor within the AOI. In addition, the FWS consultation letter included in **Appendix A** indicated concurrence with the no effect on or would not likely adversely affect the federally listed species or critical habitats that was presented in the Biological Assessment. From consultation, NMFS determined that the anticipated level of harassment from G&G activities is not likely to

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				jeopardize the continued existence of the endangered or threatened species for which "take" (by harassment) would be exempted by the Incidental Take Statement included in **Appendix A**.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.09	**v. Seals** The Harp seal (*Phoca groenlandica*) is not included with the list of pinniped species (harbor, gray, hooded). However, more frequent sightings of harp seals have been noted in Delaware than both hooded seals and gray seals (MERR Institute[3]). The presence of pinnipeds in Delaware should not be described as extralimital. The annual seasonal occurrence (typically November to May) of pinnipeds in Delaware is well documented and the preparers of this document should consult local sources for data including representatives from the NOAA-Northeast Stranding Network which track seal strandings and live sightings from Maine to Virginia. [3] Marine Education, Research and Rehabilitation Institute, Inc. (MERR). P.O. Box 411, Nassau, DE 19962	Text has been added in **Chapter 4.2.2.1.2** to address this comment.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.10	**vi. Sturgeon** The PEIS should be updated to reflect the current status of Atlantic sturgeon *(Acipenser oxyrinchus oxyrinchus)* which was listed as an endangered species within the area of interest on April 6, 2012 by NOAA-National Marine Fisheries Service as per the Endangered Species Act.	Text in **Chapters 4.2.6**, **4.3.6**, and **4.4.6** has been revised to address this comment.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.11	**vii. Invertebrates** The PEIS states that there are no known systematic studies of the effects of sonar sound on invertebrates. The following study provides evidence of the trauma caused to cephalopods from low frequency sound produced by large scale offshore activities such as the ones being proposed: Michel André, Marta Solé, Marc Lenoir, Mercè Durfort, Carme Quero, Alex Mas, Antoni Lombarte, Mike van der Schaar, Manel López-Bejar, Maria Morell, Serge Zaugg, Ludwig Houégnigan. Low-frequency sounds induce acoustic trauma in cephalopods. *Frontiers in Ecology and the Environment*, 2011; : 110408135918022 DOI: 10.1890/100124	**Chapter 4.2.1.2** and **Appendix J** have been revised to include impacts to invertebrates.
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.12	**viii. Mitigation & Monitoring** All G&G activities, including those for alternative energy and marine minerals, are expected to be required to use the appropriate mitigations to reduce environmental impacts. The Department supports a program that would monitor and track all G&G activities on the Atlantic OCS. This would enable Delaware and other coastal states to better manage and monitor OCS activities that could possibly negatively impact the State's coastal resources. Additionally, a comprehensive tracking system of proposed and ongoing G&G	Although a comprehensive tracking system may be a useful tool, it is beyond the scope of the Programmatic EIS and BOEM's mission to develop one. Information about G&G permits issued by BOEM would be publicly available. Through the Adaptive Management process, mitigation requirements could be revised or new protocols developed if new information indicates that they are infeasible or could be made more effective. A discussion regarding adaptive management has been added to **Chapter 1.7.6** and **Appendix C**, **Section 7**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			activities would foster increased inter-state and federal coordination on OCS resource management and promote regional cooperation.	
Brian Kelly, Delaware Department of Natural Resources	SA-E-6	0.13	**ix. State Coastal Zone Management Programs** The Federal Coastal Zone Management Act of 1972, as amended, requires that actions on the OCS that will have reasonably foreseeable effects on a State's natural resources or coastal uses must be consistent with federally approved State Coastal Management Programs. As such, individual exploration activities on the OCS with foreseeable impacts to Delaware's coastal resources or uses are subject to review to ensure compliance with Delaware's coastal management policies. As applicable G&G projects are submitted for a federal consistency determination, the Delaware's Coastal Management Program will review potential impacts. The details of the survey type, location, and equipment used will dictate the State's position on each project. Appendix B of the PEIS should also be updated to reflect that the Delaware Coastal Management Program has an updated Program and Policy Document as of June 2011.	Text has been revised in **Appendix B** to address this comment.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.01	Florida supports G&G activities on the South Atlantic OCS as they will play a significant role in supporting the siting of renewable energy projects and helping to locate offshore sand deposits important to beach and shoreline restoration. However, care must be taken to ensure that marine and coastal resources, especially protected species and ecosystems are provided maximum protection. Florida recommends that final requirements be the most protective but do not impose unnecessary regulation or restrictions that increase costs without providing significant benefits to environmental resources. We defer to NOAA Fisheries for final recommendations of protected resources under their jurisdiction.	Comment noted.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.02	While not critical to the implementation of the requirements of the PEIS, the description of Florida Coastal Management Program (FCMP) in Appendix B should be corrected since the Department of Community Affairs no longer exists and has been replaced by the Department of Economic Opportunity. Please refer to http://www.dep.state.fl.us/cmp/partners/state agencies.htm for corrections. In addition, the 2010, not the 2005, Florida Statutes are the most recent approved by NOAA for inclusion in the FCMP.	Text has been revised in **Appendix B** to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.03	Bureau of Beaches and Coastal Systems – It is unclear if the time-area closures proposed for right whale and sea turtle protection will apply to G&G activities, which do not use airguns, related to sand searches for beach projects, or what factors would be considered in the case-by-case decision. [Section 2.1.2.1: " However, HRG surveys proposed in critical habitat area and SMAs may be considered on a case by- case basis only if: (I) they are proposed for renewable energy or marine minerals operations; and (2) they use acoustic sources other than air guns."]	Since the release of the Draft Programmatic EIS the non airgun HRG protocol has been clarified and the case-by-case language has been removed. As a result of the clarification time-area closures would generally not be applied to surveys using non airgun HRG acoustic sources. Those clarifications have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). The Programmatic EIS has been revised to ensure that it clearly and consistently indicates what G&G methods and equipment are subject to time-area closures and other mitigation requirements. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. No airgun surveys would be authorized within the closure area during that time. HRG non-airgun surveys with sources below 1.6 kHz would be restricted within this area from May 1 to October 31. HRG non-airgun surveys with sources above 1.6 kHz would not be subject to the sea turtle time-area closure.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.04	Imposition of the area-time closures for both sea turtles and right whales would leave only two, two week periods for surveying (April 16 – April 30 and November I – November 14). Such a limitation would significantly affect the time frame for sand searches, especially if the remote sensing data would have to be reviewed prior to any seafloor-disturbing activities. What type (s) of site-specific information is required? Would new remote-sensing or other data for an area be required, or would a review of existing data from previous studies and reports be sufficient? The restriction of having to do seismic/remote sensing first, getting it reviewed, and then approving vibracoring greatly increases the time and operational costs of sand searches, as multiple deployments would be required.	Neither Alternative A nor Alternative B limits marine minerals HRG surveys to the small time periods indicated. As stated in **Chapters 2.1.3.1.1** and **2.1.3.2.1** (for the NARW time-area closure) and **Chapter 2.2.2.2** (for the sea turtle time-area closure), no airgun surveys would be authorized within the closure area during that time and non-airgun HRG surveys with sources below 1.6 kHz would be restricted within this area from May 1 to October 31. Non-airgun HRG surveys with sources above 1.6 kHz would not be subject to the sea turtle time-area closure. The two week window would be limited to airgun surveys. BOEM does not expect that airguns would be used for marine minerals HRG surveys.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.05	The Department of Environmental Protection (DEP) Bureau of Beaches and Coastal Systems expressed concerns about the application of mitigation in state waters and potential inconsistencies with Chapter 161, Florida Statutes. Throughout this document G&G activities (that do not use airguns) in support of marine minerals have negligible to minor impacts on resources. Florida has reviewed numerous G&G activities for sand searches in state waters and have found them to be negligible in impacts to resources. Legislation passed this year now exempts them from permitting [CSIHB 691]. The BOEM proposal to apply the proposed mitigation measures in state waters would appear to contradict the intent of this legislation.	BOEM does not authorize G&G activities in State waters. The scientific rationale for the proposed time-area closures and mitigation measures applicable to marine minerals HRG surveys is presented in **Appendix C**. BOEM will not place unnecessary restrictions on these projects.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			The Bureau of Beaches and Coastal Systems is charged in Chapter 161, F. S. to plan and implement a program that cost effectively restores and maintains Florida's coastal system and beaches. It would be inconsistent with this statute if unnecessary costs and restrictions were placed on sand searches.	
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.06	Florida Geological Survey – Deep stratigraphic test wells and borings to facilitate an understanding of the competence of sediments to support seabed structures present the potential to allow the activation of artesian flow from the Floridian aquifer system or other aquifers in the area. While the risk of such is presumed to be negligible, buried, infilled karstic collapse features, i.e. buried sinkholes, lying beneath the seafloor of the inner continental shelf off the east coast of Florida within the ADI are known to exist. The avoidance of such features during the placement of stratigraphic test wells, borings and foundations into the seabed is suggested.	Prior to deep test wells or borings being performed, geophysical surveys would be performed which would identify these types of features and they would be avoided.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.07	The FGS has the ability to archive geologic samples (e.g., cores and cuttings) and geophysical data collected offshore of Florida and to make those samples and data available for future research. It is requested that the FGS be given access to any geological, geochemical and geophysical data, to include bottom samples, borings and stratigraphic test information as well as high resolution shallow penetration sub-bottom profiler, side scan sonar, swath bathymetry, and traditional bathymetric survey data that might be collected proximal to the coast of Florida. The FGS is interested in what these data sets might reveal regarding the geology of Florida.	Information that can be publicly released will be made available to the Florida Geological Survey (FGS). Depending on the survey, some data collected during G&G surveys may be considered proprietary and therefore not available for public distribution.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.08	Div. of Historical Resources – This agency has concerns about potential impacts to archaeological resources off of the east coast of Florida. Proposed project activities which may impact archaeological resources include seafloor disturbing activities among other, less detrimental activities. Nevertheless, Section 2.1.2.6.1. Avoidance and Reporting Requirements for Historic and Prehistoric Sites addresses these concerns. Site specific information will be required prior to approval of seafloor disturbing activities or placement of equipment or structures on the seafloor. We concur that archaeological resource surveys be required and stipulations be in place for the protection of any significant archaeological resources. Procedures for the reporting of fortuitous finds must also be enforced.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.09	ERP – In accordance with the St Johns River Water Management District Operating Agreement, any work within waters of the state of Florida (from the shore to within 3 nmi) would require an environmental resource permit (ERP) as well as a state lands authorization from the Department for use of those sovereign bottoms where applicable. It appears as though the proposed exploration area covers two DEP regulatory districts (Northeast and Central) and both districts should be contacted.	Text has been revised in **Chapter 1.6.18** to address this comment. Coordination with the appropriate District will be handled during project specific permitting.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.10	As Jacksonville is home to Naval Station Mayport, Naval Air Station Jacksonville, and JaxPort, any activities that would interrupt shipping channels or daily operations of any of these facilities would be of concern.	As discussed in **Appendix C**, **Section 3.8**, coordination with the appropriate military command headquarters will be required for all survey activities near military installations.
Debby Tucker, Environmental Administrator, FDEP	SA-E-2	0.11	In addition to the above named facilities, the proposed exploration area is adjacent to and includes some environmentally sensitive areas such as Fort Clinch State Park Aquatic Preserve and the Nassau River-St Johns River Marshes Aquatic Preserve.	The two aquatic preserves cited are shown on **Figure 4-35**.
Chris Clark, Georgia DNR	SA-L-3	0.01	Under Georgia's Coastal Management Program, the Georgia Department of Natural Resources' Coastal Resources Division (GADNR/CRD) is the lead agency responsible for federal consistency coordination with our networked sister agencies. General information requests and dissemination will be handled by GADNR/CRD. Several other GADNR Divisions focus on discrete groups of marine resources and have technical specialists that would like to serve as Coordinating Agencies to assist in the development of the G&G PEIS.	**Appendix B** addresses the States' roles in consistency review.
Chris Clark, Georgia DNR	SA-L-3	0.02	The GADNR Wildlife Resources Divisions' (GADNR/WRD) Nongame Section would like to serve as Georgia's Coordinating Agency for Marine Mammals, Sea Turtles, and Coastal and Marine Birds.	Text has been revised in **Appendix B** and in **Chapter 1.6.18** to address this comment.
Chris Clark, Georgia DNR	SA-L-3	0.03a	Prior to initiation of any seismic activity, significant additional mitigation measures will be required to meet the needs of these whales, and to bring G&G activity into compliance with federal laws that protect them (ESA, MMPA).	The Programmatic EIS includes extensive mitigation measures during seismic surveys as detailed in **Appendix C**. All survey authorizations will require operators to be in compliance with the ESA and MMPA. Information about ESA and MMPA required compliance is presented in **Chapters 1.6.6** and **1.6.7** of the Programmatic EIS, respectively. Further detail is in **Appendix A**, which contains the BA and the BO.
Chris Clark, Georgia DNR	SA-L-3	0.03b	GADNR Considerations and Need for right whales to be included in Mineral Management Service's DPEIS: 1. Ship-based visual detection mitigation techniques for right whales are inadequate due to the animal's ability to lie just under the	Ship-based monitoring is discussed in **Appendix C**, **Sections 3.2** and **3.3**. The pre ramp-up search period (of at least 60 minutes duration) prior to the onset of ramp-up is designed to assist visual observers locate marine mammals during their normal dive (or subsurface rest)

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			surface and remain undetected.	frequency. Though right whales may lie below the surface for periods of time, it is expected that trained PSOs would spot exhalation plumes and surface disturbances. For the Preferred Alternative PAM would be incorporated into the Seismic Airgun Survey Protocol. In addition, if BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility for non-airgun HRG surveys using sources operating at or below 200 kHz effective monitoring technologies, which could include PAM would be required. These measures improve detection of marine mammals and further reduce potential impacts to the NARW and other marine mammals.
Chris Clark, Georgia DNR	SA-L-3	0.03c	2. Communication between adult female right whales and their calves is either non-auditory or at a frequency not detected with conventional acoustic equipment. As such, towed passive acoustic arrays as described by AIGC will not be adequate in and around the calving grounds to detect the most important population demographic, adult females.	It is understood that PAM is not effective if whales are silent or vocalizing at frequency levels below the detectable frequency range of the PAM hydrophone array. However, it is expected that the majority of these animals would be detectable visually by PSOs. Additionally, NMFS will work with operators to determine which PAM systems are adequate for use. The preferred Alternative, Alternative B, contains time area closures that include calving grounds for the NARW. Additionally, site-specific NEPA analysis may require further mitigation measures.
Chris Clark, Georgia DNR	SA-L-3	0.03d	3. Geologic and Geophysical activity, including seismic testing, may have dramatic and potentially lethal impacts on the behavior and health of the population of right whales. The effects of air-gun arrays used during geophysical seismic surveys on baleen whales are not well known.	Impacts of G&G activities on right whales are analyzed in **Chapter 4.2.2** and the Biological Assessment. Taking into account the mitigation included in the proposed action, potentially lethal impacts are not expected based on the best available scientific information.
Chris Clark, Georgia DNR	SA-L-3	0.03e	4· A thorough understanding of acoustic sensitivities of baleen whales does not exist and is needed.	**Appendix H** of the Programmatic EIS reviews the best available scientific information concerning the hearing and acoustic sensitivity of marine mammals. This information was incorporated into the impact analysis in **Chapter 4.2.2**. The Programmatic EIS has thoroughly examined the existing, credible scientific evidence relevant to evaluating the reasonably foreseeable, significant adverse impacts of the proposed activities. All reasonably foreseeable impacts have been considered, and the characterization of impact magnitude and duration is supported by credible scientific evidence.
Chris Clark, Georgia DNR	SA-L-3	0.03f	5. Right whales do not move out of the way from approaching vessels, making them extremely vulnerable to ship strike, particularly from larger ships traveling faster than 10 knots.	Mitigation measures to avoid vessel strikes are included in the proposed action as described in **Appendix C**, **Section 3.1.1**. Survey speeds are generally less than 5 kn (9.26 km/hr) and PSOs would be scanning the sea surface around the survey vessels. The risk of vessel strikes from survey vessels is low as noted in **Chapter 4.2.2.2.2**. BOEM's proposed guidance for vessel strike avoidance is consistent with the speed recommendations noted in this comment. All authorizations for shipboard surveys, regardless of vessel size, would include guidance for

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				vessel strike avoidance while in transit. The guidance would be similar to NTL 2012-JOINT-G01 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") (USDOI, BOEM and BSEE, 2012b), which incorporates NMFS "Vessel Strike Avoidance Measures and Reporting for Mariners" addressing protected species identification, vessel strike avoidance, and injured/dead protected species reporting. Vessel operators, crews, and visual observers or PSOs must maintain a vigilant watch for marine mammals and sea turtles and slow down or stop their vessel to avoid striking protected species. Vessel speed shall also operate within the 10 kn (18.5 km/h) speed restriction in: DMAs, Mid-Atlantic U.S. SMAs November 1 through April 30, and critical habitat and Southeast U.S. SMAs from November 15 through April 15 (in accordance with NMFS Compliance Guide for the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105). With these mitigation measures in place, survey vessels are unlikely to strike marine mammals. Seismic vessels, which account for most of the project related vessel traffic associated with the proposed action, survey at a speed of approximately 4.5 kn (8.3 km/hr). In addition, waters surrounding survey vessels for airguns and non airgun HRG operating below 200 kHz on survey would be monitored by PSOs or visual observers for the presence of all marine mammals and sea turtles. Outside of critical habitat, SMA, and DMAs, during transit to and from shore bases, seismic vessels and other survey vessels are expected to travel at greater speeds. However, as noted above, these vessel movements would be subject to BOEM guidance for vessel strike avoidance and be required to reduce speed in certain areas to comply with the Right Whale Ship Strike Reduction Rule and when mother/calf pairs, pods, or large assemblages of cetaceans are observed near an underway vessel. BOEM also conducted ESA Section 7 consultation with NMFS regarding the proposed action and will comply with reasonable and prudent measures to protect right whales and other endangered species as specified in the Biological Opinion (see **Appendix A**).
Chris Clark, Georgia DNR	SA-L-3	0.03g	6. The deployment of sensory arrays during seismic activity in the Atlantic may cause a physical threat to right whales through creating a potential entanglement source in the array, and by ship strike risk from associated vessel transects.	There has never been a reported case of a marine mammal becoming entangled in seismic equipment so the risk is considered to be very low. Mitigation measures to avoid vessel strikes are included in the proposed action as described in **Appendix C**, **Section 3.1.1**. Survey speeds are generally less than 5 kn and PSOs would be scanning the sea surface around the survey vessels. Please see responses to SA-L-3:0.03b and SA-L-3:0.03f.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Chris Clark, Georgia DNR	SA-L-3	0.03h	7. Right whales are present in southeastern U.S. waters from shore to a minimum of 40 nm seaward of land from November 15-April 15 every year. This area includes, but is more extensive than the designated Critical Habitat at described in the Right Whale Species Recovery plan.	The time-area closures for seismic airguns under both Alternatives A and B are larger than the Critical Habitat area. The closure area under Alternative A includes the Mid-Atlantic and Southeast U.S. SMAs and DMAs for the NARW. The Southeast U.S. SMA, with seasonal restrictions in effect from November 1 to April 30, is a continuous area extending from St. Augustine, Florida, to Brunswick, Georgia, extending 37 km (20 nmi) from shore. The Mid-Atlantic SMA, with seasonal restrictions from November 1 through April 30, is a combination of both continuous areas and half circles drawn with 37-km (20-nmi) radii around the entrances to certain bays and ports. Under Alternative B, the time-area closure would be expanded to a continuous 37-km (20-nmi) wide zone extending from Delaware Bay to the southern limit of the AOI and also includes DMAs. See **Chapter 2.1.2.1** and **2.2.2.1** and **Appendix C** of the Programmatic EIS. Further, at this time BOEM believes that the mitigation measures in Alternative B provide adequate protection. This mitigation measure may be considered again during site-specific analyses.
Chris Clark, Georgia DNR	SA-L-3	0.03i	8. The North Atlantic right whale population is severely compromised from historic hunting pressure but remains suppressed. Entanglement in fishing gear and collision with ships remain significant threats. The continued existence of this species is strongly dependent on the continued integrity of the calving grounds, as well as regulation to protect them throughout their migratory year.	Existing threats to the NARW population are discussed in **Chapter 4.2.2.1** and in the Biological Assessment. Cumulative impact analysis in **Chapter 4.2.2.4** and the Biological Assessment took into account the existing threats. Please see response to SA-L-3:0.03f regarding vessel strike mitigation measures.
Chris Clark, Georgia DNR	SA-L-3	0.04	Preliminary GADNR Recommendation Regarding Right Whales: Temporally restrict any Geologic and Geophysical activities, including seismic studies and any ship related activities, to a period outside of the right whale winter season off of the southeastern US coast, from November 15 to April 15. The minimum standard mitigation measures described by IAGC are not adequate to protect right whales.	The proposed action includes extensive mitigation measures that are included in **Appendix C** that are well beyond those described by International Association of Geophysical Contractors (IAGC) as referenced in this comment. Airgun and HRG Survey Protocols have been clarified since the release of the Draft Programmatic EIS and have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). BOEM has also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5.** **Chapter 5.7.3** has been revised to state that because Incidental Take under the ESA is only issued for ESA-listed marine mammals once the requirements of Section (101)(a)(5) of the MMPA have been met, seismic surveys that could affect ESA-listed marine mammals shall not commence until such time that FWS and/or NMFS have issued the appropriate MMPA ITA and coordinated its requirements with those in any existing or new ESA Incidental Take Statement. BOEM has noted that operators will be required to satisfy the mitigation requirements

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				stated in this Programmatic EIS as well as those of other agencies having jurisdiction before a permit will be issued. All authorizations for shipboard surveys, regardless of vessel size, would include guidance for vessel strike avoidance while in transit. The guidance would be similar to NTL 2012-JOINT-G01 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") (USDOI, BOEM and BSEE, 2012b), which incorporates NMFS "Vessel Strike Avoidance Measures and Reporting for Mariners" addressing protected species identification, vessel strike avoidance, and injured/dead protected species reporting. Vessel operators, crews, and visual observers or PSOs must maintain a vigilant watch for marine mammals and sea turtles and slow down or stop their vessel to avoid striking protected species. Vessel speed shall also operate within the 10-kn (18.5-km/h) speed restriction in DMAs, Mid-Atlantic U.S. SMAs November 1 through April 30, and critical habitat and Southeast U.S. SMAs from November 15 through April 15 (in accordance with NMFS Compliance Guide for the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105). With these mitigation measures in place, survey vessels are unlikely or less likely to strike marine mammals. Seismic vessels, which account for most of the project related vessel traffic associated with the proposed action, survey at a speed of approximately 4.5 kn (8.3 km/hr). In addition, waters surrounding survey vessels for airguns and non airgun HRG operating below 200 kHz on survey would be monitored by PSOs or visual observers for the presence of all marine mammals and sea turtles. Outside of critical habitat, SMA, and DMAs, during transit to and from shore bases, seismic vessels and other survey vessels are expected to travel at greater speeds. However, as noted above, these vessel movements would be subject to BOEM guidance for vessel strike avoidance and be required to reduce speed in certain areas to comply with the Right Whale Ship Strike Reduction Rule and when mother/calf pairs, pods, or large assemblages of cetaceans are observed near an underway vessel.
Chris Clark, Georgia DNR	SA-L-3	0.05	GADNR Considerations and Need for sea turtles to be included in Mineral Management Service's DPEIS: 1) The Loggerhead turtle population on the Georgia coast is compromised by depressed numbers but believed to be stable at this time. 2) Disruption of nesting and foraging activity from seismic survey noise is a real possibility. 3) An increase boat collision mortality from support vessels associated with seismic surveys.	The issues raised in this comment are addressed in **Chapter 4.2.3.2.2** including impacts of active acoustic sources and vessel traffic. It is acknowledged that airgun noise may cause behavioral responses. The risk of vessel strikes is expected to be minimized because of (1) the guidelines for vessel strike avoidance that would be part of all authorizations for shipboard surveys; (2) the typical slow speed of survey vessels; (3) the use of PSOs to scan the sea surface around survey vessels; and (4) shutdowns when sea turtles are sighted within exclusion zones.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Chris Clark, Georgia DNR	SA-L-3	0.06	Seismic surveys during the nesting season could result in increased movement of nesting females and disrupt physiological processes necessary to produce eggs for reproduction.	This issue is addressed in **Chapter 4.2.3.2.2**.
Chris Clark, Georgia DNR	SA-L-3	0.07	Any significant increase in vessel traffic from support operations could result in significant impacts to sea turtles, particularly during the nesting season when loggerhead females are concentrated along the coast.	Impacts resulting from vessel traffic are addressed in **Chapter 4.2.3.2.2** and are expected to be negligible. The risk of vessel strikes on sea turtles is expected to be minimized because of (1) the guidelines for vessel strike avoidance that would be part of all authorizations for shipboard surveys, (2) the typical slow speed of survey vessels, and (3) the use of PSOs to scan the sea surface around survey vessels. G&G related vessel traffic would represent a very small fraction of the existing vessel traffic in the region. Survey vessels are likely to remain offshore for most of the survey duration. They may be supported by supply vessels, but it is not a requirement. Renewable energy surveys are generally conducted by small vessels moving at less than 5 kn with typical duration of 3 days or less. Marine minerals surveys aren't expected to occur off the coast of Georgia as the State has never had an agreement with BOEM for joint study of OCS marine minerals resources and has never requested a non-competitive lease to use them onshore.
Chris Clark, Georgia DNR	SA-L-3	0.08	Preliminary GADNR Recommendation for Sea Turtles: Surveys should be designed to eliminate noise in the near shore area (<10 nm from shore) from May through August to ensure nesting activity is not disrupted.	BOEM recognizes the difficulty in avoiding all protected species. This is particularly difficult when Mysticetes are in the project area in the fall, spring, and winter, and sea turtles are in the area in the summer. Most mitigation measures are aimed at protecting marine mammals, knowing that many sources are audible to many marine mammals and have the potential to change their behavior. BOEM-regulated surveys would be approximately 3 miles offshore, if not further offshore. No airgun surveys would be authorized within the sea turtle closure area during that time. Non-airgun HRG surveys with sources below 16 kHz would be restricted within this area from May 1 to October 31. Non-airgun HRG surveys with sources above 1.6 kHz would not be subject to the sea turtle time-area closure. The preferred Alternative, Alternative B, contains additional details concerning time-area closures for sea turtles.
Chris Clark, Georgia DNR	SA-L-3	0.09	To summarize, the Programmatic Environmental Impact Statement should address several issues related to sea turtles including: 1) the potential disruption of loggerhead nesting activity by seismic surveys and 2) potential increase in sea turtle mortality from increased vessel traffic associated with seismic surveys.	These issues and other potential impacts on sea turtles are addressed in **Chapter 4.2.3.2.2**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Chris Clark, Georgia DNR	SA-L-3	0.10	The GADNR Coastal Resources Division (GADNR/CRD) Marine Fisheries Section would like to serve as a Georgia's Coordinating Agency for Commercial and Recreational Fisheries.	Text has been revised in **Chapter 1.6.18** to address this comment.
Chris Clark, Georgia DNR	SA-L-3	0.11	IMPACTS: The predicted impact of G&G activities on fish and invertebrates appears minimal. However, some G&G activities (such as seismic surveys) can produce an avoidance behavior in fishes but studies show large discrepancies (distance) of the affected area. There are small impacts on eggs and larval fishes, but the levels are well below the natural mortality rate of 5-15% per day for most species (Gausland, 2003). The impact of such surveys on adult fishes is greatest during spawning and migration to spawning areas, and diminishes with distance from the origin. Gausland (2003) suggests a safe zone of a few kilometers, although no study documented lasting effect on fishing or fish stocks as a result of seismic surveys.	Text has been revised in **Chapter 4.2.5.2.2** to address this comment. Please review **Appendix J** regarding impacts to fish.
Chris Clark, Georgia DNR	SA-L-3	0.12	In summary, the State of Georgia supports Outer Continental Shelf oil and gas exploration provided that negative impacts to living marine resources and their habitats are fully addressed and minimized or eliminated.	Comment noted.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.01	<u>Affected Resources and Impact Analysis: Commercial and Recreational Fisheries</u> The DPEIS finds that a 'negligible percentage' of seafloor within the Area of Interest (AOI) would be disturbed by G&G activities and concludes that seafloor disturbance, would have only a negligible impact on commercial fisheries and no impact at all on recreational fisheries. The DPEIS further states that because BOEM would require prior approval of G&G activities involving seafloor-disturbing activities or placement of bottom-founded equipment or structures, most impacts on commercial and recreational activities are expected to be avoided and thus negligible. Marine species are not evenly distributed and if the small area of disturbance occurs in prime fishing grounds or spawning areas, impacts could be more than negligible. The significance criteria for seafloor disturbances on commercial and recreational fisheries should be increased to Negligible to Minor for commercial fisheries and Negligible for recreational fisheries.	**Chapters 4.2.7.2.2**, **4.3.7.1**, and **4.4.7.1** were modified to address this comment and the impact rating was revised as indicated for commercial fisheries. Seafloor disturbance is not an impact-producing factor for recreational fisheries based on the rationale provided in the Programmatic EIS.
Kelie Moore, Georgia DNR	SA-E-4	0.02	The DPEIS finds that active acoustic sound sources, specifically seismic airguns, are likely to produce Minor	Based on the Significance Criteria definitions for commercial and recreational fisheries (**Chapters 4.2.7.2.1** and **4.2.8.2.1**, respectively) the

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Coastal Resources Division			impacts to commercial species and Negligible impacts to recreational species. Behavior and mortality in fishes as a result of seismic surveys are not well understood and difficult to quantify. Because all fish species show behavioral avoidance for some period of time, the significance criteria for seismic sound sources on both commercial and recreational fisheries should be increased to Minor to Moderate.	behavioral avoidance would be considered a minor impact as defined.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.03	The DPEIS finds that accidental fuel spills are likely to produce Negligible impacts to commercial and recreational fisheries since accidental spills are likely to be small in size. Any oil spill, no matter how small the impact area, may tarnish commercial fisheries enough that the public may hesitate from buying the product for fear of contamination and not knowing where it was caught. Similarly, recreational fisheries would also be expected to decline. The significance criteria for commercial and recreational fisheries should be increased to Minor.	BOEM reconsidered the impact rating based on this comment and revised the text accordingly (see **Chapters 4.2.7.3**, **4.3.7.2**, **4.4.7.2**, **4.2.8.3**, **4.3.8.2**, and **4.4.8.2**).
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.04	Alternatives and Mitigation Measures: Commercial and Recreational Fisheries The South Atlantic Fishery Management Council (SAFMC) has designated several Habitat Areas of Particular Concern (HAPCs) within the Area of Interest (AOI) to protect deepwater coral communities from physical damage by fishing gear. The DPEIS states that because BOEM would require prior approval of G&G activities involving seafloor-disturbing activities, drilling discharges, or placement of bottom-founded equipment or structures, impacts on sensitive benthic communities such as coral, live/hard bottom, chemosynthetic, and deepwater canyons communities are expected to be avoided. A more effective and reassuring solution to case-by-case review of proposed individual actions would be for BOEM to include a prohibition of G&G activities within HAPCs in their Preferred Alternative.	A prohibition on G&G activities within HAPCs is not warranted and would remove a substantial portion of the Area of Interest (AOI) from being surveyed. HAPCs are not “no activity” zones; they are areas within Essential Fish Habitat where fisheries management identifies a need to conserve sensitive habitats from anthropogenic activities such as fishing practices. As shown in **Figure 4-4**, substantial portions of the Area of Interest are identified as HAPCs. Some of them were established to protect pelagic fishery resources and control certain, specific fishing activities such as pelagic long lining. BOEM believes it is reasonable to focus on preventing seafloor-disturbing activities from affecting all sensitive benthic resources, whether located in an HAPC or not. Therefore, as indicated in **Chapter 2.1.2.3.2**, BOEM will require operators to provide site-specific information regarding sensitive benthic communities (including hard/live bottom areas, deepwater coral communities, and chemosynthetic communities) prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom founded equipment or structures in the AOI. BOEM has used this approach extensively and successfully in the Gulf of Mexico.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.05	Impact-producing factors (IPCs), most notably seafloor disturbance and seismic sound activities, are of most significance on commercial and recreational fisheries when conducted within 20 nautical miles (nm) of the shoreline. The significance criteria of these IPFs would be greatly reduced if BOEM would include a prohibition of seismic activities and seafloor disturbances within 20 nm of the Georgia shoreline in their Preferred Alternative.	Alternative B, which is BOEM's Preferred Alternative, includes a continuous band of time-area closure along the Georgia coast to a distance of 20 nmi from shore. Although this protective measure is seasonal and corresponds to NARW transiting the area, within this area and within the identified time window, seismic airguns would not be allowed to operate. The areal extent and degree of bottom-disturbing activity in the scenario for the three program areas is very small. The impact significance levels for both Alternatives A and B for commercial and recreational fisheries have been assessed as minor or negligible-minor for acoustic sound sources, vessel traffic, and bottom disturbance. The prohibition of all permitting activity within 20 nmi is not consistent with the purpose and need for this NEPA evaluation.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.06	<u>Alternatives and Mitigation Measures: Marine Mammals</u> The mitigation measures outlined in Alternative A are not as protective of coastal resources as could reasonably be expected given the magnitude of reasonably foreseeable impacts. Alternative B, which includes expanding the time-area closure for North Atlantic right whales and nesting sea turtles, separation between simultaneous seismic airgun arrays, and passive acoustic monitoring, is likely to mitigate more impacts to marine mammals from proposed geological and geophysical activities than Alternative A. While acknowledging that Alternative B includes mitigation measures that would add direct costs for operators undertaking G&G activities in the AOI (e.g. staff to perform passive acoustic monitoring) as well as impose indirect costs (e.g. inconvenience of deploying when and where an operator desires), it still falls short of offsetting or balancing protection of the coastal environment with competing coastal uses.	BOEM has identified Alternative B as the agency's Preferred Alternative. Alternative B would meet the Agency's purpose and need in a manner that balances orderly resource development with protection of the human, marine, and coastal environments. Both Alternatives A and B include mitigation that would help to protect marine mammals and coastal resources. In addition, this EIS is a programmatic document. Further NEPA evaluations would be required at the site/project-specific level to ensure adequate protection of the environment.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.07	The following mitigation measures should be included in BOEM's Preferred Alternative. ***Time-Area Closure for North Atlantic Right Whales*** The geographic extent of Alternative A does not adequately encompass the area used by North Atlantic right whales in the Southeast and Mid-Atlantic U.S. Georgia DNR supports the expanded time-area closure for seismic air gun arrays and non-airgun high-resolution geophysical (HRG) surveys proposed in Alternative B with the following caveats: Deep stratigraphic and shallow test drilling should not be authorized within the right whale time-area closure due to the high source levels associated with drillships during drilling (up to 191 re 1 μPa; Chapter 3, Page 3-28). The geographic extent	BOEM has identified Alternative B (which has expanded time-area closures relative to Alternative A) as the Agency's Preferred Alternative. In addition, we have revised **Chapter 2.1.3.1.1** to indicate that the time-area closures would be responsive to any future revisions of the NARW critical habitat or SMAs. The comment supports extending the time-area closure for Alternative B an additional 10 nmi seaward. BOEM considered this recommendation but will retain the 20 nmi distance. BOEM's resource evaluation staff in their 2011 Atlantic OCS Resource Assessment (USDOI, BOEM, 2012) projected geological play types that would benefit by expansive 2D or 3D seismic surveys along the North Carolina coastal area. Such surveys tend to require long periods at sea to complete and a time-area closure beyond 20 nmi imposes a restriction on

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			of the time-area closure proposed in Alternative B should be expanded an additional 10 nautical miles (NM) eastward for seismic air gun surveys to further reduce ensonification of right whales and their habitat. BOEM predicts that acoustic energy from seismic air gun arrays may propagate up to 12,737 m (~7 NM) at sufficient received pressure levels to cause Level B harassment to whales (i.e., 160 dB re 1 µPa; Appendix D, Table D-21). The geographic extent of the time-area closure proposed in Alternative B is sufficient to limit impacts from electromechanical acoustic devices, given their shorter propagation distances (i.e., a 10 NM eastward buffer is not necessary for electromechanical acoustic devices). NMFS is currently revising right whale critical habitat boundaries. Unfortunately the revised boundaries are not available at this time. However, previous modeling and telemetry studies suggest that right whales utilize all Atlantic Ocean waters within 20-30 NM of shore from Cape Canaveral, FL and northward along the GA, SC and NC coast (Keller et al. 2006ii, Garrison 2008iii, Good 2008iv, Schick et al. 2009. The time-area closure proposed in Alternative B encompasses the majority of right whale habitat delineated by these studies. Any subsequent expansion of right whale critical habitat by NMFS in the Southeast and Mid-Atlantic U.S. should be reflected in the proposed time-area closure, along with a 10 NM eastward buffer for seismic air gun surveys.	access to potential resource area that is not justified on the basis of available information. Because the 20-nmi zone was based on NOAA's SMAs and the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105), we believe that this distance provides a reasonable protective measure for NARWs and other marine mammal species transiting through the region. Although not specifically mentioned in the Programmatic EIS as activities subject to time-areas closures for Alternatives A and B, deep stratigraphic test drilling (>500 ft [152 m] below mudline) and shallow test well drilling (<500 ft [152 m] below mudline) would not be an activity that BOEM would expect to authorize inside of these closure areas when they are in effect. Although these activities would not be prohibited, BOEM would review a permit for such activity on the merits at the time we receive it, including a NEPA evaluation.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.08	*High Resolution Geophysical (HRG) Survey Protocol for Renewable Energy and Marine Mineral Sites* - Georgia DNR supports an exemption within the right whale time-area closure for non-air gun HRG surveys for renewable energy and marine minerals with the following caveat: Non-air gun HRG surveys proposed within the right whale time-area closure should be permitted on a case-by-case basis. BOEM should require applicants to utilize acoustic devices that operate at frequencies higher than 22 kHz when operationally feasible. Right whales are likely unable to hear sounds above 22 kHz (Parks et al. 2001v).	Since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. As a result of the clarification, time-area closures would generally not be applied to surveys using non airgun HRG acoustic sources. However, some exceptions exist. For example surveys authorized outside, but in the proximity of DMA boundaries are required to remain at a distance such that received levels for all sound sources, at these boundaries do not exceed the Level B harassment threshold, as determined by field verification or modeling. However, those non airgun HRG surveys which are proposed within NARW critical habitat and proposed to use acoustic sources within the NARW estimated functional hearing range will require further review prior to authorization. The additional review will need to establish if the surveys could have been planned outside of the calving and nursing season and if they fill a critical need. Those clarifications have been finalized with NMFS through formal Section 7 consultation, including additional

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				information regarding non-airgun HRG surveys that explained BOEM's strategy to mitigate or avoid adverse impacts to NARWs in SMAs and critical habitat and the issuance of a Biological Opinion (**Appendix A**). The Programmatic EIS has been revised to ensure that it clearly and consistently indicates what G&G methods and equipment are subject to time-area closures and other mitigation requirements. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.09	*Guidance for Vessel Strike Avoidance* - Vessel collisions are a leading cause of North Atlantic right whale mortality. Reducing vessel speeds to 10 kts or lower likely reduces the risk of whale mortality (Pace and Sliber 2005vi, Vanderlaan and Taggart 2007vii). Georgia DNR supports the vessel strike avoidance measures outlined in Alternative A and B with the following caveats: All vessels 65 ft or greater, including federal and federal contract vessels, should travel at speeds of 10 kts or less within the right whale time-area closure to reduce risk of right whale collisions. Vessels less than 65 ft in length should reduce their speed within the right whale time-area closure when traveling at night and during other periods of reduced visibility. All vessels operating within the right whale time-area closure should have a properly installed and operational Automatic Identification System (AIS) on board. The vessel call sign, vessel name and BOEM permit number should be provided to NMFS prior to entering the time-area closure. North Atlantic right whales are the primary species of whale observed within the portion of the time-area closure located offshore of SC, GA and FL (Georgia DNR, *unpublished data*). As such, vessel crews should assume that all whales observed within the time-area closure offshore of SC, GA and FL are likely North Atlantic right whales and maintain 1,500 ft separation accordingly.	The risk of vessel strikes from survey vessels is low as noted in **Chapter 4.2.2.2.2**. BOEM's proposed guidance for vessel strike avoidance is consistent with the speed recommendations noted in this comment. All authorizations for shipboard surveys, regardless of vessel size, would include guidance for vessel strike avoidance while in transit. The guidance would be similar to NTL 2012-JOINT-G01 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") (USDOI, BOEM and BSEE, 2012a), which incorporates NMFS "Vessel Strike Avoidance Measures and Reporting for Mariners" addressing protected species identification, vessel strike avoidance, and injured/dead protected species reporting. Vessel operators, crews, visual observers or PSOs must maintain a vigilant watch for marine mammals and sea turtles and slow down or stop their vessel to avoid striking protected species. Vessel speed shall also operate within the 10 kn (18.5 km/h) speed restriction in: DMAs, Mid-Atlantic U.S. The SMAs from November 1 through April 30, and critical habitat and Southeast U.S. SMAs from November 15 through April 15 (in accordance with NMFS Compliance Guide for the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105). With these mitigation measures in place, survey vessels are unlikely to strike marine mammals. Seismic vessels, which account for most of the project related vessel traffic associated with the proposed action, survey at a speed of approximately 4.5 kn (8.3 km/hr). In addition, waters surrounding survey vessels, for airguns and non airgun HRG equipment operating below 200 kHz, would be monitored by PSOs for the presence of all marine mammals and sea turtles. Outside of critical habitat, SMAs, and DMAs during transit to and from shore bases, seismic vessels and other survey vessels are expected to travel at greater speeds. However, as noted above, these vessel movements would be subject to BOEM guidance for vessel strike avoidance and be required to reduce speed in certain areas to comply with the Right Whale Ship Strike Reduction Rule and when mother/calf pairs, pods, or large assemblages

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				of cetaceans are observed near an underway vessel. BOEM also conducted ESA Section 7 consultation with NMFS regarding the proposed action and will comply with reasonable and prudent measures to protect right whales and other endangered species as specified in the Biological Opinion (see **Appendix A**).
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.10	*Acoustic Modeling and Marine Mammal Incidental Take Methodology* - The animal behavior values selected for right whales in the AIM model were taken from studies of right whale foraging in the Northeast U.S. and Canada and do not accurately reflect behavior and habitat in the Southeast U.S. Right whales are not known to feed in the Southeast U.S. and their Southeast U.S. habitat is considerably shallower (10-30 m) than the dive values selected in the AIM model (113-130 m; Appendix E, page E-32). Nousek-McGregor (2010viii) found that right whales tagged in the Southeast U.S. either submerged immediately below the surface for 2 min on average, or dove to the bottom to a depth of only 10-20 m for 7 min on average. Surface intervals in that study averaged 1-2 min, although we have documented surface intervals in excess of 30 min in the case of females with calves (Georgia DNR, unpublished data). BOEM should re-run the AIM model for right whales with values that more accurately reflect right whale behavior and habitat in the Southeast U.S. Any resulting changes in take estimates should be highlighted in the Final EIS.	**Appendix E** omitted the behavioral parameter for wintering right whales, but they were modeled appropriately and their behavioral parameters have now been added to **Appendix E**.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.11	*Alternatives and Mitigation Measures: Sea Turtles* - GADNR supports the proposed time-area closure offshore of Brevard County, FL outlined in Alternative B to protect nesting loggerhead sea turtles.	Comment noted.
Kelie Moore, Georgia DNR Coastal Resources Division	SA-E-4	0.12	Duplicate letter (SA-L-3) included in this comment package.	See comment entries for SA-L-3 for responses.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.01	As noted in Governor O'Malley's May 27, 2010 letter to Secretary Salazar, Maryland remains opposed to oil and gas exploration and development activities in the Mid-Atlantic region (Maryland, Virginia and Delaware). Oil and gas exploration and development in our Mid-Atlantic waters could put our sensitive coastal and marine areas at risk and consequently jeopardize our recreational, tourist, and fishing industries.	BOEM was directed by Congress to conduct a Programmatic EIS to evaluate potential impacts from G&G activities in the Atlantic OCS. The scope of this Programmatic EIS does not evaluate oil and gas leasing nor does it authorize an OCS lease sale. Further NEPA evaluation would be required for that.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.02	There are significant data and information gaps regarding marine mammal, turtle and benthic habitat density and distribution in the Mid-Atlantic region. This lack of information precludes an accurate analysis of the potential impacts of the oil and gas related G&G activities. Marine mammals and turtles are particularly vulnerable to G & G activities, some of which are rare, threatened or endangered.	The Programmatic EIS uses the best available information in its analysis of impacts to resources. Available data have been found adequate for analysis purposes in numerous other NEPA documents preceding this Programmatic EIS. The requirements of 40 CFR § 1502.22 for the treatment of incomplete and unavailable information have been met in this Programmatic EIS. The existence of incomplete and unavailable information was addressed in the following chapters: for sensitive benthic communities in **Chapters 4.2.1.1.2** and **4.2.1.2.2**; for marine mammals in **Chapter 4.2.2.1**; and for sea turtles in **Chapter 4.2.3.2.2**. BOEM believes that the available information is adequate to assess impacts to marine mammals, sea turtles, benthic communities, and other resources. As a result, the missing information is not essential to support a reasoned choice among alternatives.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.03	The proposed oil and gas related G&G activities pose additional restrictions to an already busy Mid-Atlantic region and are likely not compatible with existing coastal uses. The proposed activities will only add to potential coastal use conflicts and potentially diminish the value of key regional assets, such as the Ports of Baltimore and Norfolk, the Naval Air Station Patuxent River, and the Wallops Flight Facility. Additional constraints due to G&G surveys drive up shipping times and costs thereby reducing commercial competitiveness and could cause safety concerns during military operations.	The issues raised in this comment are addressed in **Chapter 4.2.12** (Other Marine Uses). The analysis included vessel traffic, vessel exclusion zones, aircraft traffic and noise, seafloor disturbance, and accidental fuel spills. The potential impacts were evaluated as ranging from negligible to negligible-minor and would not diminish the value of key regional assets, drive up shipping times and costs, or cause safety concerns during military operations. BOEM has been in contact with NASA and branches of the military regarding the proposed action, and their input led to changes in **Chapter 2.1.2.5** ("Guidance for Military and NASA Coordination"). They will also be consulted during future evaluations of site-specific actions.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.04	We encourage BOEM to adopt the No Action Alternative so that it can better address potential conflicting uses through the ocean planning process as called for in the President's National Ocean Policy Executive Order.	Comment noted.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.05	In closing, Maryland is most anxious to move forward expeditiously on the development of renewables like offshore wind.	Comment noted.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.06	**Benthic Habitats** - The PEIS recommends avoiding hard bottom habitats by staying clear of locations with unique benthic features, but this would only apply in areas where known locations exist. In general, locations of hard bottom, coral and other unique benthic ocean habitats in the Mid-Atlantic are largely unknown. Impacts to the seafloor off the coast of Maryland are hard to measure, as there is little to no documentation of the seafloor habitat. There is evidence of cold-water and deep-water corals, but no extensive mapping	As noted in **Chapter 3.5.1.8**, BOEM will require site-specific information regarding potential sensitive benthic communities (including hard/live bottom areas, deepwater coral communities, and chemosynthetic communities) prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom founded equipment or structures in the AOI. BOEM will use this information to ensure that physical impacts to sensitive benthic communities are avoided. With regard to mapping of sensitive benthic habitats, BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre,

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			has been completed. This does not mean there will not be an impact, only that it cannot be measured. Recommendation: A comprehensive data set of known locations should be assembled and additional surveys should be conducted in order to accurately assess potential impacts.	an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx).
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.07	**Marine Mammals and Sea Turtles** - Limited data exist in the Mid-Atlantic that describe marine mammal and sea turtle migration pathways and key habitat areas for these populations. Recommendation: New, baseline studies need to be conducted to help refine survey activity area and/or time of year restrictions.	The U.S. NAVY's Operating Area Density Estimates (NODE) data are currently the best available data for estimating marine mammal densities in the Mid/South Atlantic Planning Areas. BOEM has used these data within the analyses contained within this Programmatic EIS. The data are also used as part of the marine mammal take estimations via the Acoustic Integration Model (AIM). BOEM does agree and recognize that there are data gaps in marine mammal density information for these areas. As such, we have partnered with the National Oceanic and Atmospheric Administration (NOAA) and other organizations to fund projects to improve biological information on protected species in the U.S. Atlantic. Two notable programs include the following: • Atlantic Marine Assessment Program for Protected Species (AMAPPS) – This is an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters. The project will also collect similar data at finer scales at several sites of particular interest to NMFS and BOEM. Importantly, AMAPPS also seeks to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics (see http://www.nefsc.noaa.gov/read/protspp/mainpage/ AMAPPS/index.html and http://boem.gov/uploadedFiles/BOEM/ Environmental_Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_Studies/AT-10-x11.pdf). • BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre, an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). Ultimately, NEPA requires that Federal agencies use the best available information in environmental impact statements, which BOEM has done. **Chapter 4.2.2** discusses incomplete and unavailable information on marine mammals. BOEM believes that the available information is

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				adequate to assess impacts. As a result the missing information is not essential to support a reasoned choice among alternatives. BOEM will continue to monitor the results of AMAPPS and other relevant studies (i.e., NOAA Sound and Cetacean Density Mapping) to ensure any updated data are considered as they become available to support future, site/permit-specific NEPA evaluations of individual survey applications. Sea turtles are smaller than marine mammals, and therefore more elusive and difficult to observe in natural conditions, nevertheless, a body of biological and physiological data and information about the underwater hearing of sea turtles and their use of the AOI is available to us. **Chapter 4.2.3** discusses incomplete and unavailable information on sea turtles. BOEM believes that the available information is adequate to assess impacts. As a result the missing information is not essential to support a reasoned choice among alternatives. New baseline studies will contribute to knowledge for how these species use the AOI and how our activities affect them.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.08	**Protection of Marine Mammals and Turtles Requires Appropriate Observers On Board Vessels** - Trained objective observers on board the vessels will help ensure accurate and timely identification and response so that impacts to these communities will be minimized. The observers should be properly qualified (marine biologist trained to study marine mammals and/or sea turtles) and objective (they do not have a conflict of interest, i.e., not an employee or consultant to the oil and gas industry). <u>Recommendation</u>: Require properly trained objective observers to be on board vessels during G&G surveys to minimize impacts to marine mammals and turtles.	Training requirements are outlined in **Appendix C**, **Table C-7**.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.09	**Protection of Marine Mammals and Turtles Requires Adequate Restrictions to Vessel and Survey Activity Based on Sufficient Advanced Warning, Sea Conditions, Geographically Accurate Information and Appropriate Technology** - Throughout draft PEIS it is noted that vessel and survey activity will be interrupted or modified to minimize impacts when marine mammals are observed or suspected within certain distances from the ship. <u>Sufficient Advanced Warning</u> - BOEM should ensure that adequate protocols are in place so that the crew has sufficient time to alter operations once a marine mammal or turtle is sensed or suspected near the vessel. Proper protocols will help avoid significant direct or indirect impacts (such as collision, hearing loss or any activity affecting migratory or foraging activity to the point where	The Seismic Airgun Survey Protocol is based upon and very similar to the protocol that has been used for several years in the Gulf of Mexico as documented in a recent report (Barkaszi et al., 2012). Similar protocols are also used internationally. Therefore, both seismic survey operators and PSOs have considerable experience to draw upon in implementing these mitigation measures. In addition, Alternative B, which has been identified as BOEM's Preferred Alternative, requires PAM for seismic surveys to enhance detection of vocalizing marine mammals and may be used as an additional monitoring technology for HRG surveys using sources operating at frequencies at or below 200 kHz. Finally, a section on Adaptive Management has been added to the Programmatic EIS (see **Chapter 1.7.6** and **Appendix C**, **Section 7**). As part of its Adaptive Management program BOEM intends to review the effectiveness of mitigation measures based on monitoring data collected by PSOs during

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			health is compromised or significantly degraded). Sea Conditions - Sea conditions can affect the ability of even the best-qualified professional to locate and observe marine mammals or turtles. If visual observation is the primary means for identifying the presence of marine mammals and turtles, then vessel and survey activity should be limited to those times when sea conditions will allow ample time to locate their position and respond in a protective manner. Geographically Accurate Information and Appropriate Technology: In addition to visual observations by trained, objective professionals, there are additional means for anticipating and sensing the potential presence of marine mammals and turtles. For example, maps depicting the migration corridors can help the ship crew avoid certain areas during certain times of the year. In addition, observations made to prevent impacts can also help augment the initial survey data. Geographic Information Systems on board the vessel can help integrate various information layers such as energy resources, marine life and navigational routes to help make optimal decisions. Technologies such as listening devices for hearing marine mammals, sonar used to locate fish or marine mammals or radio signals from tagged organisms or even drones flying or navigating ahead of a ship can be deployed to increase the ability to sense and respond to marine mammals and turtles. Recommendation: The above factors should be integrated and applied strategically to enhance the ability of G & G survey companies to sense, anticipate and respond to potential encounters with marine mammals and turtles.	G&G surveys.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.10	**Include Commercial Navigation as Separate Subheading in Future NEPA Analysis** - The draft PEIS addresses existing conditions and considers potential effects of G&G activities on commercial shipping primarily in sections 2.1.3.12, 2.2.3.12 and 2.3.3.12 (Impacts on Other Marine Uses) of the document. Recommendation: Given the significance of commercial navigation throughout the region, we strongly recommend that BOEM provide this information in a standalone impact subheading in future NEPA analysis and documentation.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.11	**Require Notification of Local Pilot Associations and Commercial Seaports in Addition to Local Harbormaster and Coast Guard** - The section entitled "Impacts on Other Marine Uses" (section 2.1.3.12) indicates that the local harbormaster and US Coast Guard will be notified of proposed vessel exclusion areas. Recommendation: We recommend that the local pilot associations and commercial seaports also be notified of planned vessel exclusion zones.	As indicated in **Chapter 3.5.1.5**, prior to conducting a G&G survey, operators would submit information to the local USCG office and the local harbormaster for issuance of a Local Notice to Mariners. The Local Notice to Mariners would specify the survey dates and locations and the recommended avoidance requirements and is the standard mechanism for notifying other marine users of the planned activities.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.12	**Access to Port of Baltimore Includes Both Chesapeake Bay Entrance and Delaware Bay Via the Chesapeake and Delaware Canal** -Sections 3.6.8 and 4.2.12.1.1 entitled "Shipping and Marine Transportation" correctly recognizes that the Port of Baltimore is accessed through the Chesapeake Bay entrance to the Atlantic Ocean. However, this section does not indicate that the Port of Baltimore is also accessed from the Delaware Bay via the Chesapeake and Delaware Canal. Due to its location, the Port of Baltimore is therefore subject to impacts to navigation from both entrances. Recommendation: We recommend that BOEM revise these sections in the final PEIS to reflect both accesses to the Port of Baltimore.	Text has been revised in **Chapters 3.6.8** and **4.2.12.1.1** to address this comment.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.13	**Include Navigational Surveys in Future NEPA Studies** - Recommendation: Surveys planned adjacent to traffic separation schemes, fairways, and other important navigation areas leading to Atlantic Coast seaports should be reviewed as part of future site-specific NEPA analysis and documentation for foreseeable impacts on commercial shipping.	Comment noted.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.14	**Include Impacts of Northern Right Whale Restrictions** - Recommendation: The impact on commercial shipping and marine transportation associated with an expansion of the Northern Right Whale seasonal speed restrictions should be considered as part of further NEPA documentation for site-specific activities.	Comment noted.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.15	**Cumulative Effects of Proposed OCS Activities** -The draft PEIS indicates that cumulative effects of the full spectrum of proposed OCS activities, including wind energy development and oil and gas activities, have been considered. Recommendation: Maryland encourages BOEM to continue to consider the cumulative effects of these activities as part of the NEPA process for future OCS decisions utilizing all available information including the US Coast Guard's Atlantic Coast Port Access Routing Study and Maryland's previous	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			communications regarding offshore Wind Energy Areas and the Atlantic Wind Connection Project.	
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.16	Section 1.6.5. Introduction. Coastal Zone Management Act, and Section 5.6. Consultation and Coordination. Coastal Zone Management Act. These Sections discuss the Federal Coastal Zone Management Act (CZMA) and, more specifically, the requirements of Section 307 that proposed federal activities be consistent to the maximum extent practicable with a State's federally-approved Coastal Zone Management Program. These discussions note that OCS plans and any federal permits, e.g. permit from BOEM for proposed survey activities, required for OCS activities are subject to the Section 307 Federal Consistency provisions. Based on these discussions, MDE presumes that it is BOEM's position that a Federal Consistency determination, pursuant to Section 307(c)(1) - Direct Federal Actions - is not required for the G&G survey activities evaluated in the PEIS. If so, this should be specifically/clearly stated in these Sections of the PEIS.	This Programmatic EIS does not authorize any G&G activities, approve any OCS plan, or issue any permits and therefore a CZM consistency determination is not required. **Chapter 1.7.5**, Subsequent Actions Required Before Permits May Be Issued, of this Programmatic EIS has been added to explain that the Programmatic EIS provides the framework for subsequent environmental documents for future, site/permit-specific actions. Under subpart D of 15 CFR part 930 of the Coastal Zone Management Act (CZMA), the applicant is required to provide the necessary data and information and a consistency certification to the State Coastal Management Program (CMP) and Federal agency stating that the activities will be consistent with the enforceable policies of the State CMP. As discussed in **Chapter 5.7.1** of this EIS, requirements for the CZM consistency information are based on the approval of listed activities according to NOAA's Office of Coastal and Resource Management. If the activity is unlisted, the State must go through the process of the Office of Coastal and Resource Management approving a State's unlisted activity request on a case-by-case basis (15 CFR § 930.54). BOEM may not authorize the activity to commence unless a letter of concurrence is received from the State CMP or BOEM presumes concurrence based on 15 CFR § 930.62.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.17	Section 1.6.16. Introduction. State Permitting. This Section discusses State permitting requirements for the States within the AOI for any proposed G&G survey activities in a State's waters. The Section notes that all survey activities would require a license from the State of Georgia to use publicly owned lands beneath the mean high watermark. In addition, any "bottom-disturbing" activities would also require an authorization from Virginia, North Carolina, South Carolina, and Florida. It concludes with the statement, "For all other states within the AOI, no state permits other than the CZMA requirements would be required for G&G survey activities." lt is not clear why Maryland is not included on the list of states requiring authorization for bottom-disturbing activities. This Section should point out that a Tidal Wetlands License, pursuant to the State's Tidal Wetlands Act, would likely be required for any survey activities involving disturbance to submerged lands within Maryland waters.	Text has been revised in **Chapter 1.6.18** to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.18	Section 2.1.3.6 White Marlin are currently under review for consideration to be listed. Interactions are well documented off Maryland and along the Atlantic Coast. Atlantic Sturgeon have been listed, and a number of interactions have been documented off Maryland. Impacts to the habitat of these species should be documented.	See **Chapter 4.2.6.1**-white marlin and scalloped hammerhead were mentioned in the text as petitioned species--not candidates yet. As of January 30, 2013, NMFS determined that petitions for the white marlin do not present substantial scientific information indicating that the petitioned action may be warranted. **Chapter 4.2.6.1.3** has been revised to reflect the current status of the Atlantic sturgeon.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.19	Section 4.2.1.1.1 The description of the Mid-Atlantic Bight (MAB) benthic communities was largely based on a book published in 1979. Based on the changes in fisheries since that time, including expansion of ranges for many species, and rebounding of stocks, there are likely changes in the benthic community that are not documented. The description of the benthic community is likely outdated.	**Chapter 4.2.1.1.1** has been revised to provide additional, more recent information. The Boesch (1979) report summarized a landmark multidisciplinary study of the continental shelf that remains useful and relevant. Through its Environmental Studies Program, BOEM is continuing to collect and synthesize information about the Atlantic environment to be used in future, site/specific-specific NEPA evaluations.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.20	Section 4.2.1.2.2 Evaluation "The stress responses to marine invertebrates could potentially affect populations by reducing reproductive capacity and adult abundance." This section specifically mentions lobster, and studies that indicated sublethal effects that were sometimes observed weeks to months after exposure. The Southern New England stock of American Lobster are currently experiencing recruitment failure (ASMFC 2010). This stock occurs from Long Island Sound through the waters off North Carolina. American Lobster stocks in Southern New England can ill-afford additional impacts to their reproductive capacity. Additionally, there is limited, dated information on the benthic community in the MAB. Based on these concerns, Maryland believes that that impacts to benthic communities from active acoustic sound sources have been under-estimated.	**Chapter 4.2.1.2.2** and **Appendix J** have been revised to include additional information about potential impacts to invertebrates. Based on the literature reviewed in **Appendix J**, seismic surveys are not expected to cause significant short-term or long-term effects on lobsters or other benthic invertebrates.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.21	Section 4.2.7 Commercial Fisheries Table 4-28: Primary commercial species landed during 2006-2009 by state -these are not species that are not primary species landed from the AOI. For Maryland, Striped Bass, Clams, and Blue Crabs are listed; while Striped Bass and Blue Crabs are landed within or near the AOI, they are primarily harvested within the Chesapeake Bay. This table does not accurately represent the commercial coastal fishery in Maryland. Of primary concern are likely to be fisheries for spiny dogfish, scallops, striped bass, flounder, horseshoe crabs, rays, and clams. Additional fisheries include tuna, swordfish, lobster, black sea bass, and tautog, among others. Please feel free to contact us if you would like additional information.	**Chapter 4.2.7.1.1** has been revised to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.22	Section 4.2.7.2.2 Evaluation Active Acoustic Sound Sources Although the PEIS determined that the affects to commercial fisheries would be "minor", the local impact could be significant, Figure 4-21 indicates that April through August would be peak times for the survey work. The commercial fleet that operates out of Ocean City, Maryland is relatively small, and any impacts to that fishery during that period would be felt significantly.	The analysis in this Programmatic EIS has taken a programmatic view of proposed G&G surveys and resultant potential impacts. Future site-specific analyses will provide more detailed information regarding a proposed project and a more focused look at affected resources, such as the Ocean City commercial fleet. Future site-specific NEPA analyses could also include additional mitigation to minimize potential impacts on commercial fishing, if needed.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.23	Section 4.2.8.1.1 Recreational Fisheries - Description of the Affected Environment -Recreational Fishing Effort A word of caution: these estimates of effort were based on the Random Digit Dial (RDD) telephone survey of coastal counties. The methodology for estimating effort has changed and is now based on the National Angler Registry (i.e., a phone book of all licensed coastal anglers that was implemented in 2010). Use of the Registry should result in better estimates, and is expected to result in higher estimates than previously calculated.	The data used to determine effort was the best available data at the time the Programmatic EIS was prepared. Future site-specific NEPA analysis will evaluate impacts to specific resources, including recreational fisheries, and will use the most recent data available at that time.
Cecilia Bast, Maryland Department of Natural Resources	SA-E-7	0.24	Section 4.2.8.2.2 Evaluation Active Acoustic Sound Sources The PEIS does not adequately address the potential impacts on the recreational fishing community. Maryland disagrees that there would be a negligible effect on recreational fishing, especially at the local level. A lot of fishing is not about catching, but about the experience. People are not likely to want to go fishing if airguns are being deployed. While there may not be evidence of fish mortality from some of these G&G activities, a disturbance caused by airguns may drive fish away resulting in poor fishing for an entire year. Artificial-reef associated fish may vacate the reef and once they have vacated, they may colonize another reef and not return to their reef of origin. Lastly, in Ocean City, Maryland, there are several high dollar tournaments (e.g., White Marlin Open, and the Mid-Atlantic $500,000) that are important to the local economy. Should G&G activities occur during those times or before those tournaments impacting the availability of fish, it will have a ma or effect on the local economy and recreational fishing.	BOEM recognizes the importance of recreational fishing including tournaments and the economic benefit they provide to Maryland and other Atlantic coastal states. The Programmatic EIS has been revised to provide additional analysis of this issue in **Chapter 4.2.8.2.2**. Future site-specific NEPA analyses would consider impacts at particular locations and times and could include additional mitigation to minimize potential impacts on recreational fishing, if needed.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Matthew Fleming, Maryland Department of Natural Resources	SA-PHA-1	0.01	On behalf of Secretary John Griffin, let me thank you for the opportunity today to communicate Maryland's position regarding the proposed offshore oil and gas events.· Like to draw your attention to a letter submitted to Secretary Salazar, signed by Governor O'Malley on May 22, 2017 opposing oil and gas drilling in the Mid-Atlantic region, which we will be submitting as part of the comments today.·	Comment noted.
Matthew Fleming, Maryland Department of Natural Resources	SA-PHA-1	0.02	The O'Malley administration believes seismic testing should not be done until after completion of the regional ocean planning process called for in the National Ocean Plan pursuant to Presidential Executive Order 13547. We also -- we believe that the position to oppose the G&G surveys at this time does not embed BOEM for approving the surveys needed to determine sea floor conditions for renewable energy installations and marine mammal deposits.· This is based on our belief that BOEM has the authority to approve these activities pursuant to existing regulations and processes	Comment noted.
Christopher Moore, Mid-Atlantic Fishery Management Council	SA-L-4	0.01	It is clear that G&G activities have substantial impacts on marine environments, yet the Draft PEIS provides insufficient information about how the specific proposed G&G activities may affect fish, marine mammals, benthic communities, and ecosystem structure and function. We understand that these impacts are difficult to predict or quantify, but given the existing value of marine resources to the region and the nation, it is clear that the potential benefits do not outweigh the risks of initiating the proposed G&G activities at this point.	The Programmatic EIS provides a very detailed description for the entire process used in assessing impacts from the proposed action. **Chapter 3.0** contains a detailed summary of G&G activities, including the projected activity scenario for each of the three programs with number of line miles of seismic airgun surveys. **Chapter 4.0** takes the reader through a detailed description for each step in the impact assessment process beginning with a screening of potentially impacted resources, followed by an analysis of impact levels and impact significance criteria, leading to an analysis of impact-producing factors. A number of appendices are included to provide more in-depth discussion and analysis of a number of important topics such as acoustic modeling and incidental take methodology. Specifically, **Chapters 4.2-4.4** provides a detailed analysis of the impacts to all resources, including fish, marine mammals, and benthic communities, from the G&G survey activities. Although BOEM has identified incomplete and unavailable information as indicated in **Chapter 4.1.4.1** and in individual resource analyses in **Chapter 4.0**, BOEM believes that the available information is adequate to support a reasoned choice among alternatives.
Christopher Moore, Mid-Atlantic Fishery Management Council	SA-L-4	0.02	The commercial and recreational fishing industries in the Mid-Atlantic region support more than 166,000 jobs with an associated income exceeding $6 billion. In light of the insufficient data and analysis about potential impacts of G&G activities on these valuable marine resources, the Council cannot support the Draft PEIS.	BOEM believes that the data available is adequate to assess impacts to commercial and recreational fisheries resources and reach conclusions regarding impact to support a reasoned choice among alternatives. Fisheries resources were evaluated in **Chapter 4.2.5** for the following impact-producing factors: active acoustic sound sources, vessel and equipment noise, seafloor disturbance, drilling discharges, and accidental

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				fuel spills. The potential impacts were found to range from negligible to minor. Potential impacts on commercial and recreational fisheries were analyzed in **Chapters 4.2.7** and **4.2.8**, respectively.
Christopher Moore, Mid-Atlantic Fishery Management Council	SA-L-4	0.03	However, the extensive (months long) survey timeframe makes it likely that prolonged avoidance of the arrays will be necessary and could lead to interruptions in fish spawning and access to forage. More importantly, the area under consideration in the PEIS, which includes the entire continental shelf along the mid- and South Atlantic, is enormous, and much of the shelf is at a depth (<50 m) that would place the entire water column within the "lethal range" of the array.	As explained in **Chapter 3.0** of the Programmatic EIS, while G&G surveys may require extended periods to complete, the area covered during that time is quite large and survey vessels are only in any given location for a brief period. The analysis in **Chapter 4.0** concludes that impacts would be localized and short-term, and the significance would range from negligible to minor-moderate.
Christopher Moore, Mid-Atlantic Fishery Management Council	SA-L-4	0.04	The Council also has substantial concerns about the potential and unknown adverse impacts of G&G activities on marine mammals. The Council has participated in the development of Take Reduction Plans under the Marine Mammal Protection Act for Atlantic Large Whales, Harbor Porpoise and Bottlenose Dolphin. These efforts have resulted in area and gear restrictions for several fisheries within the Council's jurisdiction. In the case of north Atlantic right whales, which are among the most endangered whales in the world, protection measures have been extended to include seasonal vessel speed restrictions along the U.S. East Coast where endangered right whales travel to protect them from being injured of killed by ships. Initiating the activities described in the PEIS, many of which could harm or endanger marine mammals, would counteract many of the conservation measures that have taken years to enact.	Since the release of the Draft Programmatic EIS both the Seismic Airgun and HRG Survey Protocols have been clarified and additional vessel strike avoidance measures have been incorporated into the protocols. Please refer to **Chapter 2.0** and **Appendix C** for specific information related to the updated survey protocols. In addition, operators will be required to satisfy the requirements of all other agencies before an authorization will be issued. Further mitigation requirements may be applied associated with MMPA ITAs issued by NMFS or FWS for site/permit-specific actions.
Christopher Moore, Mid-Atlantic Fishery Management Council	SA-L-4	0.05	The general lack of information included in the PEIS relative to impacts of G&G activities on fish, marine mammals, and the surrounding ecosystem is of serious concern.	BOEM has identified incomplete and unavailable information as required by NEPA regulations at 40 CFR § 1502.22, as indicated in **Chapter 4.1.4.1** and in individual resource analyses in **Chapter 4.0**. However, BOEM believes that the available information is adequate to assess impacts to commercial and recreational fisheries resources, marine mammals, and other ecosystem components and to reach conclusions regarding impact. As a result. the missing information is not essential to support a reasoned choice among alternatives.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.01	Coastal Mgt., The DEIS notes that survey vessel traffic has the potential to temporarily disrupt fishing operations, that the use of acoustic devices can result in fish behaving differently, hard bottom disturbances, and that "marine space, use issues" are a growing concern. With that in mind, DCM suggests the inclusion, in the FEIS, of a mitigation measure to require that	BOEM does not believe that a mitigation measure is needed to address the issue raised in this comment. The NEPA evaluations for site-specific permit applications would consider resources such as commercial or recreational fishing and would provide the basis for determining whether additional mitigation is required to minimize adverse impacts on fishing. Under subpart D of 15 CFR part 930 of the Coastal Zone Management

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			an applicant for a BOEM G&G permit provide an assessment on whether the proposed G&G surveying activity would or would not have an effect on commercial and recreational fishing. This information would then be used as a basis for determining whether State consistency review would be required and for determining whether mitigation measures would be necessary to minimize adverse effects on commercial and recreational fishing.	Act (CZMA), the applicant is required to provide the necessary data and information and a consistency certification to the State Coastal Management Program (CMP) and Federal agency stating that the activities will be consistent with the enforceable policies of the State CMP. As discussed in **Chapter 5.7.1** of this Programmatic EIS, requirements for the CZM consistency information are based on the approval of listed activities according to NOAA's Office of Coastal and Resource Management. If the activity is unlisted, the State must go through the process of the Office of Coastal and Resource Management approving a State's unlisted activity request on a case-by-case basis (15 CFR § 930.54). BOEM may not authorize the activity to commence unless a letter of concurrence is received from the State CMP or BOEM presumes concurrence based on 15 CFR § 930.62.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.02	Coastal Zone Management Act (Section 1.6.5 and Section 5.6): These two sections require a degree of editorial revision in the final environmental impact statement (FEIS) to further clarify the consistency review process. The DEIS correctly notes that: "There are several standards of "Federal consistency", however, these standards are not clearly articulated. For example, the DEIS notes that: "Federal agency activities must be "consistent to the maximum extent practicable" with relevant enforceable policies ... , "however the standard "if an activity will have direct, indirect, or cumulative effects, the activity is subject to Federal consistency... is lost in the overall verbiage. The preceding sentence is also incomplete since it needs to incorporate the concept: "effect on any coastal use or coastal resource".	**Chapter 5.7.1**, regarding CZM, has been revised to address the concern.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.03	Coastal Zone Management Act (Section 1.6.5 and Section 5.6): The DEIS notes that G&G ancillary seismic activities may require the preparation of an OCS plan. While that may be accurate, the relevance of "Ancillary Activities" discussion to the overall consistency review process is unclear.	Ancillary activities bear mentioning because they are part of the proposed action and because any activities authorized by BOEM that have direct, indirect, or cumulative effects are subject to Federal consistency review.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.04	Coastal Zone Management Act (Section 1.6.5 and Section 5.6): While factual, the statement that: "G&G activities conducted by another Federal agency are not subject to BOEM authorization." does not negate the fact that these proposed activities may still require consistency review.	Text in **Chapter 5.7.1** has been revised to address the concern.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.05	Coastal Zone Management Act (Section 1.6.5 and Section 5.6): These sections do not disclose how BOEM intends to inform a State on proposed activities that could potentially have a "coastal effect" that may consequently require consistency review. We recommend that BOEM provide a brief description in the FEIS concerning how a State will be notified concerning proposed activities that may have a "coastal effect".	Text has been included in **Chapter 1.7.5** to address this comment.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.06	In analyzing seismic survey impacts, it will be imperative that the PEIS address the effects on fish and fish habitat including sub-lethal behavioral changes due to mechanically and electrically generated acoustic sources. These impacts could possibly include changes in feeding behavior, interruption of spawning behavior and effects from episodic acoustic events.	Text has been revised in **Chapter 4.2.5.2.2** to address this comment.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.07	Due to the habitat potential, all of the hard bottoms in the south Atlantic are designated by the National Marine Fisheries Service as Essential Fish Habitat under the Sustainable Fisheries Act of 1994. Beyond the edge of the continental shelf (greater than 600 m) there have recently been discovered, areas of deep water corals including *Lophelia* and *Enalopsammli*. Since deep penetration, deep-tow side scan sonar and electromagnetic surveys involve towed cables or receivers placed on the sea floor, the PEIS must address physical impacts to these habitats. As the deep-water corals are especially fragile, activities in and around these communities, particularly the use of deep-tow side scan sonar utilizing a chain dragged along the seafloor, must avoid these areas to preserve this biological community.	**Chapter 2.1.2.1.3.2** discusses avoidance requirements for sensitive benthic communities and **Chapter 4.2.1.2.2** addresses potential impacts on these communities. BOEM will require site-specific information regarding sensitive benthic communities (including deepwater coral communities) prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom-founded equipment or structures. All authorizations for seafloor-disturbing activities would be subject to restrictions to protect sensitive benthic communities that may include requirements for mapping and avoidance, as well as pre-deployment photographic surveys of areas where bottom-founded instrumentation and appurtenances are to be deployed. Deep-tow side-scan sonar surveys using a chain dragged along the seafloor are not part of the activity scenario analyzed in the Programmatic EIS. As discussed in **Chapter 3.2.2.2**, deep-tow side-scan sonar surveys typically are conducted for post-lease engineering studies involving the placement of production facilities and pipelines in deep water. Although in the past these surveys used a towed chain to assure consistent distance above the bottom, this approach has been replaced by the use of autonomous underwater vehicles (AUVs) or other systems that operate with a towed cable that doesn't disturb the seafloor.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.08	Division of Parks and Rec - There are at least three State Parks (Fort Macon, Bear Island/Hammocks Beach, and Jockey's Ridge), two State Natural Areas (Bald Head Island and Theodore Roosevelt), and one State Recreational Area (Fort Fisher) that are situated along or adjacent to Atlantic Ocean shoreline. DPR respectfully requests that these areas be included in the Final PEIS and any associated documents, as most are not currently listed in the DPEIS.	**Table 4-33** has been revised to address this request.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.09	Additionally, DPR respectfully requests that BOEM and its partners conduct consultations with staff of DPR properties if potential adverse impacts to DPR natural/recreational resources, or rare species habitats are identified.	NEPA requires consultations with Federal agencies that have responsibility under law for certain resources or protected species. Specific consultations with State agencies for activities on the OCS are limited. The Coastal Zone Management Act and a state's approved Coastal Zone Management Plan furnish the means by which a State exercises authority and jurisdiction over resources of concern. With respect to our renewable energy program, North Carolina participates on a task force whereby State concerns may be brought forward.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.10	Div. of Marine Fisheries - The DMF has concerns regarding the cumulative impacts of the proposed seismic survey activities on blueback herring and alewife, collectively known as river herring. These species are depleted all along the Atlantic seaboard and several states have imposed harvest moratoria until the cause(s) of the decline can be determined. North Carolina enacted a moratorium on harvest of river herring in December 2006 and has expended significant taxpayer resources to both restore the stock and determine causes of the decline. The Atlantic States Marine Fisheries Commission (ASMFC) has determined that American shad are also depleted coastwide and is taking steps to address the decline. Adequate information was not provided in the PEIS to support a finding that there would be negligible to minor impacts on these species. Given that the states are working diligently to curtail or greatly reduce fishing harvest to enhance population recovery, and that river herring is a candidate for listing, any additional negative effects to the population should be avoided. Additional information on the effects of seismic air gun blasts on, and how to avoid impacts to clupeids, sturgeon and other species should be obtained, included and considered in this PEIS.	Text has been revised in **Chapters 4.2.6.1.4**, **4.2.6.1.5**, and **4.2.6.2.2** to address this comment. **Appendix J** has been revised to incorporate behavioral effects.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.11	Seafloor disturbance associated with G & G surveys is another concern to DMF. There is extensive hard bottom habitat on the continental shelf off of NC in both state and federal waters. Hard bottom habitat is a critical habitat for many commercially and recreationally important fisheries, particularly the snapper/grouper complex. The document should include how survey activities will avoid impacting the structurally complex hard bottom. Towed gear, and test drilling could result in structural damage to hard bottom. Contamination from drilling discharge and fuel spills can chemically damage hard bottom.	**Chapter 2.1.2.1.3.2** discusses avoidance requirements for sensitive benthic communities. BOEM will require site-specific information regarding sensitive benthic communities (including hard/live bottom habitat) prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom-founded equipment or structures. All authorizations for seafloor-disturbing activities may be subject to restrictions to protect sensitive benthic communities. which may include requirements for mapping and avoidance in areas where these communities are known or suspected, as well as pre-deployment photographic surveys of areas where bottom-founded instrumentation and appurtenances are to be deployed. The Programmatic EIS addresses

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				potential impacts on sensitive benthic communities including impacts from seafloor disturbance and drilling discharges (see **Chapter 4.2.1.2.2**) and accidental fuel spills (**Chapter 4.2.1.2.3**). Impacts on Essential Fish Habitat (EFH), including EFH for the snapper-grouper complex hard bottom species are addressed in **Chapter 4.2.5.2.2**.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.12	The document states that temporary no vessel zones may be imposed around survey sites. North Carolina's coastal ocean supports significant commercial and recreational fisheries, including snapper-grouper, flounder, and shrimp. More specific details are needed on the location and type of activities, and the spatial and temporal extent of closures, to determine if no vessel zones would adversely affect commercial or recreational fishing activities.	This level of detail would be provided in the individual applications for surveys and coordination would occur through the CZMA process.
William Creech, NC Department of Administration, Department of Environment and Natural Resources	SA-E-3	0.13	Compliance with recommendations off the 20 I 0 NC Coastal Habitat Protection Plan are mandated by the Fisheries Reform Act (G.S. 143B-279.8). Recommendation 3.6 states: "Ensure that energy development and infrastructure is designed and sited in a manner that minimizes negative impacts to fish habitat, avoids new obstructions to fish passage, and where possible, provides positive impacts." The concerns raised above should be fully addressed in the final PEIS to satisfy this recommendation.	This Programmatic EIS is being prepared to address geological and geophysical survey activities only. Energy development and infrastructure design would be addressed during the NEPA analysis performed during leasing for development activities. This recommendation would be addressed at that time.
Barbara Neale, South Carolina DHEC	SA-L-2	0.01	There are numerous coastal resources occurring within and adjacent to South Carolina's coast that could be impacted by the proposed survey activities subject to consistency review by SCDHEC-OCRM. It will be critically important that applicants applying to BOEM for permits to conduct survey activities covered by this DPEIS coordinate with SCDHEC-OCRM to ensure they are fully consistent with our State's Coastal Management Program.	**Appendix B** addresses the States' roles in consistency review.
Barbara Neale, South Carolina DHEC	SA-L-2	0.02	South Carolina's coastal resources are vitally important to our State's overall economy. Tourism and commercial and recreational fishing are significant coastal activities. The G&G survey activities described in the DPEIS could result in reasonable foreseeable effects on South Carolina's coastal resource and uses which would initiate the consistency review process.	**Chapter 5.7.1** of this Programmatic EIS provides a discussion of the CZMA and how it shall be addressed relative to G&G survey proposals. **Section 5** of **Appendix B** provides a discussion specific to South Carolina's CZMA program.
Barbara Neale, South Carolina DHEC	SA-L-2	0.03	Some of the resources occurring in South Carolina's Coastal Zone subject to consistency review include historic and culturally important sites, sea turtles, avian species, marine mammals, nearshore and offshore habitats which support	**Appendix B** addresses the States' roles in consistency review.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			numerous species of commercial and recreational importance to South Carolina.	
Jaclyn Davies, State of New Jersey	SA-E-5	0.01	Under the Survey Type, COST wells, the number of sampling events is listed as 0-3. Unless BOEM is accessing data from previous COST wells, the number of sampling events should be in the range of 10-15, as was the case for the studies conducted in the 1970s.	The number of COST wells used for analysis in the Programmatic EIS is a projected estimate based on industry interest conveyed through permit applications. The actual number may vary, but impacts would be addressed in site/permit-specific NEPA evaluations; BOEM regulations require an Environmental Assessment for drilling of a COST well.
Jaclyn Davies, State of New Jersey	SA-E-5	0.02	The PEIS limits the number of concurrent G&G surveys and Alternative B addresses the issue of increasing the distance between concurrent surveys to limit marine biological impacts. Alternative B, however, does not address the issue of time overlap of surveys. For example, G&G surveys could be undertaken with a corridor of at least 25 miles between them but there could be a long time period during which one survey or the other is active. The impacts on marine life under the different scenarios could vary. The Draft PEIS should consider time separations as well as distance separations.	Although multiple applications for 2D seismic exploration surveys in the Atlantic Ocean have been submitted by G&G operators, BOEM expects that overlapping coverage (and the potential for animals to be exposed to multiple concurrent surveys) would be minimal because of the expense of conducting large-scale surveys and also because there is no prospective lease sale within DOI's current Five-Year Program. BOEM believes that the 40-km (25-mi) spatial separation between simultaneously operating surveys may be a feasible approach to limiting the exposure of animals to the highest sound levels from multiple seismic surveys. BOEM will consider the value of this separation measure at the site-specific NEPA and environmental analyses level as well as any new information available at that time. This evaluation will also consider any potential aggregate effects from existing permitted surveys (if any).
Jaclyn Davies, State of New Jersey	SA-E-5	0.03	It is significant that BOEM is not responsible for submarine cable infrastructure, although G&G HRG and geotechnical surveys related to submarine cable siting and placement may have the same impacts as G&G activities for purposes identified in the Draft PEIS. This subject needs to be addressed.	The comment is correct in noting that BOEM is not responsible for permitting submarine cable infrastructure; in general, permitting for submarine cables is handled by the USACE and impacts associated with cable siting and placement would be addressed through the USACE permitting process. However, for renewable energy activities, BOEM has accounted for G&G surveys for siting of cable right-of-ways in the proposed action. A cable infrastructure discussion has been added to **Chapter 4.2.12** and cumulative impacts sections for individual resources have been revised to consider the cumulative impacts of the proposed action taking into account similar activities such as submarine cable placement.
Jaclyn Davies, State of New Jersey	SA-E-5	0.04	New Jersey's marine habitat provides a critical calving and nursery area during the summer for coastal bottlenose dolphins (*Tursiops truncates*). Although proposed time-area closures are intended to be protective of species such as federally endangered right whales (*Eubalena glacialis*), restrictions must be expanded in order to mitigate for impacts to the breeding coastal population of bottlenose dolphins within the Mid-Atlantic region. According to Toth et al. (2011), neonates, young-of-year, and adults occur in the state's coastal southern	As discussed in **Chapter 3.2.1**, each permit application for a survey would be subject to a site-specific NEPA evaluation, which typically would be an Environmental Assessment. The impacts to marine mammals, including the bottlenose dolphin, would be evaluated at that time and additional mitigation or closures could be considered in that evaluation. BOEM has noted that operators will be required to satisfy the mitigation requirements stated in this Programmatic EIS as well as those of other agencies having jurisdiction before an authorization will be issued.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			waters from late May through late September. Adhering to the proposed timing restriction of November 1 – April 30 would put female dolphins and their calves at risk from G&G activities, including airgun survey impacts, vessel and equipment noise, and vessel strikes.	
Jaclyn Davies, State of New Jersey	SA-E-5	0.05	Acoustic detections of right whale calls by Geo-Marine, Inc. confirmed the presence of right whales within their study area (within 37 km of the shoreline approx. between Seaside Park and Stone Harbor, NJ) during all seasons, concluding that some individual right whales occur in the nearshore waters off New Jersey either transiently or regularly. Other listed marine mammals were also found year round, including humpback and fin whales (GMI, Inc. 2010). It is assumed that this is the case off Delaware as well. Despite proposed timing restrictions on airgun surveys designed to protect right whales, individual whales remaining in the area may still be impacted by noise, boat traffic, and other projects activities.	The issues raised in this comment are addressed in the Programmatic EIS. Specifically, Alternative B addresses this issue by including a time-area closure consisting of a 37-km (20-nmi; 23-mi) wide zone extending from Delaware Bay to the southern limit of the AOI. The time-area closures associated with Alternative B are primarily intended to serve as an impact mitigation measure for individual NARWs within and adjacent to their designated southeast U.S. critical habitat during their calving-nursing season, and within the Mid-Atlantic and Southeast U.S. SMAs. These measures are not designed to protect all individual right whales from possible exposure to airgun noise and potential auditory effects level A or B harassment resulting from airgun surveys within the AOI during the project period. Individual right whales and other marine mammals, including other listed Mysticetes that may be found outside of proposed Alternative B time-area closure areas may avoid or be actively displaced from the area(s) of ensonification. Visual and possibly PAM methods, in conjunction with operational mitigation procedures (sound source ramp-up and shut-down), are provided in all cases as mitigation to reduce potential auditory impacts to these individuals. The potential impacts are fully evaluated in **Chapter 4.2.2**. Airgun survey protocols have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**.
Jaclyn Davies, State of New Jersey	SA-E-5	0.06	Sea turtles likely use sound for navigation, predator avoiding, locating prey, and other activities (Piniak et al. 2012). Although information regarding the impacts of anthropogenic noise on sea turtles is somewhat lacking, there is evidence to suggest that observed effects due to airguns may include behavioral changes, as well as temporary or even permanent hearing loss (Moein et al. 1995). In addition, research by Piniak et al. (2012) suggests that sea turtles are able to hear much of the pervasive low frequency and high intensity noise in the ocean, including sonar, shipping and oil and gas exploration.	The issues raised in this comment are addressed in the Programmatic EIS. The additional reference (Dow Piniak et al., 2012) has been reviewed and considered in the analysis. A brief overview of sea turtle hearing is presented in **Chapter 4.2.3.1.6**. A more detailed description is provided in **Appendix I**. Potential effects of anthropogenic sound on sea turtles are discussed in **Chapter 4.2.3.2.2**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Jaclyn Davies, State of New Jersey	SA-E-5	0.07	Leatherback turtles. Turtles are known to be present in these locations between the months of May through September. The current timing restriction would therefore be placing turtles at risk of behavioral changes and possibly hearing loss due to airgun noise. Also, even having observers on board vessels during appropriate seasons will not eliminate the potential of injury or mortality from ship strikes.	The current timing restrictions are intended to address concerns for the NARW and the heavy concentration of nesting turtles in Florida. BOEM recognizes that sea turtles may occur throughout the area of interest and that the proposed surveys may affect them; potential impacts are addressed in the Programmatic EIS (see **Chapter 4.2.3.2.2**). The survey protocols, which include the measures mentioned, and which are fully described in **Appendix C**, have been shown to be effective in minimizing potential impacts through many years of implementation in the Gulf of Mexico. Airgun and HRG Survey Protocols have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). All authorizations for non airgun HRG surveys would include requirements for visual monitoring of a vessel strike exclusion zones by visual observers. In addition, authorizations for all HRG surveys using sound sources operating at frequencies below 200 kHz would include but not be limited to monitoring of an acoustic exclusion zone by PSOs and startup and shutdown requirements. Please refer to **Chapter 2** and **Appendix C** for detailed survey protocols. We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**.
Jaclyn Davies, State of New Jersey	SA-E-5	0.08	Noise generated from airguns has been shown to alter the behavior of captive fishes, with an increase in alarm response as noise level was increased (Fewtrell and McCauley 2012). In addition, activities such as pile driving have the potential to impact fish survival with effects such as burst swim bladder and massive internal bleeding (Halverson et al. 2011).	The airgun issues raised in this comment are addressed in the Programmatic EIS (see **Appendix J** for discussion of the effects of sound on fish). However, pile driving is not part of the proposed action.
Jaclyn Davies, State of New Jersey	SA-E-5	0.09	In April 2012, the National Marine Fisheries Service listed the New York Bight distinct population segment of Atlantic sturgeon, which includes fish from New Jersey waters, as Federally Endangered. Further, a recent status assessment conducted by the New Jersey Division of Fish and Wildlife resulted in a recommended state status of Endangered. Recent tracking data estimate the Delaware River spawning population to be fewer than 100 individuals.	**Chapters 4.2.5**, **4.2.6**, **4.3.6**, and **4.4.6** have been revised to address this comment.
Jaclyn Davies, State of New Jersey	SA-E-5	0.10	In New Jersey, Atlantic Sturgeon occur along the coast, with some individuals spawning in the lower portion of the Delaware River. If impacts from air gun noise and other project activities disturb Atlantic Sturgeon migrating into Delaware Bay for spawning in the river, and entire year class could potentially be lost, accelerating the decline of an already diminishing river stock. In addition, Atlantic Sturgeon are	The Programmatic EIS thoroughly evaluates potential impacts on Atlantic sturgeon (**Chapter 4.2.6.1.3**) and shortnose sturgeon (**Chapter 4.2.6.1.2**). The analysis included active acoustic sound sources, vessel and equipment noise, vessel traffic, trash and debris, seafloor disturbance, drilling discharges, and accidental fuels spills. In addition, BOEM has consulted with NMFS under Section 7 of the Endangered Species Act to ensure that the proposed action would not jeopardize the

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			vulnerable to injury and mortality from ship strikes, especially in the Delaware River. It is possible that increased traffic coupled with behavioral changes due to G&G survey activities may place Atlantic sturgeon at increased risk from ship strikes. Activities such as bottom sampling, drilling of test wells, and placement of equipment/structures on the sea floor could also potentially impact this demersal species, along with Shortnose sturgeon (federally endangered), that on occasion migrate into ocean waters.	continued existence of the Atlantic sturgeon (critical habitat has not been designated for either species). NMFS determined the proposed action is not likely to jeopardize the continued existence of the species. The Biological Opinion is presented in **Appendix A**.
Jaclyn Davies, State of New Jersey	SA-E-5	0.11	Although the PEIS study area is south of NJ waters (starting at the southern boundary of the NJ OWPEBS area), there could potentially be residual effects on transient/migratory species impacted in those areas that subsequently pass through or overwinter in NJ waters. Some of the exploratory activities, whether acoustic or drilling (e.g., disturbance to benthic habitats, increased turbidity, loss of prey, oil leaks, etc.), may cause migratory species to alter their movements, thus impacting species activities in NJ waters. Effects may be temporary or permanent, depending on the size and duration of the disturbance.	**Chapter 4.2.5.1.1** has been revised to address this comment.
Jaclyn Davies, State of New Jersey	SA-E-5	0.12	The PEIS lists some of the mitigation measures and other ecological/species considerations that will be used during G&G deployments. However, NJ has concerns with the use of the air gun seismic technology and acoustic-induced impacts, specifically whether the mitigation measures identified will adequately protect species within the vicinity of these deployments.	**Appendix C** of this Programmatic EIS addresses mitigation effectiveness.
Jaclyn Davies, State of New Jersey	SA-E-5	0.13	BOEM is to be commended for the depth of their species distribution analysis, as shown in numerous figures showing species hot spots along the entire eastern seaboard.	Comment noted.
Jaclyn Davies, State of New Jersey	SA-E-5	0.14	Concerning future studies, if these or similar activities were to take place within or near NJ waters, New Jersey asks that NJ's Ocean/Wind Power Ecological Baseline Studies data and results be thoroughly consulted and considered first, and added to information regarding affected species along the Atlantic coast, before proceeding with survey and other associated G&G exploration activities.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Evie Christopher, Virginia Department of Mines, Minerals and Energy	SA-E-1	0.01	Proceed with Alternative A, the Proposed Action, as being the least restrictive of the three alternatives presented in the DEIS, and the most supportive of developing all of Virginia's available energy resources.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.01	Coordinate G&G exploration activities with the commercial and recreational fishing industries to include public outreach on any temporary area closures and other anticipated impacts to mitigate any unforeseen or unnecessary economic hardships to the fisheries industries.	As indicated in **Chapter 3.5.1.5**, prior to conducting a G&G survey, operators would submit information to the local USCG office and the local harbormaster for issuance of a Local Notice to Mariners. The Local Notice to Mariners would specify the survey dates and locations and the recommended avoidance requirements. Experience in the Gulf of Mexico indicates that G&G surveys can be conducted safely without causing significant interruption of fishing activities or economic hardship to the fishing industry.
Richard Weeks, Virginia DEQ	SA-L-1	0.02	Consider time-of-year restrictions in near-shore waters for activities that would affect known spawning migrations of anadromous or catadromous fish species.	The Programmatic EIS did not identify any significant impacts to anadromous or catadromous fishes that would warrant time of year restrictions. Temporal or spatial restrictions or other mitigation measures could be required for individual surveys if the site/permit-specific NEPA analysis for that project indicated the potential for significant impacts to fish resources.
Richard Weeks, Virginia DEQ	SA-L-1	0.03	Continue to research potential G&G exploration impacts on marine mammals, sea turtles and marine/coastal birds and avoid and minimize impacts to the extent practical.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.04	DGIF finds that the PEIS addresses the primary issues with respect to fisheries resources that the agency commented on during the PEIS scoping process in 2010 and presents a reasonable assessment of those concerns.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.05	The use of seismic air guns could do unforeseen harm to a spawning run of adult female sturgeon, or any Alosine species (e.g. American shad, alewife and blueback herring), preparing to migrate into the Chesapeake Bay, and also to any young or mature adults returning to the ocean after their spawning migrations are complete.	**Chapter 4.2.6.2.2** has been revised to address this issue.
Richard Weeks, Virginia DEQ	SA-L-1	0.06	Biological impacts by seismic air-guns to burrowed overwintering blue crabs in the lower Chesapeake Bay, near the territorial sea, should be considered as this stock is still recovering from a near-collapse of the Chesapeake Bay stock in 2008.	The Chesapeake Bay is outside the AOI, and no seismic air gun surveys would occur in the Bay. Moreover, based on the invertebrate studies reviewed in **Appendix J**, seismic surveys are not expected to cause significant short-term or long-term effects on crabs.
Richard Weeks, Virginia DEQ	SA-L-1	0.07	DGIF finds that the PEIS addresses the primary issues with respect to marine mammals that the agency commented on during the PEIS scoping process in 2010 and presents a reasonable assessment of those concerns.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Richard Weeks, Virginia DEQ	SA-L-1	0.08	DGIF finds that the PEIS addresses the primary issues with respect to sea turtles that the agency commented on during the PEIS scoping process in 2010 and presents a reasonable assessment of those concerns.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.09	DGIF finds that the PEIS addresses the primary issues with respect to marine and costal birds that the agency commented on during the PEIS scoping process in 2010 and presents a reasonable assessment of those concerns.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.10	DGIF finds that the PEIS addresses the primary issues with respect to marine protected areas that the agency commented on during the PEIS scoping process in 2010 and presents a reasonable assessment of those concerns.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.11	VDACS reviewed and compared statements in the PEIS concerning endangered species with available information. VDACS finds that no additional comments are necessary in reference to endangered plant and insect species with regard to G&G activities.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.12	OCR finds that the current activity will not affect any documented state-listed plants or insects.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.13	Provided any necessary State VWPP permits are obtained and complied with for excavation, dredging, fill, or other regulated activities in state waters, the proposed activities should be consistent with VWPP regulations.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.14	According to the VMRC, encroachments in, on or over state-owned submerged land within Virginia's territorial sea associated with any infrastructure, such as pipelines, for projects on the OCS will require permits from the Virginia Marine Resources Commission (VMRC) pursuant to Chapter 12 of Title 2B.2 of the Code of Virginia. The Subaqueous Minerals Management Plan (SSMMP), which is a part of the State Minerals Management Plan (SMMP), would apply to G&G activities occurring in state-owned submerged lands. The VMRC authorizes and oversees mining, leasing, and extraction of minerals on state-owned submerged lands and grants permits for the use of such land use.	Text has been revised in **Chapter 1.6.18** to address this comment.
Richard Weeks, Virginia DEQ	SA-L-1	0.15	DEQ did not indicate that G&G activities would have a significant impact on air quality programs under its jurisdiction.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.16	DEQ finds that solid and hazardous waste issues were generally addressed in the PEIS. Specifically the report identifies vessel	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			wastes, which would include trash and debris, and sanitary and domestic wastes.	
Richard Weeks, Virginia DEQ	SA-L-1	0.17	DEQ encourages all construction projects and facilities to implement pollution prevention principles, including the reduction, reuse, and recycling of all solid wastes generated. All generation of hazardous wastes should be minimized and handled appropriately.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.18	According to DHR, BOEM must consult directly with the agency with regard to potential impacts to historic properties pursuant to Section 106 of the National Historic Preservation Act and its implementing regulation at 36 CFR part 800.	Consultation requirements under NHPA are addressed in **Chapter 5.7.5**.
Richard Weeks, Virginia DEQ	SA-L-1	0.19	The Hampton Roads Planning District Commission (HRPDC) staff reviewed the PEIS for G&G activities on the OCS and finds that the proposed activities appear to be consistent with local and regional plans and policies.	Comment noted.
Richard Weeks, Virginia DEQ	SA-L-1	0.20	Pursuant to the Coastal Zone Management Act of 1972, as amended, federal activities affecting Virginia's coastal resources or coastal uses (e.g., OCS lease sales, renewable energy competitive lease sales, and marine minerals negotiated competitive agreements) must be consistent, to the maximum extent practicable, with the Virginia Coastal Zone Management Program (VCP) (see section 307(c)(1) of the Act and Federal Consistency Regulations, 15 CFR part 930, subpart C, section 930.32).	**Appendix B** addresses the States' roles in consistency review.
Ron Villanueva, Virginia House of Delegates	SA-PHN-2	0.01	Support geological and geophysical study activities off the coast of Virginia and other regions of the Atlantic Outer Continental Shelf (OCS)	Comment noted.
Ron Villanueva, Virginia House of Delegates	SA-PHN-2	0.02	We know there is oil and natural gas in the Atlantic OCS, but we don't know how much. The program being considered by your agency through this hearing today, and others along the east coast can provide our nation with important information.	Comment noted.
Ron Villanueva, Virginia House of Delegates	SA-PHN-2	0.03	Virginia, and particularly the Hampton Roads area, could see a related and significant growth in jobs and revenue. This region is ideally located and has existing infrastructure to support such development.	Comment noted.
Ron Villanueva, Virginia House of Delegates	SA-PHN-2	0.04	As for the seismic surveys that are the focus of the hearing today, the protection of marine life off Virginia's coastline is very important and marine wildlife will be safeguarded through the survey process. State-of-the-art seismic survey techniques are carefully regulated and reliable. The permits you may issue to conduct such work will demand environmental protection.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Ron Villanueva, Virginia House of Delegates	SA-PHN-2	0.05	We need as much information as possible about Atlantic OCS energy reserves so we can make intelligent decisions about our nation's energy future. New seismic surveys are a key to those decisions and I urge you to move forward in that process.	Comment noted.
Ron Villanueva, Virginia House of Delegates	SA-PHN-2	0.06	The collection of seismic data alone will not be enough to tell us what resources may lie off the Virginia coast. Plans for a Virginia lease sale have been rejected, and there is no plan to reconsider that until 2017 at the earliest. Without a lease sale, seismic companies have little incentive to gather new data since there are no potential customers for that information.	Comment noted.
Doug Domenech, Virginia Secretary of Natural Resources	SA-PHN-1	0.01	Governor McDonnell is a strong advocate on behalf of an “all of the above” energy security strategy.	Comment noted.
Doug Domenech, Virginia Secretary of Natural Resources	SA-PHN-1	0.02	The Governor continues in his strong support for exploration and development of oil and natural gas resources off the coast of Virginia.·	Comment noted.
Doug Domenech, Virginia Secretary of Natural Resources	SA-PHN-1	0.03	While we are glad the draft PEIS for G&G has been prepared, the Commonwealth again must reiterate our strong disappointment that the Administration has decided to keep Virginia out of the next five-year plan for 2012 to 2017.	Comment noted.
Doug Domenech, Virginia Secretary of Natural Resources	SA-PHN-1	0.04	We urge the Administration to amend the 2012-2017 OCS five-year plan to allow for an oil and gas lease sale off Virginia in this cycle.· The Governor is equally interested in moving forward with siting for offshore wind, energy as well.·	Comment noted.
Doug Domenech, Virginia Secretary of Natural Resources	SA-PHN-1	0.05	Eighty percent of Virginia’s voters favor expanded offshore energy development, and our elected officials at all levels support development on a bipartisan basis.·	Comment noted.
Local Agency Representatives (sorted by Agency)				
Meg Crumpler on behalf of Mayor of the City of Charleston	LA-E-2	0.01	I encourage BOEM to adopt Alternative C- the no action alternative- in its programmatic environmental impact statement.	Comment noted.
Meg Crumpler on behalf of Mayor of the City of Charleston	LA-E-2	0.02	Offshore geological and geophysical (G & G) activities and eventual drilling can be harmful to the marine and coastal environment and thus would be inconsistent with our stated priority of maintaining our coastal resources.	**Chapter 5.7.1** of the Programmatic EIS explains the process by which coastal States (including South Carolina) would have an opportunity to review permits and license activities to determine whether they will be conducted in a manner consistent with the State’s Coastal Management Program. Further information is provided in **Appendix B**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Meg Crumpler on behalf of Mayor of the City of Charleston	LA-E-2	0.03	Acoustic pollution caused by oil and gas G & G activities such as the use of air guns, aeromagnetic surveys, and the drilling of test wells has proven associations with major impacts to marine mammals, turtles, and fish .	Potential acoustic impacts have been evaluated in the Programmatic EIS in **Chapter 4.2.2** (Marine Mammals), **4.2.3** (Sea Turtles), **4.2.5** (Fisheries Resources and Essential Fish Habitat), and **4.2.6** (Threatened and Endangered Fish Species). Please refer to these chapters for additional detail.
Meg Crumpler on behalf of Mayor of the City of Charleston	LA-E-2	0.04	Given that we would not support eventual commercial oil or gas drilling off our coast following the exploration process, surveying activities would be a wasteful investment of time, money, and energy.	Comment noted.
Brian Pennington, City of Norfolk	LA-PHN-1	0.01	We understand that there has not been any geological or geophysical studies off the coast of Virginia since the 1970s.· And we feel it makes a lot of sense to better understand what resources may actually be available.· Technology has greatly improved since the 1970s, as we feel we might not have all of the most accurate facts about what is contemplated out on the shoreline.	Comment noted.
Brian Pennington, City of Norfolk	LA-PHN-1	0.02	We believe informed decisions are best decisions so Norfolk supports the proposed geological and geophysical studies contemplated in the referenced program in the EIS.	Comment noted.
Robert Matthias, City of Virginia Beach	LA-PHN-2	0.01	The city of Virginia Beach has committed to energy development off the coast of Virginia.· We, therefore, are completely in support of the proposed geological and geophysical studies are needed before either offshore wind energy can take place or offshore oil and gas development can move forward.	Comment noted.
Robert Matthias, City of Virginia Beach	LA-PHN-2	0.02	We believe large scale wind development can happen off the coast with little to no environmental impact.·	Comment noted.
Robert Matthias, City of Virginia Beach	LA-PHN-2	0.03	And as for offshore oil and gas development, it will take place close to 50 miles off the coast of Virginia Beach, at least by 2020, the Council when adopting the Alternative Energy Task Force Report added a caveat, that it should be done to the safest extent possible and have no detrimental effect on the operations of the United States Department of Defense, National Aeronautics and Space Administration or Wallops Island, which hopes to develop a growing space exploration and launch site.	Comment noted.
Robert Matthias, City of Virginia Beach	LA-PHN-2	0.04	I will also add we are also very interested in minerals.· We put a lot of sand in our beach over the years, and we actually have quite a bit of information that we've gathered between the Corps and Virginia Institute Marine Science.· We would be	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			happy to share with you on mineral resources, primarily sand within five miles of the coast.	
Jan Brewer, St. John's County Florida	LA-E-1	0.01	I would first like to address the process. As I understand the EIS was opened for review on March 30. 2012 a public meeting for this region was held on April 16.2012 and the comment period is scheduled to end May 30, 2012. For a local government this timeframe is entirely too brief to allow a comprehensive review of the complex and lengthy reports and data associated with this EIS and then allow time to provide a briefing to and gain direction from the County Administration and local elected officials. As well. I attended the meeting held on April 16th and several individuals raised additional questions concerning this EIS. To date. I have not found where BOEM has addressed those comments. Therefore my first request is to allow an extension of time for a review and comment period for at least an additional 45 days.	The comment period was extended 30 days to provide additional time for review and comment on the Draft Programmatic EIS.
Jan Brewer, St. John's County Florida	LA-E-1	0.02	Royalties from gas/oil wells in the gulf are shared with adjacent States/Counties. There is no provision in federal law that requires royalties gained in the Atlantic Ocean be shared with adjacent States/Counties. This should be addressed prior to any lease issuance.	A lease sale is not part of the proposed action for this Programmatic EIS and therefore the issue of royalty sharing with states is premature. However, Section 8(g) of the OCS Lands Act refers to shared bonuses, rents and royalties. This provision is found in 43 U.S.C. § 1337 and provides that 27% of the OCS revenues from leases within three miles of the seaward boundary of a coastal State must be shared with that coastal State. These provisions apply to all coastal States including those on the Atlantic.
Jan Brewer, St. John's County Florida	LA-E-1	0.03	Chapter 377. "Florida Statutes, prohibits structures for drilling in Florida territorial seas (shore to three geographic miles). The EIS reads that the Area of Interest is from, the shoreline to 350 nautical miles from shore". Please address how Florida law will not be compromised.	Chapter 377.24(9), Florida Statutes specifically states that "no permit to drill a well in search of oil or gas shall be granted… within the boundaries of Florida's territorial seas as defined in 43 U.S.C. 1301." The proposed action evaluated in the Programmatic EIS does not include drilling of wells in search of oil or gas. Drilling of stratigraphic test wells may occur as discussed in **Chapter 3.2.2.4**, but these wells would be drilled to obtain information about regional stratigraphy and are most likely to be sited in deep, offshore areas such as the Blake Plateau. In any case, BOEM's authority is limited to OCS waters; the Agency cannot authorize drilling in Florida territorial waters.
Jan Brewer, St. John's County Florida	LA-E-1	0.04	The EIS failed to disclose the financial impacts to adjacent States/Counties for the potential mass stranding of impacted or dead marine mammals on County beaches. For example looking at just dolphin the EIS reports that potentially one million dolphin may be acoustically impacted and it is a real possibility that impacted animals could end up on the County beach requiring removal. A funding source needs to be	Based upon records from areas that have experienced years of G&G activities, such as the Gulf of Mexico, mass strandings of cetaceans are not expected. The numbers referred to in this comment are estimates of the number of Level B harassment "takes" (behavioral disturbances) over the entire project period. These are not expected to result in any deaths or strandings of marine mammals. In addition, mitigation methods will be used before and during surveys to reduce potential

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			identified and details provided in the EIS to address this issue and funding needs to be guaranteed to adjacent States/Counties.	impacts from seismic noise to marine mammals.
Jan Brewer, St. John's County Florida	LA-E-1	0.05	The invasive seismic survey procedure of blasting pulsating shocks of noise loud enough to penetrate deep into the sea bed and across vast ocean areas to search for possible oil and gas reserves would detrimentally impact marine habitat and potentially destabilize marine ecosystems. As an example the EIS reads the loud blasting and repeated sound waves from this process can cause temporary or permanent hearing impairment and loss serious injury from tissue trauma and hemorrhaging or even death for dolphins fish whales and sea turtles. This level of detrimental impact on the marine environment is unacceptable. As well the EIS was drafted only to address the exploratory survey activities and this is seen as a shortsighted approach. The EIS failed to disclose the financial impacts to adjacent States/Counties for the potential impacts to marine habitat, potential destabilization of marine ecosystems oil spills or mass oil release from future drilling and thus needs to be addressed.	The referenced impacts are fully evaluated in **Chapter 4.0** of the Programmatic EIS. BOEM has cooperated with NMFS during the preparation of the Programmatic EIS to ensure that resources under its jurisdiction would be adequately protected. BOEM has concluded its Section 7 Consultation under the Endangered Species Act with NMFS and FWS to ensure that the proposed action would not jeopardize the continued existence of a listed species or destroy or adversely modify critical habitat. The scope of the Programmatic EIS does not include oil and gas leasing or possible future drilling of oil and gas wells. If Congress directs BOEM to assess the impacts from opening the area of interest to oil and gas lease sales the issue raised would be addressed at that time in a separate NEPA evaluation.
Jan Brewer, St. John's County Florida	LA-E-1	0.06	Obviously the next activity will be oil drilling. NOAA responds to as many as 150 oil spills every year as stated on their website. This demonstrates the potential for the County beaches to become impacted by this activity. This would greatly affect the County's economy which is largely based on tourism and on both recreational and commercial fishing. Provisions should be made now to address the monetary impacts to the County if oil wells are drilled offshore.	The Programmatic EIS does not include drilling of oil wells. If Congress directs BOEM to assess the impacts from opening the area of interest to oil and gas lease sales the issue raised would be addressed at that time in a separate NEPA evaluation.
Jan Brewer, St. John's County Florida	LA-E-1	0.07	Finally, the County requests adequate descriptions, objectives, and schedules for all activities associated with a project: specific information on the natural resources potentially affected by the proposed activities: and specific information on onshore support base, support vessels, shallow hazards oil-spill response, wastes and discharges transportation activities and air emissions.	The NEPA evaluations for site-specific permit applications will provide the description, objectives, and schedule or each survey planned as well as the impacts from the activities and this information would need to be coordinated between the State and county.
Industry Representatives (sorted by Organization)				
Andy Radford, American Petroleum Institute	I-E-12	0.01	We recommend that BOEM provide another alternative without closure areas prior to issuance of the final PEIS. We strongly encourage that both the range of alternatives analyzed and their evaluation reflect the nature and extent of the known causes of injury and mortality faced by various protected species. In addition, for the reasons explained further in these comments,	An alternative that does not include the closure area for the NARW was not evaluated because BOEM and NMFS do not consider it to be reasonable. Allowing seismic airgun surveys to be conducted within the right whale critical habitat, SMAs, or DMAs during the times when these whales are present, including calves and nursing mothers, would not be prudent based on the endangered status of these whales. BOEM believes

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			we oppose as unwarranted several of the mitigation measures proposed as part of Alternative A. Further, we believe that Alternative B is unwarranted for a number of reasons including the finding in the DPEIS that doubling the size of the closure area does not provide additional protection for right whales or marine life generally.	that Alternative B does provide additional protection for right whales by expanding the closure to include a 20-nmi (37-km; 23-mi) corridor all along the coast from Florida to the northern boundary of the AOI. As stated in **Chapter 4.3.2.1.1**, it is estimated that the expanded time-area closure would avoid approximately 80% of the incidental takes of NARWs over the period of the Programmatic EIS (as compared with no closures). In contrast, the Alternative A time-area closure would be expected to avoid about 67 % of the right whale incidental takes. Please see response I-E-10:0.04.
Andy Radford, American Petroleum Institute	I-E-12	0.02	The approach to High Resolution Geophysical activities would be improved if the DPEIS recognized that this type of survey equipment is also used by many other sectors not identified in the DPEIS. The DPEIS should explain why a wide range of sectors can use these technologies during certain times and in locations where the oil and natural gas E&P industry could not. Since the environmental consequences of a survey tool's use do not vary by who is using it, there is no apparent basis for this discriminatory treatment, particularly if it shows lack of effect. Industry would note that a wide range of marine users, including scientific researchers, routinely apply one or more of these or similar tools.	BOEM is only responsible for authorizing G&G surveys under its jurisdiction. **Chapter 3.0** of the Programmatic EIS has been revised to indicate that the equipment suite used during G&G surveys for renewable energy and marine minerals is used widely in other applications such as research, undersea cable routing, etc. The mitigation requirements were developed based on the impacts identified and quantified in the impact analysis in **Chapter 4.0**, supported by acoustic and incidental take modeling in **Appendices D** and **E** as well as the results of newly published sound source verification modeling (Zykov and Mac Donnell, 2013; Martin et al., 2012). Mitigation measures are not specific to a program area, but are based on equipment type, acoustic source levels, and the nature of the operations, which include location and duration. Mitigation measures for different non-airgun HRG acoustic sources also differ; acoustic exclusion zone monitoring and shutdown do not universally apply to all non-airgun HRG surveys. In addition, since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. **Chapter 2** and **Appendix C** have been revised to reflect the clarified HRG Survey Protocol.
Andy Radford, American Petroleum Institute	I-E-12	0.03	The DPEIS also proposes to require unprecedented observation and shut-down zone requirements for HRG but does not provide necessary environmental impact information that would indicate adverse effects of a nature to warrant requiring such zones. The shut-down requirements are in industry's opinion, not warranted, scientifically substantiated nor feasible in many circumstances, including but not limited to, HRG activities conducted by Autonomous Underwater Vehicles (AUVs) that collect data only a few feet above the sea bed.	Since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. Mitigation measures for non airgun HRG acoustic sources differ according to source, acoustic exclusion zone monitoring, and shutdown do not universally apply to all non airgun HRG surveys. In addition, with the clarification of the HRG Survey Protocol, the NARW time-area closures do not apply to many non airgun HRG sources. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. BOEM has attempted to better draw the distinction between these activities throughout the EIS. For example, revised Seismic Airgun Survey Protocol can be found in **Chapter 2.1.3.1** and the HRG Survey Protocol can be found in **Chapter 2.1.3.2**, with an expanded discussion in **Appendix C**. We disagree that the Draft Programmatic

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				EIS does not report a basis for potentially adverse effects to establish exclusion zones. The exclusion zones that have been calculated in **Appendix D** for HRG-type tools are consistent with existing guidance from NMFS for acoustic propagation modeling and the hearing thresholds they recognize for incidental take. Since the Draft Programmatic EIS was released additional sound source verification monitoring studies have been conducted and published (Zykov and Mac Donnell, 2013; Martin et al., 2012). The results of these studies were applied to clarifying the HRG Survey Protocol.
Andy Radford, American Petroleum Institute	I-E-12	0.04	The DPEIS does a better job than some other recent NEPA documents in discussing acoustic impact analysis. However, the PEIS should contain agency explanations of all the steps, choices and assumptions that were made in impact determinations. The effects of these choices are not adequately disclosed nor discussed in the environmental consequences assessment. In the end, industry believes that the DPEIS 1) does not employ the best available science, 2) grossly overestimates the number of Level A and Level B takes, and 3) that these overestimations lead to incorrect choices in the Alternatives presented and the mitigation measures proposed.	The Programmatic EIS provides a very detailed description for the entire process used in assessing impacts from the proposed action. **Chapter 3.0** contains a detailed summary of G&G activities, including **Chapter 3.5** which provides the projected activity scenario for each of the three programs and a description of each impact-producing factor used in the analysis. **Chapter 4.0** takes the reader through a detailed description for each step in the impact assessment process beginning with a screening of potentially impacted resources, followed by an analysis of impact levels and impact significance criteria, leading to an analysis of impact-producing factors. **Appendices D** and **E** are included to provide more in-depth discussion and analysis of a number of important topics such as acoustic modeling and incidental take methodology. The Jasco acoustic propagation model was considered to be one of the best and most appropriate models for G&G acoustic propagation modeling and the Acoustic Integration Model has been peer-reviewed under the CREM guidelines and therefore is considered one of the best options for estimating marine mammal takes under the guidance of NMFS and their MMPA regulatory authority. The Level A and Level B take estimates included in the Programmatic EIS were developed based on a proposed survey level of effort and provided as a tool for evaluating impact levels. We believe they are reasonable based on the activity scenario and the modeling results presented in the Programmatic EIS.
Andy Radford, American Petroleum Institute	I-E-12	0.05	The DPEIS would be improved by placing hypothetical seismic survey risks in a context relative to the significant known risks. So doing, for example, would note that the speeds of working seismic survey vessels are less than half of the current regulatory limit of 10 knots. Industry believes that the evaluation of the need for closure areas would be different if this analysis were conducted.	The slow speed of seismic vessels is noted in the impact evaluations in **Chapter 4.0** (e.g., when evaluating the potential for vessel strikes on marine mammals and sea turtles). The identified vessel speeds under the Vessel Strike Avoidance measures are applicable to all survey vessels regardless of size during transit when vessels are within critical habitat areas, SMAs, and DMAs, the speed is not related to survey operations when vessel speeds would be below 10 kn. Although the closure areas include the right whale critical habitat areas, SMAs, and DMAs where vessel speeds are limited by NOAA's vessel strike reduction rule

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				(50 CFR § 224.105), the potential for vessel strikes was not the main reason for proposing the closures; rather, they were based on potential impacts from acoustic sources. The Programmatic EIS must still consider hypothetical risks due to the fact that the North Atlantic coast has not had large scale G&G surveys for over 30 years. Risks and effects to the species, such as the endangered NARW, can only be estimated and due to the sensitive nature of the species, protection must be planned. We believe that the time-area closures in the critical habitat and SMAs for the NARW are reasonable because of the endangered status of this species and the importance of these areas to their life cycle.
Andy Radford, American Petroleum Institute	I-E-12	0.06	Moreover, the size of the proposed closure areas is premised upon defining areas of habitat critical for life function that includes not only breeding and foraging, but also migration pathways. These three components comprise the totality of activities for these animals rather than critical habitat. The critical habitat designation for North Atlantic right whales determined in 1994 considered but rejected migration routes as inconsistent with the ESA approach to critical habitat. Although there is a petition to revise critical habitat, no decision has been made. BOEM should clearly state on what basis and under what authority it proposes to regulate using migration pathways. Industry does not agree that such regulation is permissible.	The NARW is an endangered species. The entire life cycle of their activity is subject to intervention if possible takes could occur by permitted Federal activity. We do not propose to regulate using migration pathways. We do propose to emplace reasonable and prudent protective measures consistent with the status of this species under the ESA. The migratory pathway is not being protected as critical habitat and that needs to be noted. It can be considered a SMA and this mitigation measure was developed in conjunction with NMFS to ensure added protection to this endangered species. We recognize the coastal zone as important for the transiting of these animals between their recognized critical habitat areas in the North and South Atlantic.
Andy Radford, American Petroleum Institute	I-E-12	0.07	If we consider one specific proposed mitigation, the shutdown requirement, to demonstrate just how impactful the incorrect analysis and selection of alternatives and mitigation measures can be, we believe it to be so great as to cast into doubt the very feasibility of conducting seismic activities. The proposed mitigation measures are designed to respond to and mitigate projected Type A and Type B takes. But because the DPEIS greatly overstates the number of Type A and Type B takes and exclusion zones for potential takes it greatly overstates the risk and extent for reasonable mitigation measures. This is of critical importance, because, based on predictions, some of the proposed mitigation measures would impose potentially high costs, greatly impede or altogether preclude the conduct of seismic surveys and geohazard and cultural resource identification, and deeply frustrate the achievement of the goals of the OCS Lands Act. The practical consequences of the proposed changes for the conduct of seismic surveying are enormous. We are highly doubtful that seismic survey	BOEM and NMFS appreciate the comment and are committed to ensuring that mitigation requirements are feasible. The Programmatic EIS has been revised to clarify the shutdown requirements for delphinids. Specifically, **Appendix C**, **Sections 3.2.2.5** and **3.3.3** indicate that "shutdown would not be required for dolphins approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the PSO." Since the release of the Draft Programmatic EIS the HRG Survey Protocol has been clarified and the case-by-case language has been removed. Mitigation measures for different non airgun HRG acoustic sources also differ and acoustic exclusion zone monitoring, and shutdown does not universally apply to all non airgun HRG surveys. In addition with the clarification of the HRG Survey Protocol, NARW time-area closures do not apply to many non airgun HRG sources.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			operations could even be attempted were shutdowns to be required with anything approaching the frequency estimated in the DPEIS.	Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. In November 2012, BOEM and NMFS sponsored a Mitigation and Monitoring Workshop for the Gulf of Mexico (GOM) in Herndon, Virginia. This workshop involved multiple stakeholders, including other Federal agencies, industry, academia, and NGOs. While the workshop focused on the Marine Mammal Protection Act (MMPA) and the incidental take authorization process specific to G&G activities in the GOM the goal of the workshop was to seek individual expert input from stakeholders to develop "an appropriate suite of effective and practicable mitigations" and to develop "a comprehensive monitoring plan that [would] enable stakeholders to answer questions regarding marine mammals, the effects of industry activities, and the effectiveness of mitigation measures." BOEM and NMFS will be utilizing an adaptive management process in this EIS which can be applied towards monitoring and mitigation measures. Many of the mitigation measures outlined in the draft EIS and clarified in the Final Programmatic EIS, are measures that are currently successfully implemented by geophysical operators in the Gulf of Mexico. BOEM has used the existing guidance as a starting point for the types of permit conditions that could be expected in the Atlantic. BOEM also acknowledges that differences exist in the Atlantic and GOM; the composition of species and the north-south migrations that are a feature of the Atlantic Basin are not a feature of the GOM.
Andy Radford, American Petroleum Institute	I-E-12	0.08	To build its case that seismic does have significant adverse effects, BOEM relies on models that have not been validated against field data to create unrealistic estimates of incidental takes. Further, the estimate of the number of takes is only achievable by using acoustic threshold criteria based on 15-year old obsolete data that does not meet the NEPA requirement to use the best available science. In addition, in the face of no observable injury/mortality data and no population level behavioral effect, the DPEIS demands more and more unreasonable mitigation measures, including six-month area closures and the addition of dolphins (who at times intentionally approach seismic vessels) to the list of animals that require operations to shut down. Not only is there little to no basis for these demands, the DPEIS will require the conventional energy industry to comply with operational mitigations that industries having known causes of cetacean mortality do not. In so doing, the agency decision-making is not only impossible to justify but also discriminatory.	The Acoustic Integration Model (AIM) used to calculate the take estimates incorporates acoustic propagation models that have been extensively tested against field measurements. In addition, the AIM model has undergone external peer review by NOAA's Center for Independent Experts (CIE) to document that it meets the Council for Regulatory Monitoring (CREM) guidelines for model development and evaluation. The acoustic exposures and resulting take estimates utilized the 160 dB RMS criterion for potential behavioral reactions (MMPA Level B incidental harassment) and the 180/190 dB rms criteria for cetaceans/pinnipeds, respectively, that are currently accepted by NMFS. The Programmatic EIS also presents injury calculations using the Southall criteria, which were developed in 2007 and remain the best available science based on our updated literature review in **Appendix H**. However, we cannot use the Southall criteria as the basis for take estimates because they have not been adopted by NMFS. We believe that the time-area closures in the critical habitat and SMAs for the NARW, and DMAs are reasonable because of the endangered status of this species and the importance of these areas to their life cycle. Our

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				mitigation is not limited to activities that may cause cetacean mortality. The Programmatic EIS has been revised to clarify the shutdown requirements for delphinids. Specifically, **Appendix C**, **Sections 3.2.2.5** and **3.3.3** indicate that "shutdown would not be required for delphinids approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the Protected Species Observer (PSO)." The Programmatic EIS has also been revised to include information from recent sound source verification monitoring (Zykov and Mac Donnell, 2013; Martin et al, 2012) and the results of these studies have been applied to clarifying the HRG Survey Protocol. Last, under OCSLA, BOEM can only regulate energy activities in the OCS and therefore cannot discuss the regulation of other industries.
Andy Radford, American Petroleum Institute	I-E-12	0.09	The DPEIS does not utilize the best available scientific evidence, and the conclusions reached on critical issues are therefore simply wrong. Specifically, the DPEIS errs when it concludes that exposure to sound levels in excess of 180 Db re: 1 μPa (rms) results in Level A harassment, and that exposure to sound levels in excess of 160 dB re: 1 μPa (rms) results in Level B harassment. Nor is an adequate scientific basis provided for the proposed expansion of shutdown requirements to include delphinids, the proposed expansion of the shutdown zones, or the proposed separation requirement for seismic vessels conducting simultaneous operations.	Our use of the 180-dB and 160-dB criteria, as cited in this comment, are based on their acceptance by NMFS and, therefore, we believe they are reasonable. NMFS specifies that marine mammals exposed to pulsed sounds with received levels exceeding 180 or 190 dB re 1 μPa (RMS) for cetaceans and pinnipeds, respectively, are considered to exceed Level A (Injury) levels. NMFS also specifies that cetaceans and pinnipeds exposed to levels exceeding 160 dB re 1 μPa (RMS) are considered to exceed Level B (Behavioral Harassment) criteria. The Programmatic EIS also presents injury calculations using the Southall criteria, which were developed in 2007 and remain the best available science based on our updated literature review in **Appendix H**. The Programmatic EIS has been revised to clarify the shutdown requirements for delphinids. Specifically, **Appendix C**, **Sections 3.2.2.5** and **3.3.3** indicate that "shutdown would not be required for delphinids approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the Protected Species Observer (PSO)." As stated in **Chapter 2.2.2.3**, the 40-km (22-nmi; 25-mi) separation distance was based on an operational limit to eliminate overlapping reflections received from multiple source arrays. The modeling done for this project estimated the largest exposure radii

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				for the 160-dB threshold (Level B) for a large airgun array to be approximately 15 km (8 nmi; 9 mi). However, new information suggests that, in some circumstances, airgun noise can be detected great distances from the sound source, such as across ocean basins (Nieukirk et al., 2012). Although it is unknown if detection at these distances has any effect on marine mammals, a 40-km (22-nmi; 25-mi) separation distance may not be an appropriate measures in all situations. As such, BOEM has decided to keep the 40-km separation distance as part of Alternative B but may not apply this specific measure programmatically. Instead, BOEM will consider the value of this measure at the site-specific NEPA and environmental analyses level as well as any new information available at that time. This evaluation will also consider any potential aggregate effects from existing permitted surveys (if any). BOEM does not expect concurrent surveys in nearby areas to be a common occurrence. The rationale for expansion of the shutdown zones (by comparison with the uniform 500-m radius specified in NTL 2012-JOINT-G02) is provided in **Appendix C**, **Section 3.2.1**. The radius of the exclusion zone would be based on the predicted range at which animals could be exposed to a received sound pressure level of 180 dB re 1 µPa, which is the current NMFS criterion for Level A harassment of cetaceans. The radius would be calculated for each survey but would not be less than 500 m. The expansion of the radius beyond 500 m (164 ft) is based on acoustic modeling in **Appendix D** showing that the 180-dB radius could exceed this distance (e.g., values ranged from 799 to 2,109 m [2,621 to 6,919 ft] for a large airgun array as shown in **Table D-21**). Please reference **Appendix M** for new information on acoustic criteria.
Andy Radford, American Petroleum Institute	I-E-12	0.10	Further to this, industry does not believe the principle of equating received sound levels to takes has been subjected to public comment or peer review as is required for rulemaking. In addition, this interpretive application of exposure as a proxy for incidental take is not supported by the MMPA, which requires that harassment must take place. 16 U.S.C. 1362(18)(A). In the case of Level B Harassment, the disturbance must be related to a disruption in behavioral patterns, not just behavioral change. 16 U.S.C. 1362(18)(A)(ii), 1362(18)(D). Bow-riding by dolphins is an excellent example of a normal behavioral pattern and should not therefore be assessed as a take based on received sound levels, using any metric.	BOEM and NMFS appreciate the comment and it is noted. BOEM utilizes the MMPA criteria identified by NMFS, and considers the take estimates to be conservative. BOEM acknowledges that determining whether there is "disruption" of behavioral patterns is a complex and difficult issue that is the subject of ongoing research and discussion, but there have been many scientific studies that have shown acoustic sources change the behavior of many species (see **Chapter 4.2.2** and **Appendix H**). However, BOEM is conducting an impact analysis and has no jurisdiction with respect to authorizing incidental takes. In conducting the impact analysis, we have to recognize the criteria currently used by NMFS, under which a marine mammal exposed to a sound pressure level of 180 dB re 1 µPa (rms) is considered to be a Level A incidental take. As noted in responses to previous comments, the choice of metric used to determine takes was made by NMFS.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				All of the incidental takes calculated in **Appendix E** were estimated without mitigation other than the time-area closures, and therefore, dolphins predicted to be within the exclusion zone would be counted as incidental takes in our estimates; the discussion in **Chapter 4.2.2.2.2** notes that this is a conservative assumption. We acknowledge that not all animals in all cases change their behavior, as exemplified by bow-riding dolphins. The Programmatic EIS has been revised to clarify the shutdown requirements for delphinids. Specifically, **Appendix C**, **Sections 3.2.2.5** and **3.3.3** indicate that "shutdown would not be required for delphinids approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the Protected Species Observer (PSO)."
Andy Radford, American Petroleum Institute	I-E-12	0.11	Finally, there is no jurisdictional precedent defining whether sound occurring at a certain level constitutes take. It is simply not enough for an animal to be exposed to a sound. For there to be a "take" based on harassment, there must be "disruption" of a "pattern" of behavior and it must be caused by an act of pursuit, torment or annoyance. 16 U.S.C. 1362(18)(A). B.	BOEM acknowledges that determining whether there is "disruption" of behavioral patterns is a complex and difficult issue that is the subject of ongoing research and discussion. BOEM is conducting an impact analysis and has no jurisdiction with respect to authorizing incidental takes. In conducting the impact analysis, we have to recognize the criteria currently used by NMFS, under which a marine mammal exposed to a sound pressure level of 180 dB re 1 μPa (rms) is considered to be a Level A incidental take. As noted in responses to previous comments, the choice of metric used to determine takes was made by NMFS.
Andy Radford, American Petroleum Institute	I-E-12	0.12	The PEIS lacks any analysis of the Congressional purpose enshrined in the OCS Lands Act; the manner in which the seismic surveying at issue in the DPEIS advances those goals; and the question whether Alternative A versus Alternative B, or the proposed mitigation measures contained in both Alternative A and Alternative B would have a materially negative impact upon the accomplishment of those goals. This is a fundamental flaw in the DPEIS, and one that leads to the inclusion of inappropriate proposed mitigation measures.	The purpose of the proposed action, described in **Chapter 1.4.2**, is to gather state-of-the-practice data about the ocean bottom and subsurface. The data collected through G&G surveys provides information about the location and extent of oil and gas reserves, other marine mineral reserves, seafloor topography and geological hazards for installation of structures. The need for the data is to use the information obtained through surveys to: (1) make informed decisions regarding development of OCS minerals, (2) protect existing biological and human resources, and (3) provide a knowledge base for economic purposes to allow BOEM the ability to best benefit the public in the management of our offshore resources and minerals to provide the best return and for industry to identify the best and safest development options. That oil and gas lease holders have an expectation to develop their leases

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				is clearly stated in OCSLA Section 8(b)(4). We are, however, at a stage in development of this AOI where we are considering the steps that could lead to leasing. On the way to such consideration OCSLA Section 18(H)(3) requires this Agency to select the timing and location of leasing, to the maximum extent practicable, so as to obtain a proper balance between the potential for environmental damage and the potential for the discovery of oil and gas. **Chapter 2.7** has been developed to identify Alternative B as the Agency's Preferred Alternative, and the analysis there includes consideration of the extent to which the alternatives would meet the purpose and need as described in **Chapter 1.4.2**. Last, it should be noted that BOEM promotes energy independence, environmental protection and economic development through responsible, science-based management of offshore conventional and renewable energy resources.
Andy Radford, American Petroleum Institute	I-E-12	0.13	In determining programmatic goals, and hence what proposed alternatives are "reasonable", an:"agency's evaluation of its objectives is heavily influenced by the agency's consideration of "the views of Congress, expressed, to the extent that the agency can determine them, in the agency's statutory authorization to act, as well as in other congressional directives". Pena, 972 F. Supp. at 18 (emphasis added).	The Congressional language directing the evaluation in this Programmatic EIS is reproduced in its entirety in **Chapter 2.5.1** and speaks for itself. The alternatives identified in this Programmatic EIS are based on technical feasibility and economic viability, which would be our definition of "reasonable." A proposed alternative is reasonable only if it will fulfill the Programmatic EIS's purpose and need.
Andy Radford, American Petroleum Institute	I-E-12	0.14	BOEM's only obligation is to assess reasonably likely environmental impacts, South Fork Band Council of Western Shoshone of Nevada v. DOI, 588 F.3d 718, 727 (9th Cir. 2009), not impacts that are simply a mere possibility. ―An EIS need not discuss…conjectural consequences, Sierra Club v. Hodel, 544 F.2d 1036, 1039 (9th Cir. 1976), and alternatives and mitigation measures therefore cannot be imposed to counteract purported effects for which there exists no credible scientific proof. The Draft PEIS violates these precepts in, for example, its establishment of exclusions zones based upon conjectural impacts of exposure to arbitrarily selected sound thresholds.	BOEM believes the impacts assessed in the Programmatic EIS are reasonably likely and not simply a mere possibility, conjectural, or having no credible scientific proof as stated in the comment. The effects of noise on marine mammals are well documented as summarized in **Chapter 4.2.2.2.2** of the Programmatic EIS. Although we acknowledge that the understanding of acoustic impacts is incomplete, underwater noise and the anthropogenic causes of it most certainly are stressors for marine mammals that rely on hearing acoustic communications from conspecifics for their life activities or as a means to locate prey. NMFS has established acoustic criteria for the harassment levels recognized in law, and a healthy debate continues with respect to how protective they are. However, the calculations presented in the Programmatic EIS demonstrate that without mitigation, marine mammals would be exposed to sound levels that would exceed the NMFS criteria for Level A harassment (i.e., "has the potential to injure a marine mammal or marine mammal stock in the wild") as well as the Southall et al. (2007) criteria for injury. The mitigation measures that are part of the proposed action, including the exclusion zones, are designed to reduce the potential for such impacts to occur.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Andy Radford, American Petroleum Institute	I-E-12	0.15	The DPEIS must assess economic effects. In considering alternatives and possible mitigation measures, the agency "may legitimately consider such facts as cost to the applicant and logistics."	There is no NEPA requirement for a cost-benefit analysis as a discriminator between alternatives, particularly if there are important qualitative considerations (40 CFR § 1502.23). However, an EIS should indicate considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision (40 CFR § 1502.23). A screening of cost was performed for 2-D seismic surveys and is summarized in **Chapter 2.7** and in **Table 2-7**. However, because of the proprietary nature of cost information related to much of the oil and gas seismic data acquisition, a full economic assessment was not performed nor was a cost benefit analysis conducted.
Andy Radford, American Petroleum Institute	I-E-12	0.16	The DPEIS must contain a cost-benefit analysis.	There is no NEPA requirement for a cost-benefit analysis as a discriminator between alternatives, particularly if there are important qualitative considerations (40 CFR § 1502.23). However, an EIS should indicate considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision (40 CFR § 1502.23). Therefore, a cost analysis for inclusion of the proposed mitigation measures has been performed and is included in **Chapter 2.7**. A screening of cost was performed for 2-D seismic surveys and is summarized in **Chapter 2.7** and in **Table 2-7**. However, because of the proprietary nature of cost information related to much of the oil and gas seismic data acquisition, a full economic assessment was not performed nor was a cost benefit analysis conducted.
Andy Radford, American Petroleum Institute	I-E-12	0.17	Given the lack of active leases and planned lease sales, the DPEIS greatly overstates the anticipated level of industry seismic activity. The projected activity estimates submitted in May 2010 are no longer endorsed by the geophysical industry and should not be used in the development of the DPEIS.	The projected level of activity used for analysis in the Programmatic EIS is based on survey permit applications received by BOEM. A projected level of activity was required to construct a scenario for the NEPA evaluation. The actual level of activity that results may differ. Before a site-specific evaluation begins, permit applicants to this Agency would be required to resubmit their applications using new BOEM forms. Once issued, a permit is valid for up to 1 year. The applicant would need to carefully plan the proposed work to ensure it could be completed within the year.
Andy Radford, American Petroleum Institute	I-E-12	0.18	The accuracy of the DPEIS would be enhanced by more fully characterizing the important role that geophysical imaging technologies offer E&P operations toward increasing safety and reducing environmental risks in E&P operations, particularly during drilling operations. At present, there are no commercially available and viable alternatives to current geophysical imaging technologies, which have been employed and continuously refined over the last six decades to be more efficient and emit less sound energy.	This is outside of the scope of the NEPA document, which is not meant to expand on the virtues of current technology. However, seismic imaging technology has continued to improve over the last several decades due to improvements in seismic equipment, operational techniques and data processing. An argument could be made that the resulting higher resolution seismic data enables more precise drilling which could mean that less wells may have to be drilled (lower environmental footprint) and that the wells and production platforms can be placed in safer subsurface conditions to avoid gas pockets, faults or areas where slumping occurs.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				However, the trend in seismic acquisition is not towards "less sound energy" being emitted. For example, the need for higher resolution imaging and rock property determination (seismic inversion) requires more bandwidth. Therefore the tendency in many cases is to deploy bigger airgun arrays. Moreover, the adoption of new operational techniques such as multi-azimuth and coil shooting require additional seismic sources and source vessels to be employed. In addition, BOEM conducted a Workshop in February 2013 to examine the status of quieting technologies for seismic surveying in order to identify alternative, lower energy methods of performing surveys.
Andy Radford, American Petroleum Institute	I-E-12	0.19	The DPEIS notes the requirement for reasonable alternatives: These regulations (40 CFR 1500-1508) provide for the use of the NEPA process to identify and assess reasonable alternatives to a proposed action that avoid or mitigate adverse effects of a given action upon the quality of the human environment. [Page 1- 11] The range of alternatives should include one without the closure areas for the North Atlantic right whales. This would address the agency's NEPA requirements to include a reasonable range of alternatives. In addition, for the reasons explained in Industry's cover letter and in these comments, the proposed mitigation measures should not expand the seismic airgun survey protocol beyond what already appears in NTL 2012-G02.	BOEM and NOAA believe that an alternative that does not include the closure area for right whales would not be considered reasonable. The inclusion of a time-area closure(s) recognizing the ESA status of the North American Right Whale was a reasonable alternative because the species is already protected in its critical habitat, SMAs, and DMAs by NOAA's vessel strike reduction rule (50 CFR § 224.105). Airgun and HRG Survey Protocols have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**. The requirements expressed in our NTL 2012-JOINT-G02 are minimum and applicable to the Gulf of Mexico. For example, the NTL includes water depth and longitude requirements that are specific to the GOM. The exclusion zones calculated in **Appendix D** of the Programmatic EIS are based on acoustic modeling using Atlantic conditions which show that the 180-dB radius could range from 799 to 2,109 m (2,621 to 6,919 ft) for a large airgun array as shown in **Table D-21**, and therefore the uniform 500-m (1,640-ft) exclusion radius used in the Gulf of Mexico NTL is not appropriate for the proposed action.
Andy Radford, American Petroleum Institute	I-E-12	0.20	The DPEIS presents an environmental consequences analysis that incorrectly assesses the environmental effects of seismic operations on both an absolute basis and equally importantly on a comparative basis with other known sources of risk to individual animals and populations. The analysis appears to give equivalent weight to potential risks, which are not equivalent – Level A (mortality/injury) and Level B (behavioral effect many of which are likely short-term and transitory). These low behavioral effect levels are then labeled as a greater risk ("Moderate") than non-industry activities such as vessel strikes and fishing gear entanglements involving mortality to marine mammals of concern, which are labeled as	Not all behavioral effects (Level B harassment) are considered minor. Richardson et al. (1995) states "Almost all data on disturbance reactions, whether observational or experimental, have concerned short-term behavioral reactions. These studies often determined distances or received sound levels at which animals first reacted noticeably. Recognized reactions usually involved cessation of feeding, resting, or social interaction, and onset of alertness or avoidance…In whales, avoidance may mean hasty diving, swimming away, or both…The significance of short-term, behavioral responses as they relate to the well-being of individuals and populations is rarely known. Most brief interruptions of normal behavior may have little effect on overall energy balance and reproductive performance. However, physiological

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			"Minor" environmental effects. Conflicting standards in the environmental consequence yields an internally contradicted DPEIS assessment of risks regarding a multitude of activities. Minor and short-term behavioral effects associated with seismic surveys appear to be judged more consequential than known causes of animal mortality, such as ship strikes.	reactions may occur even if no overt behavioral response is evident. The rationale for the impact determination for non-industry activities (e.g., vessel strikes, fishing gear entanglements) which may result in mortality to marine mammals (i.e., determined to be "Minor") rests, in part, on mitigation measures currently in place (e.g., restrictions on fishing gear; vessel speed restrictions) and their effectiveness. In addition, the level of G&G-related vessel activity considered in this analysis, as compared to other vessel operations, is very small.
Andy Radford, American Petroleum Institute	I-E-12	0.21	Clearly differentiate the difference between the sound field, the animals exposed to sound and injury or behavioral exposure.	An explanation of these terms can be found in **Appendix H**, **Sections 3** and **4**.
Andy Radford, American Petroleum Institute	I-E-12	0.22	Adopt the Southall Criteria (Southall, et al. 2007), which would establish the following thresholds: Level A at 198 dB re: 1 μPa2-s with M-weighting embedded in calculated RL's SEL (Sound Exposure Level); Level B at the lowest level of TTS-onset as a proxy until better data is developed.	The acoustic exposures predicted by the Acoustic Integration Model (AIM) were evaluated using both the 160-/180-dB criteria and the Southall et al. (2007) criteria. NMFS, the Federal agency that determines the MMPA thresholds, determined the criteria that were used.
Andy Radford, American Petroleum Institute	I-E-12	0.23	The DPEIS analysis does not adequately consider the fact that many animals avoid vessels regardless of whether they are emitting loud sounds and may increase that avoidance distance during seismic operations (Richardson et al. 2011). Therefore, it should be a reasonable assumption that natural avoidance serves to provide another level of protection to the animals.	The impact analysis in **Chapter 4.2.2.2.2** notes that some marine mammals may avoid acoustic sources and this behavior could result in lower levels of exposure to the highest sound levels. However, it is not possible to quantify this effect. Moreover, we would characterize avoidance behavior as an impact and not another level of protection.
Andy Radford, American Petroleum Institute	I-E-12	0.24	To foster meaningful dialogue and avoid confusion and poor decisions regarding industry acoustics issues, the DPEIS should adequately and accurately describe acoustic source levels. Evaluation of acoustic effects should include both the cumulative energy criterion in Southall et al., (2007) as well as proposed cumulative energy criterion. Southall et al. indicates that, for impulse sounds, any cetacean exposed to either a peak pressure ≥230 dB re 1 μPa or a cumulative sound exposure level (energy) of 198 dB re 1 μPa2 –sec might incur auditory injury. The DPEIS should explicitly note the SEL criteria, which is the one that will almost always (if not always) be the determining factor. The document in several places relies on Root Mean Square (RMS) Sound Pressure Level criteria for acoustic impacts. The most recent research has questioned the adequacy of these criteria.[15] Instead, they should be replaced by a combination of Sound Exposure Level limits and Peak (not RMS) Sound Pressure Levels or other metric being considered.	The acoustic exposures predicted by the Acoustic Integration Model (AIM©) were evaluated using both the 160-/180-dB criteria and the Southall et al. (2007) criteria. The criteria were used because the regulatory agency, NMFS, has not formally adopted the use of the Southall et al. (2007) criteria. The Programmatic EIS includes extensive calculations describing acoustic sources in **Appendix D**. We calculated potential impacts using the Southall criteria for comparison to the historical NMFS Level A criteria. The debate of the validity of the RMS metric for seismic and impulsive signals are well known and readily acknowledged. However, the Programmatic EIS must reflect the current exposure criteria used by the regulatory agencies.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Andy Radford, American Petroleum Institute	I-E-12	0.25	The PEIS should incorporate frequency weighting in development of incidental take estimates. Hearing (frequency) varies from species to species and among the cetaceans discussed in the DPEIS. Not all the frequencies used by industry fall within an animal's functional hearing range. In assessing the effects of noise, the M-weighted curve is applied to correct the sound-level measurement for the frequency-dependent hearing function. (Southall et al., 2007)	NMFS currently requires that exposure analyses exclude M-weighting. The Programmatic EIS reflects this regulatory requirement.
Andy Radford, American Petroleum Institute	I-E-12	0.26	The biology of dolphin hearing mechanisms should be considered in the DPEIS. It is well known in the Gulf of Mexico and other regions that dolphins frequently enter the seismic exclusion zone to bow ride seismic vessels.	Dolphin hearing (functional hearing group) is discussed in **Appendix H**, **Section 3.2** and mitigation measures regarding bow riding response to vessels, including survey vessels are discussed in **Chapters 2.1.3.1** and **2.1.3.2** as well as **Appendix C**, **Sections 3.2.2.5** and **3.3.3**. The Programmatic EIS has been revised to clarify the shutdown requirements for delphinids. Specifically, **Appendix C**, **Sections 3.2.2.5** and **3.3.3** indicate that "shutdown would not be required for delphinids approaching the vessel (or vessel's towed equipment) that indicates a "voluntary approach" on behalf of the delphinid. A "voluntary approach" is defined as a clear and purposeful approach toward the vessel by the delphinid(s) with a speed and vector that indicates that the delphinid(s) is approaching the vessels and remains near the vessel or towed equipment. The intent of the delphinid(s) would be subject to the determination of the Protected Species Observer (PSO)."
Andy Radford, American Petroleum Institute	I-E-12	0.27	The DPEIS proposes to require standard mitigation measures for all action alternatives. It also then proposes consideration of future optional mitigation measures. Consideration of mitigating measures cannot be disassociated from the risks they are intended to mitigate and requirements that they be effective. In fact, a Council on Environmental Quality memorandum notes that if agencies cannot determine if mitigation was implemented or effective, mitigation requirements fail to advance NEPA objectives of informed and transparent decision-making. [CEQ 2011] Decisions regarding mitigation come through a variety of channels as the DPEIS notes and decisions about mitigation measures should be respectful of the procedures and jurisdictions that have historically evaluated and implemented mitigation requirements.	A discussion of Adaptive Management has been added to **Chapter 1.7.6** and **Appendix C**, **Section 7** to address this issue; please see that text for an explanation of how future management changes will be incorporated into the program. Briefly, BOEM and NMFS will consider future data on the efficacy of mitigation measures to adjust mitigation requirements for individual surveys based on the best available information at that time. BOEM has recently evaluated the effectiveness of our protected species program in the Gulf of Mexico (USDOI, BOEM, 2012a), so the topic has not gone unexamined. BOEM is currently funding studies and workshops to examine the effectiveness and feasibility of mitigation measures such as the Support for JIP Controlled Exposure Experiments with Humpback Whales and Seismic Air Gun Arrays and Testing of Effectiveness of Ramp-Up (http://www.boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Studies/National/NT1008.pdf). BOEM also understands that successful adaptive management of a program and activities within that program requires stakeholder participation. Participation and input from interested parties such as other Federal agencies, State and local agencies, non-governmental organizations (NGOs), industry, tribal governments and

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				the public is key to designing and creating an adaptive management process that will be successful at all stages of its iterative course. This in turn will result in the goal of protecting the resource(s) at issue while allowing for the program and its activities to continue. In November 2012, BOEM and NMFS sponsored a Mitigation and Monitoring Workshop for the Gulf of Mexico (GOM) in Herndon, Virginia. This workshop involved multiple stakeholders, including other Federal agencies, industry, academia, and NGOs. While the workshop focused on the Marine Mammal Protection Act (MMPA) and the incidental take authorization process specific to G&G activities in the GOM, the goal of the workshop was to seek individual expert input from stakeholders to develop "an appropriate suite of effective and practicable mitigations" and to develop "a comprehensive monitoring plan that [would] enable stakeholders to answer questions regarding marine mammals, the effects of industry activities, and the effectiveness of mitigation measures."
Andy Radford, American Petroleum Institute	I-E-12	0.28	The DPEIS mentions adaptive management on page ES-34 and elsewhere. The implication is that mitigation requirements could be altered over time. Industry has supported the application of adaptive management in a number of contexts. However, in the DPEIS the term is positioned toward the use of adaptive management to further restrict activities and it does not leave room for adaptive management to reduce restrictions. Adaptive management should also be applied to the need for corrections, if new science alters existing understandings. If monitoring shows undetectable or limited impacts, an adaptive management strategy should allow for decreased restrictions on oil and gas exploration. The conditions under which decreased restrictions will occur should be plainly stated in the discussion of adaptive management.	The issue of adaptive management is important, as its use can ensure mitigation measures effectively match existing conditions and knowledge. **Chapter 1.7.6** and **Appendix C**, **Section 7** have been added to of the Programmatic EIS to better address the role adaptive management will play in the future.
Andy Radford, American Petroleum Institute	I-E-12	0.29	Right Whale Closure Area Proposal - The proposal to establish a six-month no-seismic activity zone is a significant step. BOEM should initiate rulemaking to enable sufficient study and public comment before requiring it. Such a proposal would need to consider other sound producers. Assuming that such a proposal is warranted, would such a restriction apply for example to all NOAA vessels or do the agencies propose selectively enforcing such a requirement only on one set of vessels? The Alternative B proposal is largely based upon attention to migration routes. At present, the Critical Habitat Designation for North Atlantic Right Whales does not include these areas. Establishing migration pathways as opposed to	We do not believe a separate rulemaking is necessary to establish a 6-month time-area closure for seismic airgun deployment in the right whale critical habitat and SMAs. Rulemaking is not required to analyze the use of a time-area closure as a mitigation measure for subsequently authorized G&G activities. The NARW is an endangered species and the entire life cycle of their activity, including migration routes, is relevant to the analysis of potential mitigation measures if possible takes could occur by permitted Federal activity. BOEM is only responsible for authorizing G&G surveys under its jurisdiction, not vessel activity in general. We do propose to take reasonable and prudent protective measures consistent with the status of this species based on consultation with NMFS under Section 7 of the Endangered Species Act. Further, the

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			aggregation areas for critical life functions of feeding, calving, etc. is a significant step. What basis does BOEM have in proposing such a step and has it considered rulemaking to ensure there is adequate consideration of all the factors before implementing such a regime?	public will have additional opportunities to comment on proposed mitigation measures during the Marine Mammal Protection Act permitting process when NMFS issues a *Federal Register* notice on the receipt of application and proposal to issue an Incidental Harassment Authorization. This is in addition to the site-specific analyses that BOEM will also conduct for each permit request. The authorization of G&G activities in support of all three of BOEM's program areas, under the Preferred Alternative, Alternative B includes mitigation measures to ensure the proposed G&G activities comply with existing laws and regulations. The mitigation measures include measures to reduce and avoid impacts to a variety of biological resources, with an emphasis on reducing acoustic impacts to marine mammals and sea turtles. Under the expanded time-area closure, no seismic surveys using airguns would be authorized within the NARW critical habitat from November 15 through April 15, the Mid Atlantic and Southeast U.S. SMA, from November 1 through April 30, and the expanded closure areas during the times when vessel speed restrictions are in effect under the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105) from November 1 to April 30 for the North area and November 15 to April 15 for the South area.
Andy Radford, American Petroleum Institute	I-E-12	0.30	Exclusion zone size - If sound source modeling is to be required and be used to increase the size of the exclusion zone – then it should also be available to reduce the size of the exclusion zone. The DPEIS should also be more specific as to how sound measurements are to be conducted. In addition, the proposal does not explain how long such a requirement would be in place. Experience in other areas including the U.S. Arctic have shown that after a few such field source verification tests the size of such zones are well established and there is adequate knowledge of them. Requiring verification tests after such a point brings no new knowledge and is not warranted.	BOEM agrees, the modeling could increase or decrease the size of the exclusion zone. The Seismic Airgun Survey Protocol has been revised to require that operators establish an exclusion zone for each survey. The zone shall be calculated independently, be based on the configuration of the array and the ambient environment, but shall not have a radius of less than 500 m (1,640 ft). In some cases field verification or modeling may be conducted for non-airgun high-resolution geophysical acoustic sources. Please refer to **Chapter 2.0** and **Appendix C** for the clarified mitigation requirements. In the BO, sound source verification is a term and condition. NMFS and BOEM may revisit the issue at a future date. BOEM's adaptive management process may also help inform this decision.
Andy Radford, American Petroleum Institute	I-E-12	0.31	Separation between simultaneous airgun surveys - The need for such a requirement and the manner in which it was calculated are questionable. A separation requirement for seismic surveys should therefore not be established at this time. The DPEIS acoustics risk assessments do not adequately address the issue of overlapping sound fields. The stated procedure of "rounding up to 20 and then doubling" does not convey a well thought out approach.	BOEM believes that the 40 km separation distance between simultaneously operating surveys is sufficiently conservative and will consider the value of this measure at the site-specific NEPA and environmental analyses level as well as any new information available at that time. This evaluation will also consider any potential aggregate effects from existing permitted surveys (if any). A discussion of Adaptive Management has been added to **Chapter 1.7.6** and **Appendix C**, **Section 7** to address this issue; please see that text for an

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				explanation of how future management changes will be incorporated into the program. Briefly, BOEM and NMFS will consider future data on the efficacy of mitigation measures to adjust mitigation requirements based on the best available information at that time.
Andy Radford, American Petroleum Institute	I-E-12	0.32	Dolphins Shut-down Factors - The DPEIS nonetheless proposes adding dolphins to the shut-down requirement. It is not clear on what basis BOEM proposes such a change. The DPEIS should include a biological assessment indicating that the acoustic risks to dolphins warrant such a change. It has been commonly observed, in fact, that dolphins seek to “bow ride” seismic and other vessels, challenging assertions of harm to the animals. The fact that various marine mammals want to approach and enter the ensonified area raises serious questions about the basic validity of a regulatory approach that rigidly established proximity to sound as its basis. The DPEIS recognizes this issue of forcing shut-downs for animals that want to be in the exclusion zone: However, shutdown would not be required for dolphins approaching the vessel or towed equipment at a speed and vector that indicates voluntary approach to bow-ride or chase towed equipment. If a dolphin voluntarily moves into the exclusion zone after the airguns are operating, it is reasoned that the sound pressure level is not negatively affecting that particular animal. Industry suggests that rather than adding dolphins to the survey protocol, BOEM should provide similar provisions to not shut-down when cetaceans are voluntarily in the observation zone.	BOEM developed the protocol based on the current NMFS criteria for Level A harassment. It was determined that it would not be appropriate for the protocol to automatically exclude any marine mammal species from the shutdown requirements within the exclusion zone. The protocol has been clarified in **Appendix C** and does include the provision that shutdown would not be required for delphinids approaching the vessel or towed equipment at a speed and vector that indicates voluntary approach to bow ride or chase towed equipment. The intent of the delphinid(s) would be subject to the determination of the PSO. If the PSO determines that the delphinid(s) is actively trying to avoid the vessel or the towed equipment, the acoustic sources must be immediately shutdown as per his/her instruction. **Appendix C**, **Sections 3.2.2.5** and **3.3.3** have been revised to clarify the shutdown requirements for delphinids. The exception for bow-riding delphinids does not warrant a general exception for other marine mammals to be in the exclusion zone without a shutdown.
Andy Radford, American Petroleum Institute	I-E-12	0.33	Whale Shut Down Factors - The Association recommends the wording should be changed to “steer the vessel away from the whale.” With the streamers in the water, a seismic vessel is traveling at 4 to 5 knots and is not at high speed.	The text in **Appendix C**, **Chapter 3.1.1** has been revised to reflect this change.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Andy Radford, American Petroleum Institute	I-E-12	0.34	Passive Acoustic Monitoring (PAM) and Protected Species Observers - We recommend that basic training criteria, such as that specified by many countries for marine mammal observers (MMOs), be developed and required for PAM operators. In addition, minimum requirements for PAM equipment (including capabilities of software and hardware) should also be considered.	BOEM agrees with this comment and has been undergoing efforts with NMFS, industry, and the MMC to (1) standardize PSO training, qualifications, and other requirements; and (2) develop standards for PAM for seismic operations. These two efforts are a work in progress. BOEM plans to provide any final outcomes of these efforts to all interested stakeholders, once available. NTL 2012-JOINT-G02 ("Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program") provides the guidelines for the use of PAM for seismic airgun surveys in the Gulf of Mexico. That NTL would likely be applicable to the use of PAM in the Atlantic, whether required for airgun surveys or encouraged for other surveys. The Biological Opinion issued by NMFS also provides conditions for the use of PAM relative to operator proficiency and system type.
Beau Suthard, CPE	I-E-10	0.01	In summary, BOEM should develop a Supplemental DPEIS to address the following points: 1) If HRG surveys are going to be exempt from the time-area closures for "operations" only, than "operations" must be clearly defined in detail within a Supplemental DPEIS in order for the reader and commenting Agencies to fully understand the Alternatives and the Proposed Action and their potential impacts. If the definition of "operations" means any survey or operation in support of marine mineral exploration regardless of project status than Coastal Planning and Engineering Inc. (CPE) has no issue with the DPEIS as outlined.	HRG non-airgun sources such as boomers, chirp seismic, sub-bottom profilers, side scan sonar and multibeam, swath, and single beam bathymetric sonars would be authorized year-round in the AOI, including within NARW critical habitat and SMAs from November 15 through April 15, and DMAs, subject to the requirements of the survey protocol. BOEM's use of the term "operations" related to HRG surveys means any non airgun survey or operation in support of marine minerals; oil, gas, and sulfur; and/or renewable energy regardless of project status. The Programmatic EIS has been revised to make this clear wherever similar statements are made.
Beau Suthard, CPE	I-E-10	0.02	By electing to describe the HRG system impacts in terms of their Source Level (sound energy level at the face of the transmitter) as opposed to their Transmit Level (which takes into account the transmit direction, distance from source, and energy level integration across the full signal bandwidth) the DPEIS unfairly overestimates the impact of HRG systems. The transmit levels of HRG systems must be evaluated and described within a Supplemental DPEIS, and if small enough, should justify an HRG mineral exploration exemption from the time-area closures.	A Supplemental EIS is not needed to address this comment because the information is already presented in the Programmatic EIS. In order to accurately model any sound source the source level must be the starting point. **Table 3-11** provides a summary of representative source levels for the active acoustic sound sources included in the proposed action. Source level is the maximum loudness at the source under specified settings and assumed frequency, pulse length, and directionality. Select HRG sources also allow for manipulation of power settings, etc., such that a lower source level than the maximum specified by the manufacturer is possible. While source level is important, the frequency range and whether it overlaps the hearing range of marine mammals in the area is an equally important consideration. Received levels have been calculated for all sounds sources modeled and are the basis for determining impacts resulting from use of each source. The "incidental take" modeling conducted in **Appendix E** used the received levels that animals would be exposed to in the environment, making conservative assumptions about the source characteristics including directionality,

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				beam width, towing configurations, as well as the sound transmission characteristics of the ocean and the distance of the receiver from the source.
Beau Suthard, CPE	I-E-10	0.03	HRG systems have reduced potential for marine mammal impacts due to their focused axial sound energy, reduced transmit levels, and towing configurations close to the seafloor. These facts must be addressed within a Supplemental DPEIS in order to accurately quantify the true potential for HRG impacts to marine mammals and if small enough, should justify an HRG mineral exploration exemption from the time-area closures.	A Supplemental EIS is not needed to address this comment because the information is already presented in **Appendix D** and **Appendix E** of the Programmatic EIS and those calculations were used to support the impact analysis in **Chapter 4.0**. The "incidental take" modeling conducted in **Appendix E** used the received levels that animals would be exposed to in the environment, making conservative assumptions about the source characteristics including directionality, beam width, towing configurations, as well as the sound transmission characteristics of the ocean and distance of the receive from the source. **Appendix D**, **Section 3** provides a complete description of all G&G survey equipment with separate sections for airguns and electromechanical sources, the latter group being those used for HRG surveys. **Appendix D**, **Section 4** describes the modeling methodology, with a complete sub-section for each piece of survey equipment that takes into consideration beam pattern, directionality, and operational characteristics such as towing configuration. In addition, HRG non-airgun sources such as boomers, chirp seismic, sub-bottom profilers, side-scan sonar and multibeam, swath, and single-beam bathymetric sonars would be authorized year-round in the AOI, including within NARW critical habitat and SMAs from November 15 through April 15 and DMAs, subject to the requirements of the survey protocol (**Chapter 2.1.3.2** and **Appendix C**).
Beau Suthard, CPE	I-E-10	0.04	With the proposed PSO, ramp-up, and shut-down mitigation measures in the DPEIS, potential HRG take is greatly reduced – if not totally eliminated – and therefore, HRG systems should be exempt from the time-area closures included in this DPEIS. These facts must be addressed within a Supplemental DPEIS in order to accurately quantify the true potential for HRG impacts (together with the proposed mitigation measures) to marine mammals and if small enough, should justify an HRG mineral exploration exemption from the time-area closures.	Since the release of the Draft Programmatic EIS the HRG Survey Protocol has been clarified and the case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. Mitigation measures for non-airgun HRG acoustic sources with differing source frequencies differ and acoustic exclusion zone monitoring and shutdown do not universally apply to all non-airgun HRG surveys. As part of the clarification of the HRG Survey Protocol, the NARW time-area closures do not apply to many non-airgun HRG sources. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. A Supplemental EIS is not needed because the issues raised by this comment are already addressed in the Programmatic EIS. As stated in **Chapter 2.2.2.1** (for the NARW time-area closure) and **Chapter 2.2.2.2** (for the sea turtle time-area closure), the time-area closures included in Alternatives A and B apply specifically to airgun seismic surveys. Based on the calculations in **Appendix E**, non airgun HRG surveys have the potential to result in incidental takes of marine mammals. As stated above Seismic Airgun and HRG Survey Protocols

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				have been clarified since the release of the Draft Programmatic EIS and have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**. BOEM has added a discussion of Adaptive Management to the Programmatic EIS (see **Chapter 1.7.6** and **Appendix C**, **Section 7**); through the Adaptive Management process, mitigation requirements could be modified if new information indicates that they are infeasible or could be made more effective.
Beau Suthard, CPE	I-E-10	0.05	HRG mineral exploration is most often conducted using public funds for the public benefit. The impact of reducing HRG mineral exploration to a single 6 month window – during hurricane season – to the public entities funding and constructing the shore protection projects must be evaluated within a Supplemental DPEIS from a socioeconomic standpoint, and if large enough, should justify an HRG mineral exploration exemption from the time-area closures.	Since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. Mitigation measures for different non-airgun HRG acoustic sources also differ and acoustic exclusion zone monitoring, and shutdown do not universally apply to all non-airgun HRG surveys. In addition with the clarification of the HRG Survey Protocol, the NARW time-area closures do not apply to many non-airgun HRG sources. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. HRG surveys for marine minerals are not limited to a 6 month window under either Alternative A or B. As stated in **Chapter 2.2.2.1** (for the NARW time-area closure) and **Chapter 2.2.2.2** (for the sea turtle time-area closure), the time-area closures included in Alternatives A and B apply specifically to airgun seismic surveys. BOEM does not expect that airguns would be used for marine minerals HRG surveys. Please see response I-E-100.04.
Beau Suthard, CPE	I-E-10	0.06	Cumulative impacts to regulatory agencies due to the focusing of project design, permitting, and regulatory approvals to coincide with the time-area closures after HRG mineral exploration has occurred need to be fully evaluated within a Supplemental DPEIS, and if large enough, should justify an HRG mineral exploration exemption from the time-area closures.	After careful consideration, BOEM has concluded that regulatory agencies should not be added to the list of resources for which impacts from the proposed action are evaluated.
Beau Suthard, CPE	I-E-10	0.07	The exemption afforded for "Scientific Research" creates a barrier to competition for these projects, unfairly biasing the market towards academic and federal, state, and local agencies, negatively impacting the free-market system, and potentially resulting in impacts to quality control and quality assurance safeguards. This negative impact is large enough to either invalidate the need for a Scientific Research exemption, or more appropriately, justify an across-the-board HRG mineral exploration exemption from the time-area closures.	The paragraph cited in **Chapter 3.4.1** of the Programmatic EIS provides an explanation for the authority given to BOEM by the Outer Continental Shelf Lands Act (OCSLA). As noted in that paragraph, BOEM may, under Section 11 of the OCSLA, authorize G&G prospecting for non-energy marine minerals, except in the case that another Federal agency is performing the survey on the OCS. BOEM does not have authority for scientific research. The fact that BOEM does not have authority for scientific research does not create, suggest, or imply that an exemption exists.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Beau Suthard, CPE	I-E-10	0.08	CPE asserts that the time-area closures in the North Atlantic are far too restrictive for HRG surveys in support of marine mineral exploration for shore protection projects conducted with public funds for the greater public good, and exemptions should be made for all HRG surveys conducted in the AOI.	Since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. Mitigation measures for different non-airgun HRG acoustic sources also differ and acoustic exclusion zone monitoring, and shutdown do not universally apply to all non-airgun HRG surveys. In addition with the clarification of the HRG Survey Protocol, the NARW time-area closures do not apply to many non-airgun HRG sources. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. HRG non-airgun sources such as boomers, chirp seismic, sub-bottom profilers, side scan sonar and multibeam, swath, and single beam bathymetric sonars would be authorized year-round in the AOI, including within NARW critical habitat and SMAs from November 15 through April 15, and DMAs, subject to the requirements of the survey protocol. Based on the calculations in **Appendix E**, non airgun HRG surveys have the potential to result in incidental takes of marine mammals. Therefore, BOEM does not believe it is prudent to provide a blanket exemption allowing all non airgun HRG surveys in the time-area closures. Please see response I-E-10:0.04.
Beau Suthard, CPE	I-E-10	0.09	CPE also believes that if a time-area closure is mandated for all HRG surveys, that this mandate should be enforced across the board to include Scientific Research. Allowing unlicensed professionals free reign to conduct offshore mineral exploration normally conducted under the industry standard of care under, the auspices of Scientific Research, will create quality control issues and squeeze private companies out of the free market.	Since the release of the Draft Programmatic EIS the HRG Survey Protocol has been clarified and the case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. As part of HRG Survey Protocol the Programmatic EIS would not mandate a time-area closure "for all HRG surveys." The time-area closures included in Alternatives A and B apply specifically to airgun seismic surveys. BOEM does not have authority for scientific research and cannot mandate requirements for surveys that are not under its permitting authority. Please see response I-E-10:0.04. Such work would be subject to applicable State and Federal regulations including Coastal Zone Management Act, Endangered Species Act, and Marine Mammal Protection Act.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Madeleine Findley, North American Submarine Cable Association	I-E-8	0.01	To ensure compliance with the National Environmental Policy Act ("NEPA") and other legal obligations and to achieve effective coordination and protection of potentially competing marine activities on the outer Continental Shelf ("OCS"), the North American Submarine Cable Association ("NASCA") urges the Bureau of Ocean Energy Management ("BOEM") to revise its Draft Programmatic Environmental Impact Statement ("DPEIS") in this proceeding to account for the extensive presence, critical importance, and unique legal status of undersea fiber-optic telecommunications cables. Although the potential for conflict between undersea telecommunications cables and energy-related activities on the OCS—including those in the Mid- and South Atlantic Planning Areas—continues to grow, the DPEIS makes no mention whatsoever of undersea telecommunications cables, much less the unique rights and protections due to such cables, the federal laws and agencies governing such cables, or any of the threats to undersea cables posed by energy-related activities in the OCS absent awareness and coordination.	A cable infrastructure discussion has been added to **Chapter 4.2.12.1.8**, Known Seabed Obstructions, and a figure has been added (**Figure 4-43**) showing the locations of existing cables in the AOI. BOEM recognizes the need for coordination to ensure that with placement of structures and bottom-disturbing activities are conducted in a manner that ensures the safety of the existing cable. Each individual survey applicant will be required to identify the existing infrastructure to ensure protection of the cables. Site-specific data will be required by the applicant prior to any bottom-disturbing activities. Cable data are available from numerous sources and applicants will have access to this cable location data. This site-specific data will ensure that the cables are protected. As discussed in **Chapters 1.6.10** and **1.6.14**, individual surveys will require permits from the USACOE, which will also assist in avoiding conflicts with G&G activities and the cable infrastructure.
Madeleine Findley, North American Submarine Cable Association	I-E-8	0.02	Various international treaties to which the United States is a party and customary international law (as observed by the United States) grant to undersea cables unique rights and freedoms not granted to any other activities in the marine environment. The DPEIS, however, makes no mention of these rights and freedoms or their implications for other marine activities, including energy-related ones. In the United States, undersea cables are licensed and permitted principally by the Federal Communications Commission ("FCC"), the U.S. Army Corps of Engineers ("ACOE"), and the group of national-security and law-enforcement agencies known as "Team Telecom," pursuant to various federal statutes and regulations. But the DPEIS does not even identify the FCC or Team Telecom (much less designate them as coordinating agencies" under NEPA) or describe these other statutes and regulations (including civil and criminal penalties for undersea cable damage), even though regulatory activity pursuant to those statutes and regulations could have a variety of impacts on energy-related activities on the OCS.	A cable infrastructure discussion has been added to **Chapter 4.2.12.1.8**, "Known Sea Bottom Obstructions." BOEM recognizes the need for coordination to ensure that placement of structures and bottom-disturbing activities are conducted in a manner that ensures the safety of the existing cable infrastructure. Each individual survey applicant will be required to identify the existing infrastructure to ensure protection of the cables. Site-specific data will be required by the applicant prior any bottom-disturbing activities. Cable data is available from numerous sources and applicants will have access to this cable location data. This site-specific data will ensure that the cables are protected. As discussed in **Chapters 1.6.10** and **1.6.14**, individual surveys will require permits from the USACOE, which will also assist in avoiding conflicts with G&G activities and the cable infrastructure. Furthermore, BOEM invited agencies, through the *Federal Register* Notice of Intent for the Programmatic EIS, to indicate their interest in being cooperating agencies. The potential cooperating agency mentioned, the FCC (Team Telecom is not a Federal agency), did not submit a request to act as cooperating agency as a result of the public notice.
Madeleine Findley, North American	I-E-8	0.03	Energy-related activities—including oil and gas exploration and exploitation, deep-sea mining, and alternative energy activities (wind, wave, and current)—pose numerous threats to	A cable infrastructure discussion has been added to **Chapter 4.2.12.1.8**, "Known Sea Bottom Obstructions." BOEM recognizes the need for coordination to ensure that placement of structures and

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Submarine Cable Association			undersea cables. All three categories of energy-related activities threaten to impede access for undersea cable installation and maintenance, whether on the ocean surface or seafloor, and the risk of damage due to increased vessel activity. Oil and gas-related activities also pose threats from pipeline crossings. Deep-sea mining poses additional threats from direct disturbance and seafloor erosion and abrasion. Alternative energy activities also pose additional threats, particularly from bottom-scouring from wind turbine towers and crossings by power cables of undersea telecommunications cables. None of these is discussed in the DPEIS.	bottom-disturbing activities are conducted in a manner that ensures the safety of the existing cable infrastructure. Each individual survey applicant will be required to identify the existing infrastructure to ensure protection of the cables. Site-specific data will be required by the applicant prior any bottom-disturbing activities. Cable data are available from numerous sources and applicants will have access to this cable location data. This site-specific data will ensure that the cables are protected. As discussed in **Chapter 1.6.10** and **1.6.14**, individual surveys will require permits from the USACE, which will also assist in avoiding conflicts with G&G activities and the cable infrastructure.
Madeleine Findley, North American Submarine Cable Association	I-E-8	0.04	The failure to address these threats, potential conflicts, and other legal-regulatory regimes is inconsistent with both NEPA and Congress's directive to conduct a PEIS for the Atlantic OCS, as that directive was not limited to consideration of energy matters only. With respect to NEPA, undersea cable activity is "reasonably foreseeable" and should therefore be addressed by BOEM as such in revisions to Alternatives A and B. BOEM should add conclusions that vessel traffic, grab-and-core sampling, buoy founding and anchoring, and well drilling, and any other activities under Alternatives A and B that may have an impact on undersea cables would be "moderate" or "major" absent further modifications.	A cable infrastructure discussion has been added to **Chapter 4.2.12**, "Known Sea Bottom Obstructions." BOEM recognizes the need for coordination to ensure that placement of structures and bottom-disturbing activities are conducted in a manner that ensures the safety of the existing cable infrastructure. Each individual survey applicant will be required to identify the existing infrastructure to ensure protection of the cables. Site-specific data will be required by the applicant prior any bottom-disturbing activities. Cable data are available from numerous sources and applicants will have access to this cable location data. This site-specific data will ensure that the cables are protected. As discussed in **Chapters 1.6.10** and **1.6.14**, individual surveys will require permits from the USACE, which will also assist in avoiding conflicts with G&G activities and the cable infrastructure.
Madeleine Findley, North American Submarine Cable Association	I-E-8	0.05	BOEM should also describe the other laws, regulations, treaties, and agencies relating to undersea cables, given the potential for conflict with undersea cable and energy-related activities, if left uncoordinated.	A cable infrastructure discussion has been added to **Chapter 4.2.12.1.8**, "Known Sea Bottom Obstructions." BOEM recognizes the need for coordination to ensure that placement of structures and bottom-disturbing activities are conducted in a manner that ensures the safety of the existing cable infrastructure. Each individual survey applicant will be required to identify the existing infrastructure to ensure protection of the cables. Site-specific data will be required by the applicant prior to any bottom-disturbing activities. Cable data are available from numerous sources and applicants will have access to this cable location data. This site-specific data will ensure that the cables are protected. As discussed in **Chapters 1.6.10** and **1.6.14**, individual surveys will require permits from the USACE, which will also assist in avoiding conflicts with G&G activities and the cable infrastructure.
Madeleine Findley, North American Submarine Cable	I-E-8	0.06	Finally, BOEM should consider designating the FCC and the Team Telecom agencies as "coordinating agencies" for NEPA purposes.	BOEM invited agencies, through the *Federal Register* Notice of Intent for the Programmatic EIS, to indicate their interest in being cooperating agencies. The potential cooperating agency mentioned, the FCC (Team Telecom is not a Federal agency), did not submit a request to act as

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Association				cooperating agency as a result of the public notice. The Programmatic EIS provides a programmatic review of G&G survey activities; future site-specific evaluations will require additional NEPA evaluation. Preparation of those documents as well as permit applications would provide opportunities for future coordination and consultation with Federal agencies.
Frank Salley, The North American Submarine Cable Association	I-E-2	0.01	While I have not had a chance to do an in depth review of the recent PEIS associated with G&G Activities in Mid and South Atlantic Planning Areas, upon initial review there appears to be no mention of submarine telecommunications cables. After repeated request for inclusion in your planning efforts, the continuing disregard or oversight of this critical infrastructure in your public documentation is not acceptable. Can you provide direction on how the submarine cable industry can raise this issue to the appropriate level in the BOEM where we can be heard?	A cable infrastructure discussion has been added to **Chapter 4.2.12.1.8**, "Known Sea Bottom Obstructions" and added to the cumulative impact scenario in **Chapter 3.6.12**. BOEM recognizes the need for coordination to ensure that with placement of structures and bottom-disturbing activities are conducted in a manner that ensures the safety of the existing cable infrastructure. Each individual survey applicant will be required to identify the existing infrastructure to ensure protection of the cables. Site-specific data will be required by the applicant prior any bottom-disturbing activities. Cable data are available from numerous sources, from both online and purchased, and applicants will have access to this cable location data. This site-specific data will ensure that the cables are protected. As discussed in **Chapters 1.6.10** and **1.6.14**, individual surveys will require permits from the USACE, which will also assist in avoiding conflicts with G&G activities and the cable infrastructure.
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.01	Turbine spacing within wind farms. The Draft PEIS assumes, in Section 3.3.3.2, page 2-30, that between 14 and 45 turbines will be placed within each three-by-three nautical mile (nm) OCS block. This upper bound, though, assumes relatively tight turbine spacing of approximately one half nm apart while the lower uses more generous spacing of about one nm. The document also assumes 3.6 MW and 5.0 MW turbines with rotor diameters of 110 and 130 meters respectively. European experience to date suggests that turbines selected for projects are increasing in size, resulting in fewer turbines per project with more space between the machines than ever before – in other words, moving away from 0.5 nm and closer to 1.0. This would mean many fewer geotechnical surveys per OCS block than the upper-bound 45 now in the Draft PEIS (see Table 3-6).	BOEM recognizes that technological advances will lead to changes in how wind farms and other renewable energy projects are developed. The data used represents a general assessment of current practices to ensure all likely scenarios are covered under the programmatic analysis. Individual projects would be subject to a site-specific NEPA analysis as noted in **Chapter 1.2** of the Programmatic EIS.
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.02	Economically viable water depth. Page 3-14 of the Draft PEIS states, "The distance from shore for a wind facility is generally defined at the outward limit of its economic viability, currently about 46 km (25 nmi [nautical miles]) from shore of 100 m (328 ft) water depth." While a single demonstration floating wind turbine is operating in 200 m of water off the southwest	The text has been revised throughout the document to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			coast of Norway[7], EWEA reports that 22.8 m was the average depth for commercial projects (all fixed foundation) built last year and nearly every project under construction or online is in water shallower than or equal to 40 m deep.[8] Furthermore, the eastern edge of the Mid-Atlantic WEAs exists at a water depth of approximately 30 m. Therefore, 100 m is currently not an economically, that is to say, commercially, viable water depth.	
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.03	Size and type of vessels for geotechnical studies. Page 3-17 and Table 3-9 indicate that a "small barge or a ship approximately 20 m (65 ft) in length" (p. 3-17) would be used to conduct offshore wind geotechnical studies, but we believe that for open-ocean drilling, ships, not barges, of at least 60 m will most likely be the vessels that are used.	The text has been revised in **Chapter 3.3.2.2** and **Table 3-9** has been revised accordingly.
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.04	Meteorological equipment. In Section 3.3.2.3, page 3-18, the Draft PEIS assumes that meteorological (met) buoys, but not met towers, will be used on offshore wind projects. It says that while the renewable energy G&G surveys scenario "does not preclude the use of meteorological towers," Table 3-6 shows, exclusively, between seven and 38 "bottom-founded monitoring buoys" as part of the Draft PEIS "Projected Levels of G&G Activities for Renewable Energy Site Characterization and Assessment." While the advantages of met buoys, especially those with LiDAR technology, are clear, traditional offshore wind met towers are still being deployed in Europe and the Final Mid-Atlantic EA assumed the installation of up to 12 met towers, along with 25 met buoys (p. vii).	As noted in the comment, the renewable energy G&G surveys scenario does not preclude the use of meteorological towers. The projected use of meteorological buoys was based on the best available information at the time of developing the renewable energy scenario (**Chapter 3.3.3.2**). Each survey will require a site-specific NEPA analysis to examine the impacts from the survey and the specific equipment planned to be deployed.
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.05	Survey methodologies. The description in the Draft PEIS of the offshore wind G&G activities is reasonable, however, the document should specifically address the benefits – environmental and economic, for instance – of allowing flexibility in the G&G protocols. The assumption of only a single mobilization, for example, may not hold for developers pursuing staged surveys. We therefore believe that the Final PEIS should allow for survey flexibility so that the value of this PEIS can be more fully realized with respect to offshore renewable energy.	In the activity scenario for renewable energy (**Chapter 3.3.3.2**), BOEM made certain assumptions to estimate the overall activity level; however, nothing in the programmatic analysis precludes developers from proposing staged surveys for an individual project. BOEM will consider requirements on a site-specific basis when reviewing and analyzing individual plans.
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.06	Not only are the impacts from offshore wind G&G far less than "major," they are also significantly less than "moderate" and in nearly all subject areas less than "minor."	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.07	We strongly encourage BOEM to produce a Final PEIS reflecting the Final Mid-Atlantic EA, issued in January, since it is the most relevant and up-to-date document on the offshore wind issues in this subject PEIS. In that Final EA, BOEM makes a "Finding of No Significant Impact" (FONSI) with respect to the potential effects of offshore wind leasing and site assessment and characterization activities in the Wind Energy Areas (WEAs) off the coasts of New Jersey, Delaware, Maryland, and Virginia.	The Final Mid-Atlantic EA is referenced where appropriate in the Final Programmatic EIS. Information about ongoing and planned Mid-Atlantic wind energy activities were incorporated into the description of G&G activities and the proposed action scenario in **Chapter 3.0** of the Programmatic EIS. BOEM believes the analysis in the Programmatic EIS is consistent with the findings of the Mid Atlantic EA with respect to G&G activities in support of renewable energy development.
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.08	Survey activities, including geophysical, avian and bat surveys, will be required by BOEM under the new regulations, and some must take place year-round. Potential platforms for survey activities of this nature will require service by associated vessels. Measures such as exclusion zones and marine mammal monitoring, as recommended by NMFS, particularly during migration periods for mammals such as the north Atlantic right whale, would effectively minimize potential impacts to marine mammals. There is no evidence that the existing processes provide inadequate protection for marine mammals under the governing statutes and regulations.	Comment noted.
Doug Pfeister, Offshore Wind Development Coalition	I-E-5	0.09	Bird impacts from fuel spills – much less than "moderate" for offshore wind - While it is extremely difficult, if not impossible, to tease out the impacts due only to offshore wind G&G activities, it is straightforward to determine that these potential impacts should be considered insignificant. First, the vessels performing the offshore wind HRG and geotechnical surveys would be "small" – less than 98 feet in length (Draft PEIS, pp. 3-16, 3-17) 11 – carrying just "several thousand gallons" of fuel, 2-3 orders of magnitude less than the quantity on "large seismic survey vessel[s]" (p. 3- 35). Second, the likelihood of a spill during offshore wind G&G surveys is remote; the Draft PEIS points out that a recorded oil/fuel spill "has never been recorded" in more than 54,000 nautical miles (100,000 km) of seismic surveys funded by the National Science Foundation (NSF) (p. 3-36). Third, the Final Mid-Atlantic EA rated the reasonably foreseeable impacts on water quality to be "minor," the risk of a spill "small," and the impacts "in the unlikely event of a spill" "minimal… since the spill would very likely be small, and would dissipate and biodegrade within a short time" (p. viii). The Final Mid-Atlantic EA also found "no threat of significant impacts" and	Although different size vessels may be used for the offshore survey programs and they will carry different volumes of fuels, as noted in **Chapter 3.5.2.1**, the accidental fuel spill size is based on U.S. Coast Guard data and for the purposes of this analysis, the spill scenario evaluated was a release of 1.2-7.1 bbl of diesel fuel caused by either a vessel collision or an accident during fuel transfer. This is certainly well within the volume carried by the smaller offshore survey vessels, and has the potential to occur even from these smaller vessels. The likelihood of a spill is acknowledged as very low (**Chapter 4.2.4.3**), but is indicated that depending on the location and timing of an oil spill, the impact level would vary and could result in negligible-moderate impacts for shorebirds, waterfowl, and seabird species. However, since the populations of piping plover, roseate tern, and red knot are already in peril, if an accidental fuel spill occurred that affected any of these species or their food supply, then, and only then, would the impact be considered moderate since these birds are very susceptible to oiling. The level of impact to bird species from a potential spill is based on the location and timing of the spill and what species of birds would be affected. In most instances, the impact from a spill would be considered negligible, but if a spill were to occur in a critical habitat at a time when migrating birds were present for feeding, the impact level would increase

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			"negligible" impacts to birds from a variety of sources, including "accidental fuel releases" (p. ix).	to minor and if one of the threatened bird species were impacted, the impact level could increase to moderate. Birds are very susceptible to impacts if oiling does occur, for this reason the sliding impact levels were provided and is based on location and timing of a spill.
Doug Pfeister, Offshore Wind Development Coalition	I-PHWDE-1	0.01	I just wanted to compare the document, and I haven't gone through it extensively, with the final EA that came out for the Mid-Atlantic -- for the Mid-Atlantic wind energy areas on the site survey work that would be going on there. So I wanted to -- if you could respond to that, that would be great.· If you could talk about the comparisons between the two documents.· If you can't, that's just something I would like to flag, that those two documents, unless there's good reason, should be consistent with one another.	Information about the Mid-Atlantic Wind Energy EA, as well as the document itself, can be found at http://www.boem.gov/Renewable-Energy-Program/Smart-from-the-Start/Index.aspx. The Final Mid-Atlantic EA is referenced where appropriate in the Final Programmatic EIS. Information about ongoing and planned Mid-Atlantic wind energy activities were incorporated into the description of G&G activities and the proposed action scenario in **Chapter 3.0** of the Programmatic EIS.
Kevin Bodge, Olsen Associates	I-E-9	0.01	The proposed Alternatives (A and B) would place impractical, scientifically unjustified, and burdensome requirements upon the public interests that utilize the MM sites for public shore protection (beach restoration) projects. The DPEIS is unclear and inconsistent in terms of recognizing the distinctions between (a) high-frequency, low-energy survey devices utilized for MM sites versus airguns and other lower-frequency/high-energy devices, and (b) restrictions for MM sites versus Oil & Gas (O&G) and Renewable Energy (RE) sites.	The Programmatic EIS makes clear distinctions between the active acoustic sources used for non-airgun HRG surveys versus airgun surveys. The document has been reviewed to ensure that these distinctions are presented accurately and consistently. **Chapter 3.0** presents separate descriptions of G&G activities and equipment for oil and gas related surveys (**Chapter 3.2**), renewable energy (**Chapter 3.3**), and marine minerals (**Chapter 3.4**). Airguns and electromechanical sources are described separately in **Appendix D**, and separate incidental take calculations for airgun seismic surveys and non airgun HRG surveys are presented in **Appendix E**. Separate mitigation protocols are presented for airgun seismic surveys (**Chapter 2.1.3.1**) and non-airgun HRG surveys below and above 200 kHz (**Chapter 2.1.3.2**). These protocols have been revised in the Final Programmatic EIS to clarify the differences. See **Appendix A** for further information about HRG surveys in the NARW closure area. BOEM believes that the requirements included in the proposed action are feasible, not burdensome, and are supported by explicit scientific reasoning. The rationale for the time-area closures and survey-specific mitigation protocols is provided in **Appendix C**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Kevin Bodge, Olsen Associates	I-E-9	0.02	The DPEIS fails to demonstrate adverse impacts to marine life from the high-frequency, low-energy devices commonly used to develop and monitor MM sites. The claimed (potential) impacts to marine turtles are speculative, at best. The DPEIS analysis and conclusions are based upon computer models of sound without adequate calibration and verification. The array of sound sources did not even consider the commonly used low-energy, dual-frequency fathometer; yet the DPEIS proposes restrictions on its use in tandem with all other equipment.	BOEM analyzed potential impacts on marine life using the best available scientific information. BOEM conducted acoustic modeling of representative electromechanical sources often used for marine minerals HRG surveys (**Appendix D**) and estimated incidental takes of marine mammal species found in the AOI (**Appendix E**) using credible scientific models. Information about the assumptions, data inputs, and scientific basis for the models is presented in **Appendices D** and **E**. The modeling results indicate that non airgun HRG surveys may result incidental takes of marine mammals. We agree that impacts on sea turtles are especially difficult to predict, as already noted in the Programmatic EIS; however, national Environmental Policy Act (NEPA) requires us to make a good faith attempt to estimate those impacts using the best available scientific data. Finally, **Appendix D** of the Programmatic EIS has been revised to briefly address fathometers as noted in the comment. Under the HRG Survey Protocol (see **Chapter 2.1.3.2** and **Appendix C**, **Section 3.3.3**), requirements such as the exclusion zone and startup/shutdown conditions apply only to HRG surveys in which one or more active acoustic sound sources will be operating at frequencies less than 200 kHz.
Kevin Bodge, Olsen Associates	I-E-9	0.03	The proposed calendar restrictions on activities in Alternatives A and B would limit the days available to perform surveys to impractically small windows of time – particularly given the vagaries of ocean weather and the need to identify periods of consistently calm seas to perform the surveys. Alternative B, for example, presents impossibly narrow windows to perform MM surveys offshore of Brevard County: two weeks in late April and two weeks in early November, of which the latter is typically unusable because of nor'easter storms.	Since the release of the Draft Programmatic EIS, the NARW time–area closure and related HRG Survey Protocol has been clarified and the generic case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. As a result of the clarification time- area closures would generally not be applied to surveys using non-airgun HRG acoustic sources. Those clarifications have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). Please refer to **Chapter 2.0** and **Appendix C** for detailed survey protocols. We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**. Specific to nesting sea turtles off Brevard County, if non-airgun HRG sources with sources below 1.6 kHz would be restricted within this area from May 1 to October 31. HRG non-airgun surveys with sources above 1.6 kHz would not be subject to the sea turtle time-area closure.
Kevin Bodge, Olsen Associates	I-E-9	0.04	Through its lease agreements, BOEM requires pre- and post-construction surveys of MM sites. For unjustified reasons, BOEM appears to be increasingly seeking (1) tighter restrictions on timing of those surveys relative to construction, and (2) time-intensive higher-resolution survey methods. BOEM cannot require and expect its lease partners to conduct increasingly complex surveys (presumably for the benefit of	Since the release of the Draft Programmatic EIS the NARW time – area closure and related HRG Survey Protocol has been clarified and the generic case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. As a result of the clarification, time- area closures would generally not be applied to surveys using non-airgun HRG acoustic sources. Those clarifications have been finalized with NMFS through formal Section 7

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			BOEM) amidst increasingly onerous and unrealistic restrictions. It is difficult and costly enough attempting to comply with existing restrictions and expectations for the development and monitoring of these MM sites, let alone dealing with new layers of restrictions and review.	consultation and the issuance of a Biological Opinion (**Appendix A**). Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**. A discussion of Adaptive Management has been added to **Chapter 1.7.6** and **Appendix C**, **Section 7**, please see that text for an explanation of how future management changes will be incorporated into the program. Briefly, BOEM and NMFS will consider future data on the efficacy of mitigation measures to adjust mitigation requirements based on the best available information at that time.
Kevin Bodge, Olsen Associates	I-E-9	0.05	The proposed requirements to put marine observers aboard the small vessels used for MM surveys, and to suspend surveys when animals are sighted, are unjustified and onerous. If these requirements are justified and reasonable, then should not all recreational vessels and merchant ships be equipped with marine observers and/or be required to turn off their fathometers when operating in federal waters? What defensible evidence or rational justification is there that a 25-ft survey vessel operating at trawling (survey) speeds and surveying with high-frequency, low-energy devices will impact marine animals on the Outer Continental Shelf?	BOEM is responsible for ensuring that activities it authorizes are in compliance with applicable laws and regulations, including the ESA and MMPA. That is the basis for the mitigation requirements included in the Programmatic EIS. BOEM does not regulate the use of fathometers or other devices associated with recreation or commercial navigation. **Chapter 4.2.2.2** discusses the effects of sounds on marine mammals, particularly when those sounds are within the animals hearing range and **Appendix H** provides a review of marine mammal hearing and sensitivity. The modeling results in **Appendix E** indicate non-airgun HRG surveys may result in incidental takes of marine mammals. Since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. For non-airgun HRG surveys the type and number of observers aboard any vessel will be dependent on the action of the vessel or type of acoustic source utilized during a survey. In some cases only visual observers will be required on board to implement vessel strike measures. In other cases, PSOs will be required to monitor an acoustic exclusion zone during survey operations. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. The sound modeling reported in **Appendix D** and the incidental take calculations in **Appendix E** indicate that the suite of equipment during non airgun HRG surveys can result in incidental taking of marine mammals, for which reasonable and prudent mitigations are available. BOEM believes that the PSO requirement is feasible; the HRG Survey Protocol (see **Chapter 2.1.3.2** and **Appendix C**, **Section 3.3.3**) notes that operators "may engage trained third party observers, utilize crew members after training as observers, or use a combination of both third party and crew observers."
Kevin Bodge, Olsen Associates	I-E-9	0.06	Has BOEM considered the very significant increase in costs to the public to provide such observers and to shut down a survey	The Programmatic EIS has been structured to evaluate reasonable alternatives that include practicable mitigation which would avoid or

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			for at least 30 minutes every time an animal is observed? The beach projects for which MM sand is used, at least in Florida, are constructed in the public interest and with 100% public (Federal, State, and Local) funds. Any increased restriction on OCS activities for these public projects must consider the fiscal costs of these restrictions to the public relative to the real benefit to environmental protection that will be received. At least in terms of MM sites, the proposed Alternatives A and B do not make such consideration of the public interest.	minimize adverse impacts or enhance the quality of the human environment (40 CFR § 1502.1). A cost-benefit analysis is not required to satisfy NEPA analysis requirements, particularly if there are important qualitative considerations (40 CFR 1502.23). However, an EIS should indicate considerations, including factors not related to environmental quality, which are likely to be relevant and important to a decision (40 CFR § 1502.23). Since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. For non-airgun HRG surveys the type and number of observers aboard any vessel will be dependent on the action of the vessel or type of acoustic source utilized during a survey. In some cases only visual observers will be required on board to implement vessel strike avoidance measures. Visual observers may be crew members. In cases where only visual observers are required, shutdown related to acoustic sources would not be required. In cases where non-airgun HRG acoustic exclusion zone monitoring is required, more specialized PSOs will be required.
Kevin Bodge, Olsen Associates	I-E-9	0.07	The draft PEIS is ambiguous in terms of what G&G activities are exempt from restriction for MM sites, and how exceptions will be made. Throughout the document (say, for one example, Section 2.1.2.3), it is suggested that exemptions apply to high-resolution (non airgun) surveys for RE and MM sites, but then it is stated that surveys will be "reviewed on a case-by-case basis, and authorization may include additional mitigation and monitoring requirements…." It is therefore not clear what is and is not to be allowed for G&G surveys of MM sites, nor what burdensome process might be involved in gaining approvals for surveys under either Alternatives A or B. It is clear, however, that having to submit requests – and awaiting BOEM staff time to review requests – for high-resolution (non airgun) surveys of MM sites is onerous, costly, and of no net benefit to the environment or the public interest.	Since the release of the Draft Programmatic EIS, the HRG Survey Protocol has been clarified and the case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. The Programmatic EIS has been revised to more clearly and consistently indicate what equipment types are subject to the time-area closures and mitigation protocols. Only prospecting surveys on the Outer Continental Shelf (OCS) undertaken by another Federal agency or Federal agency contractor are exempt from BOEM's G&G authorization and review process. However, those activities are subject to the same environmental laws and regulations, and the action agency is responsible for demonstrating required compliance. All other G&G prospecting surveys and/or geophysical surveys related to the use of OCS sand resources, including pre and post construction bathymetric surveys undertaken by any project proponent, are subject to environmental review and authorization by BOEM. Please see response to comment I-E-9:0.03. In addition, over time mitigation measures may be further refined. Through the Adaptive Management process as outlined in **Chapter 1.7.6** and **Appendix C**, **Section 7**, BOEM may determine that exemptions are warranted for certain equipment or survey types. We are aware that the permitting process for HRG-type surveys can be lengthy. In the meantime operators are well advised to inquire of the agency as to expectations and to allow long lead times for permit processing.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Kevin Bodge, Olsen Associates	I-E-9	0.08a	I strongly urge BOEM to consider the following recommendations: 1. Adopt Alternative C and retain the status quo for MM surveys.	Comment noted.
Kevin Bodge, Olsen Associates	I-E-9	0.08b	2. If Alternative C is untenable owing to the political pressure to address O&G sites, then adopt Alternative A – but very clearly identify those G&G methods and devices that are automatically exempt from additional restrictions, at least for MM sites. This includes exemptions from calendar restrictions and observers.	Since the release of the Draft Programmatic EIS, the HRG survey Protocol has been clarified and the case-by-case language has been removed. As a result of the clarification time- area closures would generally not be applied to surveys using non-airgun HRG acoustic sources. See **Appendix A** for further information about HRG surveys in the NARW closure area. Those clarifications have been finalized with NMFS through formal Section 7 consultation and the issuance of a Biological Opinion (**Appendix A**). The Programmatic EIS has been revised to ensure that it clearly and consistently indicates what G&G methods and equipment are subject to time-area closures and other mitigation requirements. Please refer to **Chapter 2.0** and **Appendix C** for updated survey protocols. Please see response to comment I-E-9:0.03.
Kevin Bodge, Olsen Associates	I-E-9	0.08c	3. Exemptions for high-resolution G&G activities for MM sites might specify types of allowable equipment and methods but should additionally specify the minimum frequency and maximum energy level, to avoid confusion or uncertainty regarding what is and is not exempt equipment.	The Programmatic EIS has been revised to ensure that it clearly and consistently indicates what G&G methods and equipment (and where applicable, frequencies and energy levels) are subject to time-area closures and other mitigation requirements. Under the HRG Survey Protocol (see **Chapter 2.1.3.2** and **Appendix C**, **Section 3.3.3**) requirements such as the exclusion zone and startup/shutdown conditions apply only to HRG surveys in which one or more active acoustic sound sources will be operating at frequencies less than 200 kHz. Please see response to comment I-E-90.03.
Kevin Bodge, Olsen Associates	I-E-9	0.08d	4. Exemptions for listed equipment/methods should be automatic and not require case-by-case review and approval. Review and approval otherwise burdens both BOEM staff and the public.	Since the release of the Draft Programmatic EIS the HRG survey Protocol has been clarified and the case-by-case language has been removed. See **Appendix A** for further information about HRG surveys in the NARW closure area. We have also identified the review and approval process that would be utilized for site/permit-specific activities in **Chapter 1.7.5**.
Kevin Bodge, Olsen Associates	I-E-9	0.08e	5. Alternative B should not be adopted nor further considered.	Comment noted.
Non-Governmental Organization (NGO) Representatives (sorted by Organization)				
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.01	Seismic and other oil and gas G&G has caused no harm under current, longstanding regulation by BOEM. In sum, past regulation of OCS oil and gas G&G has adequately protected the environment. With the possible exception of reasonable temporal and zoning restrictions in order to protect the endangered right whale, there is no reason to believe a different approach is required in the Atlantic.	The mitigation protocol used in the Programmatic EIS is built largely on (and very similar to) the protocol used over a multiyear period in the GOM. There are biological and physical differences between the Atlantic and the GOM that warrant adjustments to the mitigation protocol to further reduce the potential for impacts. For example, several endangered mysticete whales, including the NARW, are present in the Atlantic but are rare or extralimital in the Gulf of Mexico. The GOM

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				protocol does not apply to water depths less than 200 m (656 ft) in the Gulf of Mexico west of 88ºW where most of the marine mammal population consists of two species (bottlenose dolphins and Atlantic spotted dolphins); this depth limitation was not deemed applicable in the Atlantic protocol. Also, BOEM conducted extensive modeling of acoustic transmission characteristics of the water column in the Atlantic and used that region specific information to evaluate the adequacy of the exclusion zone required by the Seismic Airgun Survey Protocol. BOEM believes it is reasonable to adapt the mitigation protocol to account for the biological and physical conditions in different regions, and the Agency has previously included different requirements for seismic survey permits in regions other than the GOM (e.g., Alaska).
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.02	The DPEIS proposes a new Draft Protocol for regulating seismic airgun surveys. The CRE asks BOEM to confirm or deny that the DPEIS' Draft Protocol is only proposed for the Atlantic, and is not intended for any other water body.	The seismic airgun protocol presented in the Programmatic EIS applies to and is intended for G&G activities in the Atlantic.
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.03	Acoustic Integration Model ("AIM"). There is no public record showing that AIM has been peer reviewed for its proposed application in the Atlantic PEIS. BOEM should identify in the public record each and every AIM peer review that they believe has occurred. BOEM should allow public comment on those and all other peer reviews relevant to the DPEIS. All AIM peer reviewers should be advised of the Information Quality Act ("IQA") requirements applicable to BOEM. NMFS' Peer Review Report for AIM states that the AIM input data on behavioral effects are inadequate. BOEM also repeatedly states that adequate input data do not exist for most of the marine mammals that AIM models. Consequently, before BOEM uses AIM to estimate Takes BOEM should conduct external peer review of AIM in order to determine, among other issues, whether the behavioral effects data input into the model are adequate to estimate Takes.	AIM© received a peer review from the Center for Independent Experts (CIE), a process that was initiated by NMFS. This was a 3-day in-person review, which was preceded by document evaluation and followed by a review period after which each panel member prepared a report. Since then, AIM© results have been included in several publicly reviewed, Federal agency-approved environmental compliance documents (e.g., U.S. Dept. of the Navy, 2012; National Science Foundation and U.S. Dept. of the Interior, Geological Survey, 2011). With respect to concerns about inputs to the animal movement model, the CIE panel reported that "It was generally agreed by the Panel that the animal movement methods used in AIM© were appropriate given the level of available data. The qualifier is important here. The Panel did not perceive a problem with AIM's© animal movement methods. They do acknowledge a problem with the absence of the type of data needed to realistically simulate animal movement within AIM." The state of knowledge of marine animal behavior has improved greatly since 2006. MAI has continued to review new data reports on animal movements and update its database of animal movement parameters. For example, one of the concerns of the CIE panel was the 'lumping' of species into behavioral groups due to a lack of species-specific data. Since the review, sufficient data have been published on pilot whales to allow them to be represented as a separate modeling entity where they were previously 'lumped' in the blackfish group. There is also now enough data to accurately model the behavior of sea turtles. Furthermore, following best modeling practices, the values of the

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				behavioral input parameters are included in the environmental compliance reports in which they are used, along with the peer-reviewed published literature from which they were derived. Therefore, the reader has the ability to evaluate the original research, review the use of the data to derive the behavioral input parameters, and reach their own conclusion on the validity of those input values. This was done for BOEM's Mid- and South Atlantic G&G Programmatic EIS. Finally, the animal movement model itself has been updated and improved. An example is the ability to assign a probability value for each behavioral state. Thus, if a species makes frequent shallow dives and occasional deep dives, the animal can be probabilistically programmed to reflect that behavior. In conclusion, the structure of the AIM© model was found to be appropriate by the Center for Independent Experts. The model has continued to be refined and improved since then. The animal movement parameter values have been continuously updated and still represent the best available data for impact analysis.
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.04	Passive Acoustic Monitoring ("PAM") should be required in the Atlantic, and PAMGUARD should be encouraged. PAM is already being required in most NMFS regulation of seismic, and it is "strongly encouraged" by BOEM's NTL 2012 G0-2, so this is not a significant change in current regulation.	Alternative B which requires PAM for airgun surveys and may be used as an additional monitoring method for night-time or periods of reduced visibility for HRG surveys using sources operating at frequencies at or below 200 kHz has been identified by BOEM as the Agency's Preferred Alternative. PAM has been incorporated into the Seismic Airgun and HRG Survey Protocols to improve detection of marine mammals and further reduce potential impact to the NARW and other marine mammals. In addition, a separate section on PAM has been added to the Programmatic EIS (**Appendix C**, **Section 3.2.2.6**). Given the 10-year time period covered by the Programmatic EIS, BOEM does not believe it is appropriate to recommend specific PAM software at a programmatic level.
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.05	The DPEIS, and all BOEM information disseminations, must meet IQA requirements. These IQA requirements apply to any outside or third-party information that BOEM uses or relies on.	Comment noted.
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.06	BOEM will have to prepare a new Information Collection Request ("ICR") for public comment and for Office of Management and Budget ("OMB") review before BOEM could regulate seismic in a manner that is significantly different from current regulation under NTL No. 2007-G02.	Comment noted.
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.07	BOEM should proceed with Alternative A in the PEIS, but should do so by incorporating all of the above recommendations.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Jim Tozzi, Center for Regulatory Effectiveness	NGO-E-8	0.08	BOEM SHOULD MAKE THE PUBLIC COMMENTS AVAILABLE TO THE PUBLIC. CRE urges BOEM to embrace a more transparent process in conducting the Atlantic PEIS by making the public comments available to the public immediately after the comment period closes.	Public Comments were posted on the BOEM website at http://www.boem.gov/Oil-and-Gas-Energy-Program/GOMR/GandG.aspx on November 26, 2012.
Heather Stafford (Saffert), Clean Ocean Action	NGO-PHAC-15	0.01	Of the many scientific concerns I have for this EIS, I'm most troubled by the under estimation of impact and the many data it gives. For example, there are scientific data, some identified, that I've brought to the attention of this agency over thirty years ago on understanding the impact of seismic surveys on our environment.· These data gaps are frustratingly left unfulfilled even after BOEM, EOI, and other agency scientists themselves called for more research intruding on the seasonal distribution of the ocean communities, migration impact, spawning periods, biological responses to air damage, and overall impact for species ranging in size from tiny plants to whales. Information's lacking on the impact of noise on turtles, whales, fish, dolphins, and more.	BOEM prepared the Programmatic EIS using the best available data and included conservative assumptions to avoid underestimating impacts. BOEM is involved in several ongoing programs to improve existing data for marine mammals and underwater noise as discussed in **Appendix E**. Future site-specific NEPA analyses will use the best data available at that time. **Chapter 4.1.4.1** of the Programmatic EIS discusses unavailable and incomplete information as required by NEPA. For each resource in **Chapter 4.0**, the Programmatic EIS notes where data are unavailable or incomplete. BOEM is currently involved in multiple efforts to improve information. For example, BOEM has partnered with the National Oceanic and Atmospheric Administration (NOAA) and other organizations to fund projects to improve biological information on protected species in the U.S. Atlantic. Two notable programs include the following: • Atlantic Marine Assessment Program for Protected Species (AMAPPS) – This is an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters. The project will also collect similar data at finer scales at several sites of particular interest to NMFS and BOEM. Importantly, AMAPPS also seeks to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics (see http://www.nefsc.noaa.gov/read/protspp/mainpage/ AMAPPS/index.html and http://boem.gov/uploadedFiles/BOEM/ Environmental_Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_Studies/AT-10-x11.pdf). • BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre, an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). See **Appendix G**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Heather Stafford (Saffert), Clean Ocean Action	NGO-PHAC-15	0.02	The determination of air gun impact is highly questionable in this EIS.· There are substantial reasons for concern about the harm that air gun blasts have on tiny, little creatures, to plants, to whales.	**Chapters 4.2** and **4.3** provide a discussion of the potential impact of airguns on marine resources in the Area of Interest.
Heather Stafford (Saffert), Clean Ocean Action	NGO-PHAC-15	0.03	All of these impacts really must be considered and taken seriously. In 2010 when BOEM first proposed testing we asked BOEM to conduct a base line survey of noise levels in the region so that the environmental impact could be differentiated from existing noise such as from shipping and Department of Defense testing and training activities.	BOEM and NMFS appreciate the comment. BOEM continues to fund research, including Characterization and Potential Impacts of Noise Producing Construction and Operation Activities on the OCS, which can be seen at http://www.boem.gov/uploadedFiles/BOEM/ Environmental_ Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_ Studies/GM-09-11.pdf.
Heather Stafford (Saffert), Clean Ocean Action	NGO-PHAC-15	0.04	We also asked BOEM to assess cumulative impact on adding seismic surveys to this already noisy ocean region. The only response was to affirm that data was lacking.	The cumulative activities scenario in **Chapter 3.0** has been revised to include additional activities, and the cumulative activities analysis in **Chapter 4.0** has been revised and expanded to address this issue.
Michael Jasny, NRDC	NGO-E-10	0.01	We believe that the DPEIS not only fails to meet the environmental review standards prescribed by the National Environmental Policy Act ("NEPA"), but fails to an extent that cannot be remedied through the issuance of a final EIS. Accordingly, if BOEM intends to allow oil and gas exploration in the Atlantic, we believe that the document must be thoroughly revised and reissued as a draft for further public review and comment.	BOEM was directed by Congress to develop a Programmatic EIS that analyzes impacts resulting from G&G survey activities in specific planning areas of the Atlantic. This document is designed and constructed to accomplish that analysis. The procedural steps required by NEPA have been followed. A 60-day public comment period was subsequently extended by 30 days. An Agency Preferred Alternative was not identified in the Draft Programmatic EIS because BOEM wished to examine the aggregate comment record before making that decision. BOEM has presented a rationale for how the Agency chose the Preferred Alternative reported in the Final Programmatic EIS. Under NEPA regulations at 40 CFR § 1502.9(c), agencies shall prepare supplements to either draft or final environmental impact statements if: (i) the agency makes substantial changes in the proposed action that are relevant to environmental concerns; or (ii) there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. Neither of these conditions is the case, and therefore, we do not believe a Draft Programmatic EIS needs to be reissued.
Michael Jasny, NRDC	NGO-E-10	0.02	NEPA dictates that BOEM must employ rigorous standards of environmental review, including a fair and objective description of potential impacts, a comprehensive analysis of all reasonable alternatives, and a thorough delineation of measures to mitigate harm. Unfortunately, the DPEIS falls far short of these standards. Instead, it provides an analysis that on almost every crucial point is disconnected from the relevant science, in a way that consistently tends to understate impacts and, consequently, to rationalize BOEM's proposed action.	BOEM disagrees with this assessment of the Programmatic EIS. For the preparation of the Programmatic EIS, BOEM included current and new information to inform the analyses. We also note that the EPA review of the document states that "the Draft Programmatic EIS provides an adequate discussion of the potential environmental impacts and we have not identified any potential environmental impacts requiring substantive changes."

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.03	BOEM relies on a 13-year-old, cookie-cutter threshold for harm that was recently castigated by some of the world's leading experts in this field as "overly simplified, scientifically outdated, and artificially rigid" – leading to a serious misconception of the scale of the impact area and a massive underestimate of marine mammal take.	The "cookie-cutter threshold" referred to was established by NMFS as a standard to define takings under MMPA and is still used by NMFS for that purpose. It is the standard used by the regulatory agency having jurisdiction. In addition, we calculated incidental takes using the Southall et al. (2007) criteria (see **Appendix E**) and considered this information in the impact analysis in **Chapter 4.2.2**. The Southall criteria were developed by a group of acoustics and marine mammal experts, published in a peer-reviewed paper, and remain reasonable based on our literature update in **Appendix H**. We note in particular that Level A incidental takes (injury) would be much lower using the more recent (Southall) criteria and therefore we do not agree that use of the NMFS criteria results in a "massive underestimate" of marine mammal takes.
Michael Jasny, NRDC	NGO-E-10	0.04	The DPEIS fails to assess the far-reaching cumulative impacts of airgun blasting on marine mammal communication, despite the availability of Cornell and NOAA models, simply stating without any discernible support (and contrary to the literature) that masking effects on marine mammals would be "minor."	The text in **Chapters 3.6.11** and **4.2.2.4** has been added and revised to better address cumulative impacts.
Michael Jasny, NRDC	NGO-E-10	0.05	The DPEIS fails to incorporate new studies, accepted by the Navy and other state and federal agencies and incorporated into their recent impact statements, demonstrating that marine mammals are more susceptible to hearing loss than previously believed.	Please see the response to NGO-E-1:0.60. The cumulative impact analysis in the Programmatic EIS has been revised and expanded to address this issue. The revised analysis explicitly addresses the incidental take numbers for the proposed action as well as the Navy's Atlantic Fleet Training and Testing (AFTT) EIS findings and other reasonably foreseeable activities. Information about activities and potential impacts (including incidental take) from Navy activities has been added to the cumulative activities scenario in **Chapter 3.6.7**, and the cumulative impact sections in **Chapter 4.0** have been reviewed and updated where appropriate to address the range of activities included in the cumulative scenario. The Programmatic EIS is using these NMFS thresholds while discussing the Southall criteria as a way of comparison in the document. While other thresholds may not be peer reviewed, until the established thresholds are changed, BOEM must follow existing thresholds. BOEM recognizes that literature suggests that there is a need for a change to the standard and that a new standard may be provided. When it is provided, BOEM will be responsive to those changes at that time and each individual survey would utilize the new thresholds. Until then BOEM must use the existing, prescribed, and regulated thresholds.
Michael Jasny, NRDC	NGO-E-10	0.06	In lieu of a serious analysis of cumulative impacts, the DPEIS strings together a few unsupported and indeed baseless statements, ignoring not only its own marine mammal take numbers but also failing to consider such patently foreseeable	The cumulative impact analysis in the Programmatic EIS has been revised and expanded to address this issue. The revised analysis explicitly addresses the incidental take numbers for the proposed action as well as the Navy's Atlantic Fleet Training and Testing (AFTT) EIS

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			impacts as the Navy's substantial takes of the same populations over the same period (just analyzed in the Navy's Draft EIS for the Atlantic Fleet).	findings and other reasonably foreseeable activities. Information about activities and potential impacts (including incidental take) from Navy activities has been added to the cumulative activities scenario in **Chapter 3.6.7**, and the cumulative impact sections in **Chapter 4.0** have been reviewed and updated where appropriate to address the range of activities included in the cumulative scenario. Further, BOEM is actively coordinating with the Department of Defense, the U.S. Navy in particular, to avoid respective activities and ensure thorough monitoring of the environment.
Michael Jasny, NRDC	NGO-E-10	0.07	Despite acknowledging that airguns can cause wide-scale displacement of fish species – disrupting spawning and reproduction, altering migration routes, and impairing feeding, and dramatically reducing catch rates – it assumes without support that effects on both fish and fisheries would be localized and "minor."	The text has been revised in **Chapter 4.2.5.2.2**, **4.2.7.2.2**, and **4.2.8.2.2** to address this comment. The conclusion is based on literature review and expert analysis.
Michael Jasny, NRDC	NGO-E-10	0.08	The fundamental problem is that the agency simply does not take the problem of cumulative, sublethal impacts seriously; and misprising the scale and potential significance of the impacts, it fails to consider alternatives and mitigation adequate to address it.	The text has been added to **Chapter 3.6** and in the individual resource sections of **Chapter 4.0**, to better address cumulative impacts, including sublethal impacts and their potential significance.
Michael Jasny, NRDC	NGO-E-10	0.09	The DPEIS does not even attempt to identify biologically important areas within the enormous activity area, aside from critical habitat for the right whale and loggerhead sea turtles. It does not attempt to reduce the extraordinary amount of activity by restricting exploration from areas that are unlikely to be leased, beginning with important Navy training areas, or to reduce the environmental footprint of the activity that does occur. It fails even to devise a long-term monitoring plan, which is a staple of Navy mitigation and essential to any meaningful adaptive management program.	**Chapter 4.0** provides a complete assessment of the biological resources within the activity area and identifies biologically important areas such as critical habitat, Essential Fish Habitat, Habitat Areas of Particular Concern, Marine Protected Areas, and fishery management areas. In the current phase it is premature to implement survey activity restrictions in the AOI. The scope of individual seismic surveys is not determined by BOEM but by the survey operators who have submitted applications based on what they believe industry interest may be, and what data sets they may be able to market. The analyses that will be needed for BOEM permit conditions and NMFS' MMPA permit conditions will further mitigate at the project-specific level and will also reevaluate biologically important areas as well as other activities occurring in the area. A discussion of Adaptive Management has been added in **Chapter 1.7.6** and **Appendix C**, **Section 7**. As part of its Adaptive Management program, BOEM intends to review the effectiveness of mitigation measures based on monitoring data collected by PSOs during G&G surveys or other information. Further, restricting G&G exploration at this time from certain areas does not meet the purpose and need of this Programmatic EIS.
Michael Jasny, NRDC	NGO-E-10	0.10	Supports Alternative C.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.11	BOEM must correct the fundamental errors in the present DPEIS. Merely revising the draft into a final EIS is not sufficient, because its pervasive flaws and omissions have effectively deprived federal and state agencies, the scientific community, and the general public of their statutory right to an objective description of the activity and a meaningful opportunity to comment.	The public, all affected parties, and any party taking an interest had a 94 day comment period for the Draft Programmatic EIS, in addition to the initial scoping of the Programmatic EIS in 2010. We do not agree that Federal and State agencies, the scientific community, and the general public have been deprived of their statutory right to meaningfully comment on the Draft Programmatic EIS, and we do not believe that our approach was in some way fundamentally in error. We also note that the U.S. Environmental Protection Agency's (USEPA's) review of the document states that "the Draft Programmatic EIS provides an adequate discussion of the potential environmental impacts and we have not identified any potential environmental impacts requiring substantive changes." There will be additional opportunities to comment at the project-specific stage when NMFS advertises receipt of applications and request for comments for Marine Mammal Protection Act permitting.
Michael Jasny, NRDC	NGO-E-10	0.12	BOEM should assess alternatives that place meaningful caps or limits on offshore activities, to reduce disruptions of marine mammal behavior.	BOEM and NMFS have considered various mitigation measures, including time-area closures to limit offshore activities, which is a cap or limit of activities and would reduce overall sound input. These mitigation measures can be seen in **Chapters 2.1.2** and **2.2.2** and **Appendix C**. Please see the response to comment NGO-E-10:0.36 regarding activity cap or limits. Additional and different mitigation measures that may reduce overall sound input may be considered during site-specific analyses.
Michael Jasny, NRDC	NGO-E-10	0.13	BOEM should eliminate duplication of survey effort by prescribing or incentivizing the use of common surveyors, particularly for the extensive 2-D surveys expected within the first five years of activity.	BOEM has considered the reduction of duplication of effort as a mitigation measure to reduce the overall sound input, for this Atlantic G&G Programmatic EIS, as well as in other forums such as the Mitigation and Monitoring Workshop BOEM hosted in November 2012, which was aimed at measures for the GOM, but could also be applied in other regions. The reason for currently eliminating an alternative to eliminate duplicative survey effort has been clarified in **Chapter 2.5.5**. However, this mitigation measure may be considered again during site-specific analyses.
Michael Jasny, NRDC	NGO-E-10	0.14	BOEM should develop alternatives for the development and implementation of "greener" exploration technology.	We have revised and updated the discussion of non-airgun alternatives in **Chapter 2.5.6** and **Appendix C**, **Section 6.0**. BOEM does seek to promote the development and implementation of alternatives to the impulse airgun. However, this Programmatic EIS is not the appropriate outlet to compel the development and implementation of "greener" technologies. NEPA alternatives must be developed to meet the Agency's purpose and need. BOEM evaluated a non airgun alternative in **Chapter 2.5.6.8**, and found that it would not meet the Agency's purpose and need because none of the non airgun alternatives currently are economically feasible or technically viable for commercial

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				deployment; all of them being in various stages of development. Evaluations of recent technologies are undertaken by BOEM's Technology Assessment & Resource Program. Also, through the Environmental Studies Program, BOEM recently sponsored a workshop on "Quieting Technologies for Reducing Noise during Seismic Surveying and Pile Driving" (February 25-27, 2013, in Silver Spring, Maryland), which addressed this very topic, and will continue to work cooperatively to evaluate the development of new and alternative technologies. We do seek an orderly transition by industry toward alternatives to the impulse airgun. BOEM also believes that permitting incentives are worthy of consideration. Incentives may take the form of selective lifting of certain mitigation measures in the seismic protocol, or operating in an area or at a time that airguns are not permitted. It is important to recognize that BOEM is not seeking rulemaking on behalf of industry to operate in the Area of Interest.
Michael Jasny, NRDC	NGO-E-10	0.15	BOEM should exclude from G&G exploration areas that are unlikely to be leased in the near future, whether for biological, political, or economic reasons, such as waters within 50 miles of the Virginia shore or waters important to the Navy's national security mission.	Broad scale seismic surveys are needed to help identify prospective locations for oil and gas development and are essential to providing BOEM's accurate resource assessments and potential reserve estimates. The scope of individual seismic surveys is not determined by BOEM, since BOEM does not conduct its own surveys, but by the survey operators who have submitted applications based on what they believe industry interest may be, and what data sets they may be able to market to potential clients. In addition, broad scale seismic surveys provide geological framework data that helps to identify and map regional structures, even if some of the areas surveyed would not be suitable for future exploration leasing. The G&G surveys in support of renewable energy and marine minerals programs would be conducted only at specific sites identified by developers or agencies, and by definition these sites would be at least potentially suitable for the proposed development or use. **Chapter 3.0** identifies the likely depth ranges for renewable energy and marine minerals activities. Finally, high resolution G&G site surveys, whether for oil and gas, renewable energy, or marine minerals development, are essential in identifying sensitive benthic communities, archaeological resources, and other features for avoidance. Locations of many such features are not known until a geophysical survey is conducted. The examples of potential conflicting uses provided will certainly be considered when site-specific projects go through the evaluation process. Further, restricting G&G exploration at this time from certain areas does not meet the purpose and need of this Programmatic EIS.

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Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.16	BOEM should consider establishing buffer zones around all of its time-area closures, to prevent ensonification of important habitat at disruptive levels.	The time-area closures were based on specific areas that are either protected by laws and regulations (NARW critical habitat and SMAs) or documented as high use areas (sea turtle nesting in Brevard County, Florida). BOEM has determined that the extent of the time-area closure will remain at 20 nmi (37 km; 23 mi) from shore for Alternative B, the Agency's Preferred Alternative and believes this is adequate for ensuring ensonification is not at disruptive levels. Airgun surveys conducted outside of the critical habitat, SMAs, or DMAs would be required to remain at a distance such that received levels at those boundaries do not exceed the Level B harassment threshold. BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat or SMAs. We also note that proposed surveys adjacent to right whale CH or SMAs (but not within closure areas) could be subject to additional mitigation requirements if determined reasonable and prudent by NMFS. Airgun surveys authorized outside of CH, SMAs, and DMAs shall operate at distances such that received levels at the boundaries of these areas do not exceed the Level B harassment threshold as determined by field verification or modeling. Additional mitigation measures to reduce impacts caused by sound producing activities proposed in or near the boundaries of an NMS would be determined during site/permit-specific reviews in consultation with the Sanctuary Superintendent pursuant to Section 304(d) of the NMSA.
Michael Jasny, NRDC	NGO-E-10	0.17	BOEM should develop time-area closures for marine mammals based on a systematic analysis of their density, distribution, and habitat use within the area of interest. To begin with, it should expand the time-area closure for North Atlantic right whales to fully capture the calving grounds and migration corridor, and put the Cape Hatteras Special Research Area off limits on a year-round basis.	The time-area closures were based on specific areas that are either protected by laws and regulations (NARW critical habitat and SMAs) or documented as high use areas (sea turtle nesting in Brevard County, Florida). BOEM considered expanding the time-area closures based on areas likely to be of interest to industry as well as information made available since release of the Draft Programmatic EIS that includes BOEM's 2012 Atlantic resource assessment (USDOI, BOEM 2012) and NOAA's cetacean stock assessment; however, BOEM has determined that for airgun surveys the extent of the closure will remain at 20 nmi from shore for Alternative B, the Agency's Preferred Alternative. BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat, SMAs, and/or DMAs. The designation of the Cape Hatteras Special Research Area (CHSRA) relates specifically to commercial longline fishing and regulatory and non-regulatory measures to reduce marine mammal and other species bycatch from that fishery. The designation of the CSHRA does not include restrictions on other activities including navigation through the area and, therefore, would not

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				warrant a year-round area closure for other activities including G&G activities.
Michael Jasny, NRDC	NGO-E-10	0.18	BOEM should extend the seasonal Brevard County time-area closure for sea turtles to near-coastal areas through North Carolina, and should consult with NMFS to ensure inclusion of all loggerhead critical habitat in any closure provision.	As noted in **Chapter 2.2.2.2**, 25 percent of all loggerhead nesting in the U.S. occurs in the Archie Carr NWR. Annual numbers of loggerhead nests for all counties north of Brevard County are 1 to 3 orders of magnitude lower and at this time do not warrant time-area closures. This is why this area was included in Alternative B for additional closures for airgun surveys. Closure of the entire coastal areas through North Carolina for sea turtles along with the closures for right whales, would preclude airgun survey activities for most of the year except for two, 2-week periods in this nearshore area. As discussed in **Chapter 4.2.3.2.2**, subbottom profilers, sonars, and depth sounders are largely beyond the functional hearing range of sea turtles and are expected to have negligible effects. These non-airgun HRG surveys are expected to be the types of surveys most likely to be performed in the near shore areas rather than the airgun surveys. Additional mitigation measures are included for protection of sea turtles including vessel strike avoidance and acoustic exclusion zone shutdowns, please refer to **Chapters 2.1.2.1.1**, **2.1.2.2**, and **Appendix C**. BOEM has conducted formal ESA consultation with NMFS throughout this process. On May 24, 2013, NMFS issued a Final BO and on July 19, 2013, NMFS issued a revised Final BO. NMFS concluded in the BO that the proposed G&G activities are not likely to jeopardize the continued existence of the species under consultation. NMFS also concluded the proposed action is not likely to destroy or adversely modify NARW critical habitat. The following sea turtle species were included in the consultation; green, hawksbill, Kemp's ridley, leatherback and Northwest Atlantic loggerhead sea turtles.
Michael Jasny, NRDC	NGO-E-10	0.19	BOEM should consider alternatives that exclude key fish habitat and fisheries, including submarine canyons in the mid-Atlantic, and Habitat Areas of Particular Concern designated by the Mid-Atlantic and South Atlantic Fishery Management Councils.	Habitat Areas of Particular Concern (HAPCs) and any areas designated as EFH are reviewed and would be mitigated as required in consultations under the Magnuson Stevens Fisheries and Conservation Management Act with the NMFS Office of Habitat Conservations at the permit/site-specific level. Additionally, on June 1, 2012, NMFS determined BOEM's request for Programmatic EFH Consultation was not an appropriate mechanism to evaluate EFH impacts of BOEM's G&G activities in the Atlantic OCS based on information available at the time. In response, BOEM has proposed each activity that occurs under this proposed action would receive an environmental review, including an EFH assessment from BOEM. Based on the impact analysis presented in the Programmatic EIS, the areas proposed are not worthy of

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				a separate alternative. Further, BOEM incorporated the report, "Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities" from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed key fish habitat, fisheries, and areas of concern in the mid- and South Atlantic.
Michael Jasny, NRDC	NGO-E-10	0.20	BOEM should exclude airgun surveys within a 145 dB isopleth around established dive sites.	All surveys within or near an MPA will require coordination with the MPA manager. As part of the process for site/permit-specific activities BOEM and BSEE's Environmental Enforcement Division will conduct future consultation and coordination with NOAA's Office of National Marine Sanctuaries (ONMS). These coordination activities will include the discussion on notification of divers and boaters in the region, beyond the Notice to Mariners, discussion of set-back from the Monitor and Gray's Reef National and Marine Sanctuaries and environmental monitoring and enforcement efforts. BOEM and BSEE have begun this process through the November 2, 2012, letter to Mr. Daniel Basta the Director of the Office of National Marine Sanctuaries. Please see revisions to **Chapter 5.7.6**.
Michael Jasny, NRDC	NGO-E-10	0.21	BOEM should require that airgun survey vessels use the lowest practicable source levels, minimize horizontal propagation of the sound signal, and minimize the density of track lines consistent with the purposes of the survey, and, to this end, should consider establishing an expert panel within the agency to review survey designs with the aim of reducing their wildlife impacts.	In November 2012, BOEM hosted a workshop on Mitigation and Monitoring that addressed these very ideas. While the workshop was specific to the Gulf of Mexico region, many of the ideas discussed could also be applicable to the Atlantic OCS. Many of the monitoring and mitigation ideas are reflected in **Chapter 4.0** of this Programmatic EIS. At this time, BOEM believes that Alternative B, the Preferred Alternative, provides the most appropriate protection to the environment through monitoring and mitigation measures. However, additional measures will be evaluated through analyses for individual, site-specific activities.
Michael Jasny, NRDC	NGO-E-10	0.22	BOEM should require operators to validate in situ the assumptions about propagation distances used to establish safety zones and calculate take, as is required in the Arctic.	The Seismic Airgun Survey Protocol has been revised to require that operators establish an exclusion zone for each survey. The zone shall be calculated independently, be based on the configuration of the array and the ambient environment, but shall not have a radius of less than 500 m (1,640 ft).
Michael Jasny, NRDC	NGO-E-10	0.23	BOEM should therefore require that all vessels associated with G&G activities, including support vessels and vessels used in HRG surveys, adhere to a 10 knot speed limit when operating or transiting at all times.	BOEM believes it will be impractical for vessels to adhere to a 10-kn speed limit at all times. However, all authorizations for shipboard surveys, regardless of vessel size would include guidance for vessel strike avoidance. The guidance would be similar to NTL 2012-JOINT-G01 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") (USDOI, BOEM and BSEE, 2012b), which incorporates NMFS "Vessel Strike Avoidance Measures and Reporting for Mariners" addressing protected species identification, vessel strike avoidance, and

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				injured/dead protected species reporting. As described in **Chapter 2.1.2.1.1** vessel speeds within critical habitat from November 15 to April 15 and SMA and DMAs from November 1 to April 30 will be required to operate within the 10 kn (18.5 km/h) speed restrictions. In addition, year-round vessel strike avoidance and crew members, visual observers/PSOs are required to maintain watch during transit to avoid striking marine mammals and sea turtles.
Michael Jasny, NRDC	NGO-E-10	0.24	BOEM should require that vessels avoid important habitat, such as right whale calving grounds, when transiting to G&G activities.	BOEM believes it will be impractical to avoid calving grounds entirely when transiting during G&G activities. However, all authorizations for shipboard surveys, regardless of vessel size would include guidance for vessel strike avoidance. The guidance would be similar to NTL 2012-JOINT-G01 ("Vessel Strike Avoidance and Injured/Dead Protected Species Reporting") (USDOI, BOEM and BSEE, 2012a), which incorporates NMFS "Vessel Strike Avoidance Measures and Reporting for Mariners" addressing protected species identification, vessel strike avoidance, and injured/dead protected species reporting. As described in **Chapter 2.1.2.1.1** vessel speeds within CH from November 15 to April 15 and SMA and DMAs from November 1 to April 30 will be required to operate within the 10 kn (18.5 km/h) speed restrictions. In addition, year-round vessel strike avoidance and crew members, visual observers/PSOs are required to maintain watch during transit to avoid striking marine mammals and sea turtles.
Michael Jasny, NRDC	NGO-E-10	0.25	BOEM should require that all vessels used in oil and gas G&G activities undergo measurement for their underwater noise output per American National Standards Institute/ Acoustical Society of America standards (S12.64); that all such vessels undergo regular maintenance to minimize propeller cavitation; and that all new industry vessels be required to employ the best ship-quieting designs and technologies available for their class of ship.	BOEM appreciates the comment, but the suggested requirements are outside of BOEM's jurisdiction.
Michael Jasny, NRDC	NGO-E-10	0.26	BOEM should consider prescribing larger, more conservative separation distances, since marine mammals can experience displacement and other impacts well beyond the 160 dB isopleth, on which the current proposed separation distance is based.	BOEM will consider the value of this measure at the site-specific NEPA and environmental analyses level as well as any new information available at that time. This evaluation will also consider any potential aggregate effects from existing permitted surveys (if any).

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Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.27	BOEM should require that operators working close to shore design their tracklines to minimize the potential for embayments and strandings.	Geological and geophysical surveys conducted close to shore are likely to be in support of the renewable energy or marine minerals programs. Most of the equipment used for those surveys operates at higher frequencies or produces a directed output, both factors tending to limit the area ensonified. Survey equipment that doesn't fall into those categories will be closely scrutinized during the individual site-specific review and analysis.
Michael Jasny, NRDC	NGO-E-10	0.28	BOEM should reconsider the size of the safety zones it would prescribe as part of its nominal protocol for seismic airgun surveys, taking into account new data on the threshold shift in marine mammals; and should consider establishing larger shutdown zones for certain target species, such as right whales.	The size of the safety zone for airgun surveys will vary according to the source output level, as indicated in **Appendix C**, **Section 3.2**, based on the acoustic criteria established by NMFS. Should NMFS choose to make changes to criteria BOEM will incorporate them into the mitigation protocol. The purpose of the Seismic Airgun Survey Protocol is to prevent injury (Level A harassment) of marine mammals to the maximum extent practicable. The radius of the exclusion zone would be based on the predicted range at which animals could be exposed to a received sound pressure level of 180 dB re 1 µPa, which is the current NMFS criterion for Level A harassment of cetaceans by pulsed (and continuous) sources. The radius of the exclusion zone would be calculated, modeled, or field verified on a survey-specific basis but would not be less than 500 m (1,640 ft). Based on calculations in **Appendix D**, the 180-dB zone for a large airgun array (5,400 in^3) ranges from 799 to 2,109 m (2,622 to 6,920 ft), with a mean of 1,086 m (3,563 ft). For HRG surveys using a small airgun array (90 in^3), the calculated 180 dB zone ranges from 76 to 186 m (249 to 610 ft), with a mean of 128 m (420 ft).
Michael Jasny, NRDC	NGO-E-10	0.29	BOEM should improve its real-time monitoring requirements, by reducing the length of time a marine mammal observer can continuously work; requiring that observers used on airgun surveys have meaningful field experience; mandating, or at least presumptively requiring, the use of passive acoustic monitoring; prescribing aerial surveillance on a case-by-case basis; and, for HRG surveys, requiring two trained observers in order to maintain coverage on both sides of the survey vessel.	Alternative B, which includes requirements for PAM, has been identified as the agency's Preferred Alternative. In its Biological Opinion, NMFS has required the use of PAM for airgun surveys. The Seismic Airgun and HRG Survey Protocols specify that PSOs must have completed a training course, and based on our experience with the same requirement used in the Gulf of Mexico, we expect that PSOs would have meaningful field experience. Observers shall operate under the following guidelines: (1) other than brief alerts to bridge personnel of maritime hazards, no additional duties shall be assigned to observers during their watch; (2) a watch shall be no longer than four consecutive hours; (3) a break of at least two hours shall occur between watches, no other duties shall be assigned during this period; and (4) an observer's combined watch schedule shall not exceed 12 hours during a 24-hour period. Due to shift requirements two PSOs would be onboard these HRG vessels; however, one PSO is on watch at a time. Due to the smaller size

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Name, Organization	ID	No.	Comment	Response
				of the HRG vessels for these types of surveys, one PSO can adequately monitor the required exclusion zone. The PSO requirements in the survey protocol are consistent with the General Mitigation and Monitoring Requirements in the BO. For HRG sources operating at frequencies below 200 kHz there are monitoring requirements for both an acoustic exclusion zone and a vessel strike exclusion zone. For non-airgun HRG sources operating at frequencies above 200 kHz, only a vessel strike exclusion zone would be monitored. Through the Adaptive Management process, mitigation requirements could be revised if new information indicates that they are infeasible or could be made more effective.
Michael Jasny, NRDC	NGO-E-10	0.30	BOEM should commit to consider limiting activities in low-visibility conditions on a case-by-case basis, and describe the conditions under which it might be required.	BOEM recognizes that visibility can influence the effectiveness of Protective Species Observers. The Seismic Airgun Survey Protocol in **Section 3.2** and **3.3** of **Appendix C** addresses this issue. Alternative B, which has been identified as the Agency's Preferred Alternative, includes the required use of PAM for seismic surveys and may be used as an additional monitoring technology for HRG surveys using sources operating at frequencies at or below 200 kHz to help locate animals at all times, including those when visual conditions are not ideal. The Seismic Airgun and HRG Survey Protocols in **Section 3.2** of **Appendix C** address this issue. The Seismic Airgun Survey Protocol specifies that operators cannot initiate start-up procedures at night or when they cannot visually monitor the exclusion zone for marine mammals and sea turtles if the minimum source level drops below the current level B harassment threshold. If BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility for HRG non-airgun surveys using sources operating at frequencies at or below 200 kHz, operators must use effective monitoring technologies to monitor the exclusion zone. Possible tools include shipboard lighting, enhanced vision equipment, night-vision equipment and/or passive acoustic monitoring. Future site-specific analyses may provide additional limitations, as necessary.
Michael Jasny, NRDC	NGO-E-10	0.31	BOEM should immediately develop a long-term monitoring program, to establish environmental baselines, to determine long-term impacts on populations of target species, and to test whether the biological assumptions underlying the DPEIS are correct.	BOEM has partnered with NOAA and other organizations to fund projects to improve biological information on protected species in the U.S. Atlantic. Two notable programs include the following: • Atlantic Marine Assessment Program for Protected Species (AMAPPS) – This is an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters. The project will also collect similar data at finer scales at several sites of particular interest to

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Name, Organization	ID	No.	Comment	Response
				NMFS and BOEM. Importantly, AMAPPS also seeks to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics (see http://www.nefsc.noaa.gov/read/protspp/mainpage/AMAPPS/index.html and http://boem.gov/uploadedFiles/BOEM/Environmental_Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_Studies/AT-10-x11.pdf). • BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre, an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/ Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). BOEM continues to consider other opportunities to improve knowledge of the biological baseline as well as opportunities to develop a long-term monitoring program. BOEM agrees that a long-term monitoring program is beneficial and will further develop such a program during individual, site-specific analyses. Ultimately, NEPA requires that Federal agencies use the best available information in environmental impact statements, which BOEM has done. BOEM will continue to monitor the results of AMAPPS and other relevant studies (i.e., NOAA Sound and Cetacean Density Mapping) to ensure any updated data relevant to the Atlantic OCS are considered as they become available to support future, site/permit-specific evaluations of individual survey applications. Finally, as part of its Adaptive Management program BOEM intends to review the effectiveness of mitigation measures. Mitigation and requirements could be revised if new information indicates that they are infeasible or could be made more effective.
Michael Jasny, NRDC	NGO-E-10	0.32	BOEM should incorporate an adaptive management plan into its alternatives, and should also set forth a protocol for emergency review or suspension of activities, if serious unanticipated impacts are found to occur.	A discussion of Adaptive Management has been added to **Appendix C**, **Section 7**. Adaptive Management is an iterative process for decision-making in the face of uncertainty where systematic monitoring is employed over time to reduce uncertainty. The process will provide the framework for changing mitigation requirements based on evaluation of monitoring data.
Michael Jasny, NRDC	NGO-E-10	0.33	Other impacts on commercially harvested fish include habitat abandonment	Impacts to commercial fisheries from acoustic sound sources is discussed in **Chapter 4.2.7.2.2** and additional supporting information is presented in **Appendix J**. As noted in the Programmatic EIS, several studies suggest that the spatial displacement of fishes is limited and that fishes move back into their preferred areas after cessation of seismic

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				survey activity (e.g., within a few minutes to several days). Some study results suggest that fishes do not respond to sounds that are not biologically produced. The studies referenced in this comment do not provide any data on reproductive performance nor do they support the suggestion that habitat abandonment is a likely impact of seismic surveys. Further, BOEM incorporated the report, "Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities" from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed fish species and fisheries of concern and the impacts on these resources from sound.
Michael Jasny, NRDC	NGO-E-10	0.34	Several studies indicate that airgun noise can kill or decrease the viability of fish eggs and larvae.[18]	BOEM incorporated the report, "Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities" from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed effects of sound on the viability of fish eggs and larvae. This subject is addressed in **Section 7.2** of **Appendix J**.
Michael Jasny, NRDC	NGO-E-10	0.35	The PDEIS' alternatives and mitigation analyses are incomplete and do not satisfy the regulatory standards.	BOEM believes that it has followed the regulatory standards for developing NEPA alternatives, which included to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." (Section 102 [42 U.S.C. § 4332]). The construction of our alternatives followed the simple premise that to be a valid alternative it would have to fulfill the purpose and need for the proposed action and be economically feasible and technically viable. The range of alternatives was developed based on the underlying purpose and need. Alternatives that did not meet the purpose and need were not carried forward for further analysis. In addition to alternatives carried forward for detailed analysis, a number of alternatives were considered, but not analyzed. These can be found in **Chapter 2.5**, and include a series of non-airgun acoustic source alternatives. A detailed explanation as to why each was not carried forward for analysis can be found in that section. See also our responses to comments NGO-E-1:0.36 through NGO-E-1:0.52.
Michael Jasny, NRDC	NGO-E-10	0.36	The DPEIS declines even to consider an alternative limiting the amount of activity that can be conducted in the Atlantic, or part of the Atlantic, over a given period. The DPEIS does not provide any reason for BOEM's lack of consideration of activity limits.	The concept of limiting survey activity on the OCS it is not necessarily a practical concept in both prelease and post-lease phases. First, before the DOI schedules a lease sale or opens an AOI for prelease G&G activity, geophysical contractors gauge the level of interest by potential clients and may set up a survey plan with specified parameters to license their data to more than one user. This business model tends to self-limit the number of surveys because a geophysical vendor is not going to go

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				through the effort to design, permit and authorize, and conduct a survey unless they know there is a reasonable expectation of making a return on their investment. Furthermore, the parameters for a seismic survey can be designed to address various purposes, all of which can't be known beforehand. No one survey, or scheme to parsimoniously meter survey opportunities, can serve all desired outcomes and to expect the industry to do so simply demonstrates a lack of understanding for how the data are used. At this early stage of activity, before leasing is even contemplated, there is no reason to request or require industry to self-limit the degree to which they may be interested in acquiring OCS leases. Second, the OCSLA established the basis for administering access to public lands. Parcels available for leasing are divided into blocks of approximately 9 mi^2 that are distributed in protraction areas of various size. Nine square miles is a comparatively fine parceling of the OCS compared to the partitioning of other country's OCS. With the OCS block as the fundamental post-lease business unit, leaseholders pursue their interests within these areas, part of which may require G&G surveying. In summary, in the current prelease phase it is premature to consider any sort of survey activity restriction, in this Programmatic EIS, because our awareness for what is out there is based on 30-year-old 2D seismic data that is by no means of a quality that is state-of-the-practice. Furthermore, BOEM believes that the mitigation measures in Alternative B provide adequate protections to the environment. Further and different measures may be considered at the site/project-specific level
Michael Jasny, NRDC	NGO-E-10	0.37	Determining the legally acceptable limits of activity is essential to NMFS' issuance of take authorizations in the Atlantic – which, presumably, would be that agency's purpose and need. Pursuant to NMFS' own general regulations, an incidental harassment authorization must be revoked if the authorized takings "individually or in combination with other authorizations" are having more than a negligible impact on the population or an unmitigable adverse impact on subsistence. Unfortunately, the DPEIS makes no attempt to assess whether the scope of activities it contemplates satisfies the negligible impact standard.	The Programmatic EIS presents an impact analysis within the NEPA framework and is not an application for an Incidental Harassment Authorization. As a cooperating agency, NMFS may use this Programmatic EIS to support site-specific permit requests under the MMPA. At that time, NMFS will determine if the activities meet the criteria for a permit, such as not having more than a negligible impact on the population or an unmitigable adverse impact on subsistence. **Chapter 5.7.3** has been revised to state that because Incidental Take under the ESA is only issued for ESA-listed marine mammals once the requirements of Section (101)(a)(5) of the MMPA have been met, seismic surveys that could affect ESA-listed marine mammals shall not commence until such time that FWS and/or NMFS have issued the appropriate MMPA ITA and coordinated its requirements with those in any existing or new ESA Incidental Take Statement. BOEM has noted that operators will be required to satisfy the requirements of all other agencies before a permit will be issued. Operators will be required to

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				abide by any mitigation requirements stated in this Programmatic EIS, in addition to those included in an issued MMPA ITA or ESA ITS.
Michael Jansy, NRDC	NGO-E-10	0.38	In the Arctic, instead of developing a suitable alternative for the EIS, the agencies proposed, in effect, to consider overall limits on activities when evaluating individual applications under OCSLA and the MMPA. It would, however, be much more difficult for NMFS or BOEM to undertake that kind of analysis in an individual IHA application or OCSLA exploration plan because the agencies often lack sufficient information to take an overarching view of the activities occurring that year. Determining limits at the outset would also presumably reduce uncertainty for industry. In short, excluding any consideration of activity limits from the alternatives analysis in this EIS frustrates the purpose of programmatic review, contrary to NEPA.	The purpose of a programmatic document isn't to limit activities, but "to focus on the actual issues ripe for decision at each level of environmental review." In looking at anticipated activities within the three program areas over the time period in question, this document does that. The activity levels defined in this document provide regulators with an overarching view of future years to be utilized in reviewing site-specific actions and related documents and permit applications that will tier under this Programmatic EIS. Also please see response to comment NGO-E-1:0.36.
Michael Jasny, NRDC	NGO-E-10	0.39	Failure to develop alternative based on eliminating duplicative survey effort. The DPEIS does not analyze this alternative "because its main benefit (a limit on concurrent surveys) is already addressed by Alternative B." DPEIS at 2-49. BOEM has obviously mischaracterized the effects and benefits of a consolidation measure. Consolidating surveys would reduce concurrence by the standards of BOEM's Alternative B only if the surveys in question happened to come within 40 km of one another while operating – a scenario that seems likely to represent a relatively small number of instances. On the contrary, the plain benefit of consolidation is to reduce the cumulative, not necessarily simultaneous, impacts of seismic activity on marine species. BOEM's stated rationale for not considering this alternative does not make sense.	**Chapter 2.5.5** has been revised to address the comment. We acknowledge that the geographic separation of concurrent surveys under Alternative B does not accomplish the same objective as the "consolidate and coordinate surveys" alternative. The reason for eliminating the latter alternative has been clarified in **Chapter 2.5.5**.
Michael Jasny, NRDC	NGO-E-10	0.40	BOEM avers that consolidating and coordinating surveys "does not clearly fall under the mandates of this Agency," or its sister agencies the Department of Energy and U.S. Geological Survey. DPEIS at 2-49. This argument seems similar to one advanced in the Arctic DPEIS, wherein the agencies suggested that BOEM could not adopt a data sharing measure, on the grounds that it cannot "require companies to share proprietary data, combine seismic programs, change lease terms, or prevent companies from acquiring data in the same geographic area." Yet this analysis overlooks BOEM's statutory duty under OCSLA to approve only those permits whose exploration activities are not "unduly harmful" to marine life. BOEM must consider an alternative that eliminates duplicative effort.	BOEM's duty under OCSLA Section 11(g)(3) to issue permits for G&G activities that are not "unduly harmful to aquatic life" does not provide a mandate to consolidate and coordinate G&G surveys as suggested in this comment. A consolidation and coordination alternative was considered but eliminated because (1) it would not meet industry's information needs and (2) BOEM believes it would be impractical at this time to require the coordination and consolidation of surveys. Additionally, it would not eliminate the need for site-specific surveys in support of individual projects. Please refer to **Chapter 2.5.5** for a full discussion of this alternative.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.41	The DPEIS, despite acknowledging the potential for alternative technology to reduce potential impacts on marine wildlife, has failed to develop and consider any alternatives for the development and implementation of that technology. DPEIS at 2-54. The draft EIS instead relies on out-of-date information in characterizing the availability of certain technologies. For example, marine vibroseis – which has the potential to reduce peak sound levels by 30 decibels or more and virtually eliminate output above 100 Hz – is on the verge of commercial availability, with useable arrays produced by Geo-Kinetics and PGS now being tested for their environmental impacts on fish, and other models in development through the Canadian government and a Joint Industry Program.[34] Yet the DPEIS uses a 2010 personal communication with PGS for the proposition that a commercial electric vibroseis array is not “available for data collection at this time” (DPEIS at 2-50) – an outdated observation that does not reflect current fact. Nor does the DPEIS consider the specific airgun modifications discussed in Weilgart (2010). See DPEIS at 2-53.	We have updated the discussion of non-airgun alternatives in **Chapter 2.5.6** and **Appendix C**, **Section 6.0**. The Geo-Kinetics marine vibrator is currently in the R&D stages, is scheduled to be field tested, and still currently not available for commercial use and therefore, is not a replacement for surveys using airguns. BOEM recently sponsored a workshop on “Quieting Technologies for Reducing Noise during Seismic Surveying and Pile Driving” (February 25-27, 2013, in Silver Spring, Maryland), and we will continue to work cooperatively to evaluate the development of new and alternative technologies. The construction of our alternatives followed the simple premise that to be a valid alternative it would have to be economically feasible, technically viable, and fulfill the purpose and need for the proposed action. We found that we could not fashion a NEPA alternative based on one or many of alternative acoustic sources to impulse seismic air guns that are described in **Appendix C**, **Section 6** because none of them were economically feasible or technically viable for commercial deployment; all of them being in various stages of development. That conclusion has been reevaluated and verified for the Final Programmatic EIS (see **Chapter 2.5.6.8**).
Michael Jasny, NRDC	NGO-E-10	0.42	Critically, the DPEIS fails to include any actionable alternatives to require, incentivize, or test the use of new technologies in the Atlantic, or indeed in any other region. Such alternatives include: (1) mandating the use of marine vibroseis or other technologies in pilot areas, with an obligation to accrue data on environmental impacts; (2) creating an adaptive process by which marine vibroseis or other technologies can be required as they become available; (3) deferring the permitting of surveys in particular areas or for particular applications where effective mitigative technologies, such as marine vibroseis, could reasonably be expected to become available within the life of the EIS; (4) providing incentives for use of these technologies as was done for passive acoustic monitoring systems in NTL 2007-G02; and (5) exacting funds from applicants to support accelerated mitigation research in this area. The final EIS must consider these alternatives.	**Chapter 2.5** of the Programmatic EIS, Alternatives Considered but not Analyzed, addresses the concerns regarding vibroseis and other types of survey equipment in development. That section contains a discussion as to why those potential alternatives were not carried forward for analysis. We have revised and updated the discussion of non-airgun alternatives in **Chapter 2.5.6** and **Appendix C**, **Section 6**. We have also added a discussion of Adaptive Management in **Chapter 1.7.6** and **Appendix C**, **Section 7**. BOEM does seek to promote the development and implementation of alternatives to the impulse airgun. We evaluated a non airgun alternative in **Chapter 2.5.6.8**, and found that it would not meet the Agency’s purpose and need because none of the non airgun alternatives currently are economically feasible or technically viable for commercial deployment; all of them being in various stages of development. That conclusion has been reevaluated and verified for the Final Programmatic EIS. We do seek an orderly transition by industry toward alternatives to the impulse airgun and permitting incentives are worthy of consideration. Incentives may take the form of selective lifting of certain mitigation measures in the seismic protocol, or operating in an area or at a time that airguns are not permitted. The ability of BOEM to compel an applicant to deploy a specific technology they may not consider as adequate to their purpose has not been tested.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.43	Time and place restrictions designed to protect high-value habitat are one of the most effective means to reduce the potential impacts of noise and disturbance, including noise from oil and gas exploration. However, the PDEIS, while identifying two possible time-area closures for North Atlantic right whales and one possible closure for sea turtles, does not consider any other areas for any other species.	Time-area closures are not the only mechanism to protect sensitive resources. Time-area closures were determined to be the most effective mitigation to avoid certain significant impacts identified through the impact evaluation. These included impacts to NARWs in their critical habitat during the calving/nursing season, their SMAs, and DMAs and impacts to sea turtles offshore Brevard County, Florida during sea turtle nesting season. Other species and resources were considered in the impact analysis, but given the expected limited impacts as evaluated in **Chapter 4.0**, closures beyond those in Alternatives A and B were not reasonable. However, other mitigation measures were developed to protect other resources. For example, **Chapter 2.1.2.3.2** addresses the measures that BOEM would take to avoid impacts to sensitive seafloor resources. We also note that activities near certain areas such as National Marine Sanctuaries and Habitat Areas of Particular Concern would be addressed through the consultation process for individual survey applications.
Michael Jasny, NRDC	NGO-E-10	0.44	The PDEIS does not give any consideration to year-round area closures, for reasons that are unclear.	There are several reasons why year-round closures were not considered: the proposed time-area closures are designed to address certain species that use defined areas for specific periods of the year; also, year-round closures would significantly reduce access of the renewable energy and marine minerals programs to relevant portions of the Area of Interest.
Michael Jasny, NRDC	NGO-E-10	0.45	Recommends increasing the Atlantic Right Whale closure area from 20 nm to 30 nm coastal exclusion (which is being considered by NMFS). However, this 30 nm exclusion zone does not include a buffer zone as the DPEIS suggests (DPEIS at 4-213), but reflects the extent of the right whale migratory corridor itself. Regardless of their status as critical habitat, this additional areas should be avoided, and added to the DPEIS' alternatives analysis as an extension to the 20 nm coastal time-area closure of Alternative B.	BOEM considered expansion of the time-area closures but will keep the 20 nmi time-area closure as proposed in the draft. BOEM's resource evaluation staff in their 2011 Atlantic OCS Resource Assessment (USDOI, BOEM, 2012) projected geological play types that would benefit by expansive 2D or 3D seismic surveys along the North Carolina coastal area. Such surveys tend to require long periods at sea to complete and a time-area closure beyond 20 nmi imposes a restriction on access to potential resource area that is not justified on the basis of available information, in as much as the 20 nmi zone outward from shoreline and the seasons to which it applied was recognized in NOAA's Right Whale Ship Strike Reduction Rule (50 CFR § 224.105). We believe that a 20-nmi (37 km; 23-mi) time-area closure provides a credible protective measure for NARWs and other marine mammal species transiting through to critical habitats at either end of their north-south seasonal migration. BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat, SMAs, or DMAs. PSO and visual observers are required on all vessels year-round. Including these requirements will further protect NARWs and decrease the potential for greater impacts to the species.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.46	For Alternatives A and B (see DPEIS at 2-4), a seasonal exclusion for right whales should also apply to HRG surveys, including for renewables. We would support allowing some small amount of sub-bottom profiling activity to occur during the winter exclusion period provided (1) that the operators have conscientiously planned to complete their HRG surveys outside the seasonal exclusion months, (2) that their inability to complete the surveys is due to unforeseen circumstances, and (3) that permitting some small amount of HRG activity to occur during the winter months would allow them to avoid extending their survey effort into the following calendar year. That said, given the conservation status of this species, we recommend extension of the right whale time-area closure to HRG activity.	The consultation process with NMFS and issuance of a Final BO has provided clarification and revision to previously proposed HRG Survey Protocol (see **Appendix C**). The Preferred Alternative includes mitigation measures to reduce and avoid impacts to a variety of biological resources, with an emphasis on reducing acoustic impacts to marine mammals and sea turtles. Under the expanded time-area closure in the Preferred Alternative, no seismic surveys using airguns would be authorized within the NARW critical habitat from November 15 through April 15, DMAs, the Mid Atlantic and Southeast U.S. SMAs, and the North expanded closure area from November 1 to April 30 and in the South expanded closure area from November 15 to April 15. Time-Area Closures would generally not be applied to G&G activities using HRG devices which do not use airguns sources. In most cases, the HRG sound sources for operational and monitoring surveys for the Marine Minerals Program and the Renewable Energy Program are conducted with devices utilizing sound sources which are above the hearing range of NARW. The devices could also operate with acoustic sound sources that would be within the hearing range of low-, mid-, and high-frequency cetaceans and could cause a behavioral response but would not likely cause physiological injury. HRG Operational and Monitoring surveys could be authorized within NARW critical habitat and SMAs year round including the time period when these areas are closed to airgun surveys. See **Appendix A** for additional detail.
Michael Jasny, NRDC	NGO-E-10	0.47	BOEM must consider excluding The Cape Hatteras Special Research Area from proposed surveys.	BOEM recognizes the commenter's concern about the unique biological area. Currently, the designation of the CSHRA does not include restrictions on other activities including navigation through the area. Site-specific reviews will evaluate any proposed activities in this area.
Michael Jasny, NRDC	NGO-E-10	0.48	BOEM has not attempted any systematic analysis of marine mammal habitat for purposes of establishing time-area closures within the area of interest. Indeed, given the importance of time-area closures in mitigating acoustic impacts, such an analysis (and the gathering of any needed data in support of that analysis) is essential to a reasoned choice among alternatives.	The analysis contained in this Programmatic EIS is adequate in that it reflects a complete assessment of the resources within the Area of Interest, the status and treatment those resources receive from other agencies, and the potential impacts to those resources. Therefore, the alternatives developed from this analysis reflect a reasoned choice among alternatives and incorporate the importance and value of time-area closures in mitigating impacts to affected resources.
Michael Jasny, NRDC	NGO-E-10	0.49	Over the past few years, researchers have developed at least two predictive models to characterize densities of marine mammals in the area of interest: the NODE model produced by the Naval Facilities Engineering Command Atlantic, and the Duke Marine Lab model. Indeed, the Navy employed the NODE model in developing three habitat-based alternatives, in	The U.S. Navy's Operating Area Density Estimates (NODE) data are currently the best available data for estimating marine mammal densities in the Mid/South Atlantic Planning Areas. BOEM has used these data within the analyses contained within this Programmatic EIS. The data are also used as part of the marine mammal take estimations via the Acoustic Integration Model (AIM©).

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			its own programmatic EIS, for sonar training off the U.S. east coast from 2009 to 2014. Further, NOAA has convened a Cetacean Density and Distribution Mapping Group with the purpose of evaluating, compiling, supplementing, and enhancing available density information for marine mammals within the U.S. EEZ. Its product, which includes habitat-based density maps and other data for nearly all of BOEM's area of interest, broken down by species and month, was shared in late May at an expert workshop that was partly funded by BOEM, and is slated for public release in early July. BOEM must use these sources, which represent best available science and, indeed, have partly been used in prior Navy NEPA analyses and rulemakings, to identify important marine mammal habitat and develop reasonable alternatives to the proposed action. Species of particular importance, aside from the North Atlantic right whale, include the five other large whale species listed under the Endangered Species Act, i.e., blue, fin, sei, humpback, and sperm whales; and beaked whales and harbor porpoises, whose vulnerability to anthropogenic noise is well recognized. Marine mammal densities are correlated over medium to large scales with persistent ocean features, such as ocean currents, productivity, and surface temperature, as well as with concentrations in other marine species, such as other apex predators and fish. The occurrence of these features is often predictable enough to define core areas of biological importance on a year-round or seasonal basis. In the area of interest, the most important of these features is the Gulf Stream; warm-core rings that develop off the Gulf Stream are likely to provide particularly important habitat for beaked whales, which are considered especially sensitive and vulnerable to anthropogenic sound. Analysis of these features should figure in predictive mapping, but can be used to supplement maps that do not take dynamic features into account.	BOEM does agree and recognize that there are data gaps in marine mammal density information for these areas. We have adjusted the Programmatic EIS text accordingly and revised **Appendix E** to better explain any limitations to the density inputs used in the AIM©. To help improve density information, BOEM has partnered with the NOAA and other organizations to fund projects to improve biological information on protected species in the U.S. Atlantic. Two notable programs include the following: • Atlantic Marine Assessment Program for Protected Species (AMAPPS) – This is an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters. The project will also collect similar data at finer scales at several sites of particular interest to NMFS and BOEM. Importantly, AMAPPS also seeks to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics (see http://www.nefsc.noaa.gov/read/protspp/mainpage/ AMAPPS/ index.html and http://boem.gov/uploadedFiles/BOEM/ Environmental_ Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_ Studies/AT-10-x11.pdf). • BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre, an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/ Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). Ultimately, NEPA requires that Federal agencies use the best available information in environmental impact statements, which BOEM has done. BOEM will continue to monitor the results of AMAPPS and other relevant studies (i.e., NOAA Sound and Cetacean Density Mapping) to ensure any updated data are considered as they become available to support future, site/permit-specific evaluations of individual survey applications.
Michael Jasny, NRDC	NGO-E-10	0.50	BOEM should extend its proposed Brevard County exclusion to coastal areas from Florida up through North Carolina during the sea turtle nesting season, from May 1 through October 31; should identify and exclude important foraging and migrating habitat outside the nesting areas; and should establish time-area closures for all loggerhead critical habitat, which NMFS is	As noted in **Chapter 2.2.2.2**, 25 percent of all loggerhead nesting in the U.S. occurs in the Archie Carr NWR. This is why this area was included in Alternative B for additional closures for airgun surveys. Annual numbers of loggerhead nests for all counties north of Brevard County are 1-3 orders of magnitude lower and at this time do not warrant time-area closures. Closure of the entire coastal areas through North Carolina for

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			required to designate, under the Endangered Species Act, by September 2012.	sea turtles along with the closures for right whales, would preclude airgun survey activities for most of the year except for two, 2-week periods in this nearshore area. As discussed in **Chapter 4.2.3.2.2**, subbottom profilers, sonars, and depth sounders are largely beyond the functional hearing range of sea turtles and are expected to have negligible effects. These non-airgun HRG surveys are expected to be the types of surveys most likely to be performed in the near shore areas rather than the airgun surveys. NMFS has not designated critical habitat for the loggerhead turtle at the time of the Final Programmatic EIS. Both NMFS and FWS will be included in the reviews related to site-specific surveys, and any concerns raised will be addressed on a site-specific basis.
Michael Jasny, NRDC	NGO-E-10	0.51	The Final PEIS must consider alternatives that exclude key fish habitat and fisheries from the proposed action. These areas include: Charleston Bump and gyre complex; The Point (also known as Hatteras Corner); Ten Fathom Ledge and Big Rock; Submarine canyons and canyon heads; Areas designated as Habitat Areas of Particular Concern ("HAPCs") by the Mid-Atlantic or South Atlantic Fishery Management Councils; South Atlantic Deepwater MPAs; Gray's Reef National Marine Sanctuary; and Areas known to be inhabited by and/or proposed as critical habitat for Atlantic sturgeon.	We do not believe that an alternative or closure for fish habitat and fisheries is warranted based on the low level of impacts identified in **Chapter 4.0**. This Agency's site-specific evaluations ensure that proposed activities do not set down on sensitive biologic communities by conducting bottom surveys, which could include photography, to screen areas where equipment or discharges may contact the bottom. There is no practical way to avoid a degree of ensonification of the water column across the substantial areas identified in this comment and in **Figure 4-4** of this Final Programmatic EIS as HAPCs and still collect the data that is necessary to meet the proposed action's purpose and need. We also will mitigate these areas, as required by consultations, as EFH or protected habitats. In the Programmatic EIS **Figure 4-2** shows seafloor features, **Figure 4-4** the HAPCs, and **Figure 4-33** the NMS. It is anticipated that NTLs in the Atlantic would be created with similar protective elements as in those existing for the GOMR. See NTL 2009-G39 and NTL 2009-G40 (http://www.boem.gov/uploadedFiles/BOEM/Regulations/Notices_To_Lessees/2009/09-G39.pdf and http://www.boem.gov/uploadedFiles/BOEM/Regulations/Notices_To_Lessees/2009/09-G40.pdf).
Michael Jasny, NRDC	NGO-E-10	0.52	BOEM must analyze an alternative that would require any entity carrying out the proposed activities to identify aggregations of forage species and prohibit operations within the vicinity of such aggregations that might disturb them. Similarly, BOEM must analyze an alternative that would prohibit the proposed activities from being carried out in the vicinity of spawning aggregations of grouper and snapper species, as well as concentrations of Sargassum, which provides vital nursery habitat to numerous species in Atlantic shelf waters and the Gulf Stream.	The alternatives identified in this Programmatic EIS are based on technical feasibility and economic viability, which would be our definition of "reasonable," which are conditions that are evident in the proposed alternatives. The prospect of applying mitigations based on commercially important fish species was entertained, but not found to be actionable. Comments on the Programmatic EIS also did not surface actionable mitigations for any commercially important fish species or Essential Fish Habitat (EFH). As part of the site-specific permitting, BOEM would coordinate with NOAA NMFS through the EFH Consultation process to address fishery and habitat concerns. **Chapter**

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				5.7.4 provides this information about EFH consultation. Briefly, on June 1, 2012, NMFS determined BOEM's request for Programmatic EFH Consultation was not an appropriate mechanism to evaluate EFH impacts of BOEM G&G activities in the Atlantic OCS based on information available at the time. In response, BOEM has proposed each activity that occurs under this proposed action would receive an environmental review including an EFH assessment from BOEM.
Michael Jasny, NRDC	NGO-E-10	0.53	BOEM should consider establishing a cumulative exposure metric for temporary threshold shift in addition to the present RMS metric, as suggested by Southall et al. (2007).	The comment is appreciated but BOEM must use the threshold criteria provided by NMFS. NOAA has expressed the intention to release new acoustic impact criteria. BOEM will evaluate the implications for BOEM's permitting responsibility, participate in the public vetting that would accompany new criteria, and observe or participate in the peer review assembled to evaluate them.
Michael Jasny, NRDC	NGO-E-10	0.54	The DPEIS cites to the applicable Council of Environmental Quality ("CEQ") regulation and maintains that it identifies those areas where information is unavailable to support a thorough evaluation of the environmental consequences of the alternatives. See DPEIS at 4-6. In fact, however, the document evades the analysis that § 1502.22 requires. In the first place, it fails to identify certain obvious gaps in information – such as important habitat areas for marine mammals – essential to a reasoned choice among alternatives. Beyond this, its modus operandi is to acknowledge major information gaps on virtually every topic under analysis, then insist – without any specific findings about their significance for the agencies' decision making – that BOEM agency has an adequate basis for proceeding. See, e.g., PDEIS at 4-46 (masking in marine mammals), 4-47 to 4-49 (stress and behavioral impacts in marine mammals), 4-79 (behavioral impacts on sea turtles). This approach simply does not satisfy NEPA.	The incomplete and unavailable information guidelines found in the CEQ regulations are intended to provide guidance for agencies evaluating reasonably foreseeable significant adverse effects. The Draft and Final Programmatic EIS have thoroughly examined the existing credible scientific evidence that is relevant to evaluating the reasonably foreseeable significant adverse impacts of G&G proposed activities on the physical, biological, and human environments. The subject-matter experts that prepared this EIS conducted a diligent search for pertinent information, and BOEM's evaluation of such impacts is based upon current theoretical approaches or research methods generally accepted in the scientific community. All reasonably foreseeable impacts were considered, including impacts that could have catastrophic consequences, even if their probability of occurrence is low. Throughout **Chapter 4.0**, where information was incomplete or unavailable, BOEM complied with its obligations under NEPA to determine if the information was relevant to reasonably foreseeable significant adverse impacts; if so, whether it was essential to a reasoned choice among alternatives; and, if it is essential, whether it can be obtained and whether the cost of obtaining the information is exorbitant, as well as whether generally accepted scientific methodologies can be applied in its place (40 CFR § 1502.22).
Michael Jasny, NRDC	NGO-E-10	0.55	Agencies have an obligation pursuant to NEPA "to ensure that data exists *before approval*" so that decision makers can "understand the adverse environmental effect *ab initio*." BOEM has not done so here.	This Programmatic EIS is not a decision-making document, but an analysis to aid in the decision-making process. The Programmatic EIS has utilized all available information in its analysis, where information has not been available that has been noted. BOEM is confident the information upon which the analysis is based is sufficient to allow an informed decision, in accordance with NEPA. As a programmatic document this EIS serves as an overview of G&G surveys for the three

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Name, Organization	ID	No.	Comment	Response
				program areas. Individual projects will receive additional analysis under NEPA and will require permit approvals as applicable to the site-specific activity.
Michael Jasny, NRDC	NGO-E-10	0.56	The DPEIS has vastly underestimated marine mammal take from the proposed activity. The reasons for this are manifold, but lie principally in the agency's mistaken adoption of a 160 dB threshold for Level B take and its failure to calculate impacts from masking. Nor has BOEM performed a sensitivity analysis to determine how significantly its take and impact estimates would differ if some of its core assumptions – such as its 160 dB threshold – are wrong.	BOEM has utilized the thresholds provided by NMFS, and until the established thresholds are changed, BOEM must follow existing thresholds. BOEM recognizes that literature suggests that there is a need for a change to the standard and that a new standard may be provided. When it is provided, BOEM will be responsive to those changes at that time and each individual survey would utilize the new thresholds. Until then, we must use the existing thresholds. BOEM also utilized acoustic propagation and marine mammal take modeling to estimate the number of marine mammals that may be harassed by the noise. These models utilize the best scientific data available, including propagation loss equations, physical oceanographic properties of the Atlantic OCS, and the most current marine mammal density data available at the time of the modeling to calculate these estimates.
Michael Jasny, NRDC	NGO-E-10	0.57	The DPEIS uses a single sound pressure level (160 dB re 1 μPa (RMS)) as a threshold for behavioral, sublethal take in all marine mammal species from seismic airguns. This approach simply does not reflect the best available science, and the choice of threshold is not sufficiently conservative in several important respects. BOEM must use a more conservative threshold for the following reasons: (a) The method represents a major step backward from recent programmatic authorizations. For Navy sonar activity, NMFS has used a combination of specific bright-line thresholds (for harbor porpoises) and linear risk functions that endeavor to take account of risk and individual variability and to reflect the potential for take at relatively low levels. (b) The 160 dB threshold is non-conservative, since the scientific literature establishes that behavioral disruption can occur at substantially lower received levels for some species. (c) The use of a multi-pulse standard for behavior harassment is non-conservative, since it does not take into account the spreading of seismic pulses over time beyond a certain distance from the array. (d) The threshold's basis in the root mean square ("RMS") of sound pressure, rather than in peak pressure, is non-conservative.	BOEM has utilized the thresholds provided by NMFS. The Programmatic EIS is using these NMFS thresholds while discussing the Southall criteria as a way of comparison in the document. BOEM recognizes that literature suggests that there is a need for a change to the standard and that a new standard may be provided. When it is provided, BOEM will be responsive to those changes at that time and each individual survey would utilize the new thresholds. Until then, we must use the existing thresholds.
Michael Jasny, NRDC	NGO-E-10	0.58	NMFS must revise the thresholds and methodology used to estimate take from airgun use. Specifically, we urge the following: (a) NMFS should employ a combination of specific	BOEM has utilized the thresholds provided by NMFS. The Programmatic EIS is using these NMFS thresholds while discussing the Southall (2007) criteria as a way of comparison in the document. BOEM

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Name, Organization	ID	No.	Comment	Response
			thresholds for which sufficient species-specific data are available and generalized thresholds for all other species. (b) Data on species for which specific thresholds are developed should be included in deriving generalized thresholds for species for which less data are available. (c) In deriving its take thresholds, NMFS should treat airgun arrays as a mixed acoustic type, behaving as a multi-pulse source closer to the array and, in effect, as a continuous noise source further from the array, per the findings of the 2011 Open Water Panel. (d) Behavioral take thresholds for the impulsive component of airgun noise should be based on peak pressure rather than on RMS, or dual criteria based on both peak pressure and RMS should be used. Alternatively, BOEM should use the most biologically conservative method of calculating RMS.	recognizes that literature suggests that there is a need for a change to the standard and that a new standard may be provided. When it is provided, BOEM will be responsive to those changes at that time and each individual survey would utilize the new thresholds. Until then, we must use the existing thresholds. BOEM also utilized acoustic propagation and marine mammal take modeling to estimate the number of marine mammals that may be harassed by the noise. These models utilize the best scientific data, including propagation loss equations, physical oceanographic properties of the Atlantic OCS, and the most current marine mammal density data available at the time of the modeling to calculate these estimates. If new methodology is later determined, BOEM and NMFS may utilize the new methodology, as well as new data, for sound source modeling and take modeling for individual, site-specific analyses.
Michael Jasny, NRDC	NGO-E-10	0.59	The DPEIS fails to consider masking effects, either from continuous noise sources such as ships or from mixed impulsive/continuous noise sources such as airguns. Accordingly, BOEM must evaluate the loss of communication space – and consider the extent of acoustic propagation – at far lower received levels than the DPEIS currently employs.	Masking effects are included (see **Chapter 4.2.2.2.1**, **Chapter 4.2.2.2.2**, and **Appendix H**). Text has been added to **Chapter 4.2.2.2.2** to address this issue.
Michael Jasny, NRDC	NGO-E-10	0.60	The DPEIS appears to estimate cases of temporary threshold shift, or hearing loss, in two ways: by using the original NMFS threshold of 180 dB (SPL), and by applying the hybridized standards set forth in Southall et al. (2007) for different marine mammal functional hearing groups.[132] Unfortunately, BOEM's particular use of Southall et al. (2007) neglects the modifications that have since been made to these standards, by Dr. Southall and the U.S. Navy, in light of new scientific information. First, BOEM must modify its standard for high-frequency cetaceans to account for new threshold shift data on harbor porpoises. The new data show that harbor porpoises experience threshold shift on exposure to airgun signals at substantially lower levels than the two mid-frequency cetaceans (bottlenose dolphins and beluga whales) on which the Southall et al. acoustic criteria were based. Given similarities between the harbor porpoise ear and that of other high-frequency cetaceans, both the U.S. Navy – in its recent DEISs for the Atlantic Fleet and the Southern California and Hawaii Range Complexes, and in a related technical report prepared by SPAWAR – and Dr. Southall and colleagues from St. Andrew's University, in their Environmental Impact Report for	While take estimate numbers based on the Southall approach are included in the document, all assessments of impact are based on the criteria established by NMFS which specifies that marine mammals exposed to pulsed sounds with received levels exceeding 180 or 190 dB re 1 μPa (rms) for cetaceans and pinnipeds, respectively, are considered to exceed Level A (Injury) levels; cetaceans and pinnipeds exposed to levels exceeding 160 dB re 1 μPa (rms) are considered to exceed Level B (Behavioral Harassment) criteria. BOEM also utilized acoustic propagation and marine mammal take modeling to estimate the number of marine mammals that may be harassed by the noise. These models utilize the best scientific data, including propagation loss equations, physical oceanographic properties of the Atlantic OCS, and the most current marine mammal density data available at the time of the modeling to calculate these estimates. If new methodology is later developed, BOEM and NMFS may utilize the new methodology, as well as new data, for sound source modeling and take modeling for individual, site-specific analyses.

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Name, Organization	ID	No.	Comment	Response
			a seismic survey off the central California coast, have significantly reduced the temporary and permanent threshold shift criteria for all high-frequency cetaceans. BOEM must do the same. Second, and similarly, BOEM must modify its Southall et al. standard for low-frequency cetaceans: the baleen whales. New data from SPAWAR indicates that mid-frequency cetaceans have greater sensitivity to sounds within their best hearing range than was supposed at the time Southall et al. was published.[135] It is both conservative and consistent with the methodology of that earlier paper to assume that low-frequency cetaceans, which have never been studied for threshold shift, also have greater sensitivity to sounds within their own best hearing range. For this reason and others, Dr. Southall and his St. Andrew's colleagues reduced the threshold shift criteria for baleen whales exposed to airgun noise, in the report they recently produced for the California State Lands Commission. Again, BOEM should do the same. Hearing loss remains a very significant risk where, as here, the agency has not required aerial or passive acoustic monitoring as standard mitigation, appears unwilling to restrict operations in low-visibility conditions, has set safety zone bounds that are inadequate to protect high frequency cetaceans, and has not firmly established seasonal exclusion areas for biologically important habitat. BOEM should take a conservative approach and apply the more precautionary standard, once the necessary modifications to Southall et al. (2007) have been made.	
Michael Jasny, NRDC	NGO-E-10	0.61	BOEM has also failed to set appropriate take thresholds for sub-bottom profilers and other active acoustic sources. As NMFS's Open Water Panel has indicated, some sub-bottom profilers used in Arctic oil and gas surveys have source levels and frequency ranges approaching that of certain active military sonar systems, with shorter intervals between pings.[138] Indeed, the chirp systems analyzed in the DPEIS (DPEIS at D-28) have threshold source levels close to that of the Navy's SQS-56 midfrequency, hull-mounted sonar.[139] Additionally, these levels vastly exceed those analyzed for similar chirp systems used in HRG surveys for renewables, according to BOEM's recent programmatic EA for mid-Atlantic offshore wind.[140] BOEM's use of a 160 dB threshold under these circumstances is inappropriate. While we do not recommend	NMFS is the agency responsible for setting all marine mammal take thresholds under MMPA. The ability to formulate species-specific or species-group acoustic criteria appears to be in the near future and BOEM will incorporate and apply any new criteria during individual, site-specific analyses. As a practical matter the exclusion zones established as a condition for approval for permitted seismic activities will be based on some combination of modeled source influence.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			the application of the Navy's generalized risk functions for mid-frequency sonar, enough data are available for some taxa to indicate species-specific thresholds. For purposes of authorizing mid-frequency sonar training, NMFS assumes that harbor porpoises are taken at received levels above 120 dB (RMS); and the Navy has adopted a 140 dB (RMS) threshold for beaked whales based on the findings of Tyack et al. (2011). At minimum, BOEM should adopt these specific thresholds for the midfrequency acoustic sources considered in the DPEIS. Furthermore, while the DPEIS does not provide ping intervals for sub-bottom profilers, the EA suggests that these sources may sound several times each second.	
Michael Jasny, NRDC	NGO-E-10	0.62	The DPEIS posits 230 dB (RMS) as a representative source level for purposes of modeling takes from large airgun arrays and 210 dB (RMS) for modeling takes from small arrays. DPEIS at 3- 26. We see two significant issues with these assumptions. First, as with behavioral risk thresholds, using the root mean square ("RMS") rather than peak pressure to estimate source levels for airguns is non-conservative and may not be biologically appropriate. We recommend that BOEM use peak-pressure, or dual criteria of peak-pressure and RMS, to determine behavioral take for the impulsive component of the airgun source. Alternatively – and at the very least – BOEM should use the most biologically conservative method of determining RMS. Second, it is not self-evident that using a single representative or average source level for large or small arrays is a reasonable and sufficiently conservative approach to BOEM's take analysis. BOEM should conduct a sensitivity analysis to ensure that any representative source level, or levels, chosen for modeling do not negatively bias the analysis towards an undercount of take. If there is negative bias, the agency should modify the source level, or levels, and either rerun the model or use a conservative corrective factor to estimate take.	The difference between peak sound pressure and root-mean-square (rms) sound pressure are noted in **Appendix E**. Use of rms source levels is specified by NMFS as the agency responsible for setting take thresholds under MMPA. The Programmatic EIS uses representative equipment and source levels because it is a programmatic analysis. Individual equipment may differ, and BOEM has stated that any issued BOEM approval for G&G activities will be conditional on the operator obtaining any necessary MMPA authorization prior to commencing G&G activities. NMFS would evaluate those applications with respect to the MMPA legal and regulatory requirements at that time. **Appendix E** has been revised to provide additional information about factors influencing the accuracy of incidental take calculations.
Michael Jasny, NRDC	NGO-E-10	0.63	While the DPEIS proposes two time-areas closures to reduce impacts on right whales, these measures are inadequate to address the impacts described here, for reasons discussed earlier in these comments. Nor does the DPEIS provide any quantitative or even detailed qualitative analysis of masking effects or other cumulative, sub-lethal impacts on right whales. BOEM has again violated NEPA.	BOEM believes the time-area closures are reasonable and we have consulted with NMFS under the ESA to ensure that the proposed action would not jeopardize the continued existence of the NARW or destroy or adversely modify critical habitat (see **Appendix A**). **Chapters 3.6.11** and **4.2.2.2** have been revised to better address the issue of cumulative impacts, including masking.

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Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.64	While the DPEIS acknowledges the potential for injury, and indeed allows that some marine mammals will undergo permanent threshold shift as a result of the activity, it improperly dismisses the risk of mortality and serious injury from acoustic impacts. First, the DPEIS fails entirely to consider the adverse synergistic effect that at least some types of anthropogenic noise can have on ship-strike risk. Second, as noted above (and contrary to representations in the DPEIS), a number of recent studies indicate that anthropogenic sound can induce permanent threshold shift at lower levels than anticipated. Third, the DPEIS wrongly discounts the potential for marine mammal strandings, even though at least one stranding event, the September 2002 stranding of beaked whales in the Gulf of California, is tightly correlated with geophysical survey activity; and even though high-intensity sounds in general have long been used by drive fisheries to force marine mammals ashore. Fourth, and finally, as noted above, the DPEIS makes no attempt to assess the long-term effects of chronic noise and noise-related stress on life expectancy, survival, and recruitment although proxies are available from the literature on terrestrial mammals and other sources. The DPEIS must be revised conservatively to account for potential mortality of marine mammals in the short- and long-term.	Ship-strikes are considered in **Chapter 4.2.2.4**, which states that it is expected to be negligible due to the slow nature of survey vessels and following the monitoring and mitigation guidelines set by BOEM and NMFS. Language has been added to this section to discuss the effects of acoustics and the potential to increase ship strike incidents. BOEM believes awareness and vigilance is the best mitigation to acoustic impacts and ship strikes. All authorizations for shipboard surveys, regardless of vessel size would include guidance for vessel strike avoidance. The guidance would be similar to NTL 2012-JOINT-G01 (“Vessel Strike Avoidance and Injured/Dead Protected Species Reporting”) (USDOI, BOEM and BSEE, 2012b), which incorporates NMFS “Vessel Strike Avoidance Measures and Reporting for Mariners” addressing protected species identification, vessel strike avoidance, and injured/dead protected species reporting. As described in **Chapter 2.1.2.1.1** vessel speeds within Critical Habitat from November 15 to April 15 and SMAs and DMAs from November 1 to April 30 will be required to operate within the 10 kn (18.5 km/h) speed restrictions. In addition, year-round vessel strike avoidance and crew members, visual observers/PSOs are required to maintain watch during transit to avoid striking marine mammals and sea turtles. BOEM further incorporates discussions of anthropogenic sound and permanent threshold shift (PTS) and other effects into it into future, site-specific analyses. BOEM and NMFS appreciate the recommendation to utilize the literature regarding chronic noise and noise-related stress and will consider it in future analyses. Regarding the stranding event in September 2002 of beaked whales in the Gulf of California, the report prepared by Dr. Roger L. Gentry (NMFS Office of Protected Resources) titled: Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000 (Report Prepared: November 4, 2002), stated the necropsy report is inconclusive. In summary the report denotes, it did not find trauma of the type that is typically associated with acoustic sources (hemorrhage in acoustic fats, around the eyes or ear bones, see USDOC, NMFS and U.S. Dept. of the Navy; 2001). On the other hand, it did not examine the brain, which sometimes shows hemorrhages when animals have been exposed to intense sound fields. Therefore, the necropsy report can neither confirm nor deny acoustic injury. It is not feasible that the sound field from the R/V *Maurice Ewing* affected animals that were resident near the stranding site. Since spreading loss causes the intensity of a sound to drop by a factor of 4 with each doubling of distance from the source, the level at more than 200 nmi would have been well below the levels known to cause tissue

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				damage in laboratory animals. There is no mechanism presently known by which beaked whales could have been affected by an acoustic source at such a distance. It is possible that these beaked whales were exposed close to the ship and swam to the stranding site thereafter. Field measurements show that healthy marine mammals can swim at 3 m (10 ft) per second and thereby could cover 270 nmi (500 km; 311 mi) in 48 hours. Whether animals that have been disoriented or injured by an airgun array could have done so is not known. *Conclusions* It is not possible to conclude whether the R/V *Maurice Ewing* was involved in this stranding. Cause and effect can only be determined from necropsy results which, in this case, were inconclusive. Correlation does not substitute for cause and effect, but it can indicate whether certain causes are feasible. In this case, the stranding and the seismic survey were correlated in time, but not in space. There is no obvious mechanism that bridges the distance between this source and the stranding site. Therefore, the cause remains indeterminate.
Michael Jasny, NRDC	NGO-E-10	0.65	The document makes no attempt to analyze the cumulative and synergistic effects of masking, energetic costs, stress, hearing loss, or any of the other impact mechanisms identified over the last several years, whether for its own action alternatives or for the combined set of activities it identifies in its "cumulative impact scenario." This bare-bones approach disregards available information and analytical methodologies that are clearly relevant to an analysis of reasonably foreseeable impacts. 40 C.F.R. § 1502.22. Available information includes Qualitative or detailed qualitative assessment; Models of masking effects; Energetics; Chronic noise; Stress; and Impacts from other sources. The DPEIS' summary conclusions to the contrary are made without support, and without even attempting to address data gaps through methods accepted within the scientific community.	See additional text in **Chapters 3.6.11** and **4.2.2.2** to address this issue. Additional site-specific analyses will include more detailed cumulative analyses.
Michael Jasny, NRDC	NGO-E-10	0.66	For each resource, the DPEIS provides specific impact criteria, which are then used to determine whether the overall effect on the resource qualifies as "negligible," "minor," "moderate," or "major." DPEIS at 4-44, 4-50. Unfortunately, as the ultimate measure of potential effects, these descriptors, as stated and as applied, are problematic in the extreme. They do not incorporate all of the factors relevant to NEPA "significance" analysis; and insofar as they reflect standards embodied in	This comment is part of comment NGO-E-10:0.67. Please see response to that comment.

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Name, Organization	ID	No.	Comment	Response
			other statutes, such as the Marine Mammal Protection Act and Endangered Species Act, they are fundamentally misapplied.	
Michael Jasny, NRDC	NGO-E-10	0.67	Failure to Adequately Define Impact Levels. For each resource, the DPEIS provides specific impact criteria, which are then used to determine whether the overall effect on the resource qualifies as "negligible," "minor," "moderate," or "major." DPEIS at 4-44, 4-50. Unfortunately, as the ultimate measure of potential effects, these descriptors, as stated and as applied, are problematic in the extreme. They do not incorporate all of the factors relevant to NEPA "significance" analysis; and insofar as they reflect standards embodied in other statutes, such as the Marine Mammal Protection Act and Endangered Species /Act, they are fundamentally misapplied. As BOEM states at the outset, the DPEIS is intended to provide the information necessary for agency compliance with the Marine Mammal Protection Act, Endangered Species Act, and other statutes, as well as the Outer Continental Shelf Lands Act and NEPA. DPEIS at vii. Agencies are required by NEPA to explain how alternatives in an EIS will meet requirements of "other environmental laws and policies." 40 C.F.R. § 1502.2(d). But that does not remove the obligation to evaluate significance according to the factors articulated in CEQ's regulations: e.g., "(3) "Unique characteristics of the geographic area," including "ecologically critical areas"; (4) the degree to which impacts "are likely to be highly controversial"; and (5) the degree to which potential impacts "are highly uncertain or involve unique or unknown risks.	CEQ guidelines specify that NEPA analyses require considerations of both context and intensity. The guidelines further stipulate the evaluation of intensity shall take into consideration 10 factors, including the three quoted. The analysis in the Programmatic EIS took into consideration both the context and intensity of impact, based on four parameters – detectability (i.e., measurable or detectable impact), duration (i.e., short-term, long-term), spatial extent (i.e., localized, extensive), and severity (i.e., severe, less than severe). The first of the three factors in question, unique characteristics of the geographic area, has been addressed primarily through the selection of resource categories considered in this programmatic baseline characterization and impact analysis. Of the 17 categories, the following help define the unique characteristics of the Area of Interest and form the basis for analysis of impacts: archeological resources, marine protected areas, geology/sediments, air and water quality, physical oceanography, and recreational resources. The second factor, the degree to which the effects on the quality of the human environment are likely to be highly controversial, is also addressed through the development of affected resource categories. The following categories apply in this case: human resources and land uses, commercial and recreational fisheries, marine protected areas, recreational resources, and archeological resources. The analysis of impacts from impact-producing factors applicable to each resource area (see **Table 4-2**) form the basis on which to address the third factor, the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks. Because the proposed actions aren't new or unique, this Programmatic EIS also draws on information and analysis from past environmental assessment documents including the Programmatic EA for G&G activities in the Gulf of Mexico, the Draft EA of wind energy on the Atlantic OCS, as well as a series of applicable EISs covering both oil and gas and renewable energy activities and non-BOEM authorized G&G surveys conducted for scientific research (NSF, USGS, and NOAA).
Michael Jasny, NRDC	NGO-E-10	0.68	NEPA regulations require agencies to explain how alternatives meet the requirements of other applicable statutes. 40 C.F.R. § 1502.2(d). And yet BOEM, while referencing elements of the MMPA's "negligible impact" standard, does not appear to apply the relevant OCSLA standard, "undue harm," anywhere in the DPEIS. See 43 U.S.C. § 1340(a). The omission is	**Chapter 1.6.2** of the Programmatic EIS has been edited to cite the OCSLA wording referenced in the comment. Specifically, Section 11(a)(1) of the OCSLA states that, "[A]ny agency of the United States and any person authorized by the Secretary may conduct geological and geophysical explorations in the outer Continental Shelf, which do not interfere with or endanger actual operations under any lease maintained

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			puzzling given the DPEIS' ostensible aim of supporting permitting decisions made under OCSLA. DPEIS at vii. BOEM should consider "undue harm" into its analysis.	or granted pursuant to this Act, and which are not unduly harmful to aquatic life in such area." Section 11(g) specifies that permits for geological explorations shall be issued only if the Secretary determines that "such exploration will not be unduly harmful to aquatic life in the area…." BOEM regulations at 30 CFR § 551.6 state that permit holders for G&G activities must not "cause harm or damage to life (including fish and other aquatic life), property, or to the marine, coastal, or human environment." The EIS is a programmatic NEPA document that analyzes impacts with respect to context and intensity as required by NEPA regulations at 40 CFR § 1508.27. The impact criteria and their rationale are explained in **Chapter 4.1.2** of the Programmatic EIS. The use of impact criteria based on context and intensity is well established and the level of detail and analysis presented in the Programmatic EIS provides sufficient information for BOEM to evaluate individual plans and permit applications to ensure compliance with OCSLA requirements and BOEM regulations, including the specific provisions cited above. BOEM's G&G permits may include stipulations to ensure that permitted activities meet the OCSLA requirements.
Michael Jasny, NRDC	NGO-E-10	0.69	The DPEIS, having incorporated the MMPA's "negligible impact" standard into its significance criteria, fails completely to apply it. In practice, the document does not provide, for example, the necessary information for determining whether any of the proposed alternatives will have a greater than negligible impact on any marine mammal stock. Instead, the DEIS offers qualitative conclusions, made without any apparent support or indeed any apparent attempt at assessing the cumulative impacts of the activity. For example, Level B takes are considered to result in only "moderate" impacts, even though the surveys "would affect a large number of individuals," since "it is presumed that exposure to elevated sound would be somewhat localized and temporary in duration." DPEIS at 4-55. Not only does this analysis make assumptions about behavioral response and take thresholds that are inconsistent with the available literature, it makes no attempt to translate short-term behavioral impacts into long-term impacts on populations – a failure that violates NEPA.	The 'negligible' term used in the Programmatic EIS significance criteria is not intended to be equivalent to the MMPA negligible determination. The Programmatic EIS defined 'negligible' as "little or no measurable/detectable impact" whereas the MMPA regulations (50 CFR § 216.103) define 'negligible impact' as "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival." Programmatic EIS **Chapter 4.2.2.2.1** has been revised to explain that the use of the term "negligible" does not imply equivalence to the MMPA definition that would be used by NMFS when evaluating applications for incidental take authorizations (ITAs) for individual surveys. BOEM has noted that operators will be required to satisfy the requirements of all other agencies before a permit or authorization will be issued. Operators will be required to abide by any mitigation requirements stated in this Programmatic EIS, in addition to those included in an issued MMPA ITA or ESA ITS. The impact analysis in **Chapter 4.2.2** has been expanded to more quantitatively address the long term and cumulative impacts of the proposed action on marine mammals.
Michael Jasny, NRDC	NGO-E-10	0.70	The activities considered in the DPEIS have potential to detrimentally affect multiple fish species, harm vital fish habitat, and conflict with multiple fisheries. The DPEIS's	**Chapter 4.2.5.2.2** and **Appendix J** have been revised to address this comment. Potential impacts on Atlantic sturgeon were evaluated in further detail in the Biological Assessment (see **Appendix A**). BOEM

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Name, Organization	ID	No.	Comment	Response
			consideration of impacts does not give adequate weight to the effects of repeated seismic testing and other activities on the behavior of fish and invertebrates. For instance, the DPEIS dismisses temporary hearing loss in fish as a minor effect without considering whether the hearing loss may be permanent or whether even a temporary loss of hearing renders the fish vulnerable to predation, unable to locate food, or unable to locate a mate. In addition, sublethal disturbance that causes fish to avoid key feeding or spawning areas could have a detrimental effect on the population of the species itself. For example, the DPEIS acknowledges that the activities it describes could disrupt feeding by Atlantic sturgeon, which is listed under the Endangered Species Act because its numbers are critically low. DPEIS at 4-131, 4-138. Yet it gives virtually no consideration to what effect disrupted feeding and effects benthic habitat will have when added to the species' ongoing struggle to survive in severely degraded, limited habitat. The DPEIS does not even consider the impacts such as masking, and silencing of fish vocalizations, may have on fish breeding success. For example, masking of black drum fish and toadfish choruses, which overlap with the low-frequency output of seismic airguns, could significantly impair breeding in those species.	incorporated the report, "Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities" from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed hearing loss as well as effects of sound on fish behavior.
Michael Jasny, NRDC	NGO-E-10	0.71	In the case of coastal pelagic species, also known as forage species, the action's adverse effects could ripple through the food chain. The DPEIS acknowledges that forage species are often very sensitive to sound and tend to avoid the sort of noise generated by G&G activities. DPEIS at 4- 131. These species, such as herring, alewife, and others, comprise an important part of the diets of many predatory fish, including tuna and swordfish. Changes in aggregation behavior or movements of forage species could reduce the available food for predatory species, reducing their fitness and numbers and potentially causing them to shift their own movement patterns in response. Any such effects on predatory fish species would likely adversely affect the commercial and recreational fisheries that depend on them.	Based on the analysis in **Chapter 4.2.5.2.2**, impacts on coastal pelagic species (forage species) are not expected to cause significant "ripple" effects at higher trophic levels. Predatory species such as tuna, swordfish, and sharks are constantly moving and are expected to locate displaced prey fishes. BOEM recognizes the potential for sound to affect fish (prey) species and then the effect it might have on predator species. BOEM incorporated the report, "Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities" from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed effects of sound on fish.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.72	Nor does the PDEIS assess the impact of G&G activities on invertebrates, such as cephalopods like squid and octopus, even though a number of studies have demonstrated that seismic and other low-frequency sound sources can disrupt, injure, and kill these taxa.[170]	The text has been revised in **Chapter 4.2.1.2.2** and **Appendix J** to provide additional information about potential acoustic and particle motion impacts on invertebrates. BOEM recognizes the potential for sound to affect invertebrates. BOEM incorporated the Report, "Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities" from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed effects of sound on invertebrates.
Michael Jasny, NRDC	NGO-E-10	0.73	Airgun surveys are known to significantly affect the distribution of some fish species, which can impact commercial and recreational fisheries and could also displace or reduce the foraging success of marine mammals that rely on them for prey. Yet the DPEIS – which acknowledging that displacement can increase the risk of predation, disrupt fish spawning and reproduction, alter migration routes, and impact feeding – appears to assume without support that effects on both fish and fisheries would be localized and "minor." PDEIS at 4-120. The DPEIS fails to recognize the scale of seismic survey impacts on commercial fish species, does not assess impacts of decreased prey availability on marine mammals, ignores the potential for acoustic impacts on Essential Fish Habitat – and, finally, fails to consider measures to mitigate these impacts, such as excluding surveys from spawning areas and other areas of biological importance to Arctic fish species. BOEM must improve its scant analysis.	BOEM recognizes the potential for sound to affect fish species important to commercial and recreational fisheries. BOEM incorporated the report, *Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities*, from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed effects of sound on fish and fisheries. Text has been revised in **Chapter 4.2.5.2.2**, **4.2.7.2.2**, and **4.2.8.2.2** to address this comment. The conclusions are based on literature review and analysis and are not unsupported assumptions.
Michael Jasny, NRDC	NGO-E-10	0.74	The analysis related to the effects of climate change is faulty in a two key respects: (1) it fails to analyze the direct and indirect effects of the proposed action on climate change and ocean acidification, and (2) it fails to explain how the proposed action will impact the marine environment against the backdrop of ocean warming and acidification. Yet NEPA requires analysis of the direct and indirect effects of greenhouse gas ("GHG") emissions and their consequences for climate change. Indeed, proposed guidance by CEQ concludes that the NEPA process "should incorporate consideration of both the impact of an agency action on the environment through the mechanism of GHG emissions and the impact of changing climate on that agency action." First, BOEM must fully analyze the direct and indirect effects on climate change from the greenhouse gas emissions attributable to its G&G operations from vessels and	As a program, this Agency considers the effects of GHG emissions in the Five-Year Leasing Program EIS. **Chapter 3.3** for the current program (2012-2017) considers climate change and the baseline environment in the areas proposed for oil and gas leasing, however, the Atlantic AOI has not been proposed for such leasing. For the G&G surveying considered in this Programmatic EIS we have included climate change as part of the cumulative impact scenario in **Chapter 3.6.10**. The relevant effects are identified; physical and biological systems will be subject to rising water temperatures, changes in ice cover, pH and salinity, oxygen levels, and circulation. Anticipated impacts reported include shifts in ranges and changes in algal, plankton, and fish abundance in high-latitude oceans; increases in algal and zooplankton abundance in high-latitude and high-altitude lakes; and range changes and earlier fish migrations in rivers. In the AOI, indirect effects of climate change could include altered migratory routes or timing for marine life or birds and the decreased

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			other sources. While the DPEIS acknowledges that survey vessels and aircraft involved in G&G activities would emit greenhouse gas pollution, it never quantifies or evaluates the impact of those emissions. See DPEIS at 4-4. Additionally, the DPEIS cannot ignore the greenhouse gases that will be released in to the atmosphere as a result of the oil and gas produced as a result of the exploration activities authorized here. NEPA requires that agencies consider a proposed action's future indirect effects, which are those "caused by an action and are later in time or farther removed in distance, but are still reasonably foreseeable." The stated need for the action is to determine the extent and location of oil and gas reserves to facilitate oil and gas development. DPEIS at 1-8. Accordingly, BOEM must calculate not only the greenhouse gas emissions from the vessels and activities used for the G&G operations, but the impacts of the greenhouse gases emitted from the produced oil and gas reserves. Second, the DPEIS fails to explain how its G&G activities will impact marine species and ecosystems that are already compromised by rapid climate change and ocean acidification. The DPEIS' cursory description of climate change and ocean acidification, which concludes without analysis that the environmental effects are likely to be small, incremental, and difficult to discern from effects of other natural and anthropogenic factors (DPEIS at 3-43), falls short of the hard look required by NEPA. Additionally, critical habitat designation for the North Atlantic DPS of loggerhead sea turtles is imminent, and accordingly BOEM should evaluate the extent to which the proposed action will affect areas of potential marine and beach critical habitat. Other coastal wildlife species are also impacted by sea level rise, and these effects must also be evaluated.	ability of marine life to form calcified hard parts because of lower pH in marine waters, and coastal estuaries and coastlines could experience altered configuration from rising sea level. For the temporary and transient duration of G&G activities and the limited impacts posed by vessel or aircraft deployment, we do not believe that an analysis beyond that provided is necessary.
Michael Jasny, NRDC	NGO-E-10	0.75	Contrary to the statements in the DPEIS, the impacts of climate change are happening within the next decade and are already occurring. For the North Atlantic, ocean warming has already been reported as contributing to ecosystem shifts.[199] Changes are seen from phytoplankton to zooplankton to fish and are modifying the dominance of species and the structure, diversity and function of marine ecosystems.[200] These changes in biodiversity, combined with other impacts from fishing, oil and gas exploration and development, and ocean acidification, can contribute to the decline or extinction of species and must be analyzed in the DPEIS.	See the response to comment NGO-E-10:0.74

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Name, Organization	ID	No.	Comment	Response
Michael Jasny, NRDC	NGO-E-10	0.76	BOEM must examine the impacts of its proposed project on the marine environment in light of changes that are already occurring due to ocean acidification. Especially relevant to the proposed project is that the oceans are becoming noisier due to ocean acidification.	See the response to comment NGO-E-10:0.74.
Michael Jasny, NRDC	NGO-E-10	0.77	In assessing their MMPA obligations, BOEM presupposes that industry will apply for IHAs rather than 5-year take authorizations and that BOEM will not apply to NMFS for programmatic rulemaking. DPEIS at 1-13, 5-9. But the potential for mortality and serious injury bars industry from using the incidental harassment process to obtain take authorizations under the MMPA. BOEM should therefore consider applying to NMFS for a programmatic take authorization, and revise its impact and alternatives analyses in the EIS on the assumption that rulemaking is required.	The incidental harassment process to obtain take authorizations under the MMPA allows the applicant to apply for an IHA for an activity if it can be shown that (1) there is no potential for serious injury or mortality or (2) the potential for serious injury of mortality can be negated through mitigation requirements that could be required under the authorization. The tiering approach, both for NEPA and other applicable statutes, has been adopted to ensure that permits and authorizations are issued based on sufficient information. For G&G surveys, sufficient information will typically be available on a project-specific basis. At this time, BOEM has determined that it is not necessary to apply for 5 year regulations under the MMPA. However, if activity levels increase significantly, BOEM may consider applying for rulemaking in the future.
Michael Jasny, NRDC	NGO-E-10	0.78	Additionally, we are concerned about BOEM's general statement that an IHA "may not be necessary" for certain HRG surveys if operators can demonstrate that they can effectively monitor out to the 160 dB isopleth, which BOEM construes as the threshold for Level B take. DPEIS at C-15. As noted above, we believe that BOEM has applied the incorrect threshold given (1) the potential for take from mid-frequency sources at received levels well below 160 dB (RMS); (2) the demonstrated sensitivity of some species, such as harbor porpoises and beaked whales, requiring far lower take thresholds; and (3) the virtually continuous acoustic output of some sub-bottom profilers, which suggests that a standard designed for transient sounds should not be used. It is not possible for operators to effectively monitor out to the impact distances implied by these conditions; indeed, it is highly unlikely that operators could monitor – with the 100% efficacy that would be necessary – the smaller distances that BOEM appears to contemplate here, especially if surveys occur at night and other times of low visibility.	The statement in question has been reworded. BOEM does not have the regulatory authority to determine if an MMPA permit is necessary for each activity, but BOEM does require MMPA compliance within our own permits. Please see the revised HRG Survey Protocol in **Chapter 2.1.3.2** and **Appendix C**, **Section 3.3.2**. Please also see the responses to comments FA-L-1:0.06 and FA-L-1:0.07, and refer to **Appendix A**.
Michael Jasny, NRDC	NGO-E-10	0.79	The DPEIS indicates that BOEM has begun the consultation process, and that a Biological Opinion, if issued, will be included as an appendix to the final document. To be sure, the consultation should include every listed marine mammal, sea turtle, fish, and seabird species in the region, but the agencies	The Biological Opinion issued by NMFS can be found in **Appendix A**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			should spend particular attention on the North Atlantic right whale. Without substantial additional mitigation, NMFS cannot legally issue a no-jeopardy opinion for this species.	
Michael Jasny, NRDC	NGO-E-10	0.80	In order to comply with the ESA, BOEM must select an alternative that sufficiently protects the right whale, its designated critical habitat, and all known migratory corridors, feeding areas, calving and nursery grounds. The seasonal exclusion proposed in Alternative A would not avoid jeopardy, nor would the additional exclusion (though superior) proposed in Alternative B.	BOEM has conducted Section 7 consultation with NMFS to ensure required compliance with the ESA and has selected Alternative B as the Preferred Alternative through this NEPA process. BOEM believes that this alternative provides the necessary protection for the NARW.
Michael Jasny, NRDC	NGO-E-10	0.81	The DPEIS acknowledges the multi-stage nature of consistency review under the CZMA, but does not indicate that BOEM will undergo review at the present stage. See 5-8 to 5-9. BOEM must.	As a programmatic document this EIS will not be used to seek a consistency statement under CZMA. Future site-specific projects will be evaluated for consistency with applicable State's CZMA plans as outlined in **Chapter 1.7.5** and **Chapter 5.7.1**.
Michael Jasny, NRDC	NGO-E-10	0.82	Perhaps most pressingly, BOEM must include New Jersey – which is omitted from the DPEIS' distribution list (DPEIS at 5-6) – among the affected coastal states. Further, BOEM must acknowledge the full scope of activity that would affect coastal resources under the CZMA, for purposes of satisfying this important provision at both the planning and permitting stages.	As a programmatic document, this EIS will not be used to seek a consistency statement under CZMA. The Programmatic EIS has provided as full and complete a description of future G&G activity within the AOI as is possible, given available information. Future site-specific actions will provide more detailed information to determine if the actions of a particular proposed project require consistency under a state (or states) CZMA plan.
Michael Jasny, NRDC	NGO-E-10	0.83	It is crucial that BOEM provide a thorough analysis of the proposed action's effects on the myriad coastal resources that State programs are designed to protect. Without such a thorough analysis, it is impossible for the states to assess the validity of any consistency determination BOEM issues. In its final PEIS, BOEM must present these missing alternatives and information, and give State CZM programs sufficient time to assess the information and the proposed actions' consistency with their enforceable policies.	As a programmatic document, this Programmatic EIS will not be used to seek a consistency statement under CZMA. Future site-specific actions will provide more detailed information to determine if the actions of a particular proposed project require consistency under a State (or States) CZMA plan. A summary of the CZMA program and its requirements for each of the States bordering the Area of Interest is provided in **Appendix B** of the Programmatic EIS. Further, BOEM cannot authorize activities within State waters. However, the coastal resources that may occur there have been considered in this Programmatic EIS.
Michael Jasny, NRDC	NGO-E-10	0.84	In compliance with the Magnuson-Stevens Fisheries Conservation and Management Act. Accordingly, and as the DPEIS anticipates, BOEM must consult with the Secretary of Commerce through NMFS and the Mid- Atlantic and South Atlantic Fisheries Management Councils. DPEIS at 5-9.	**Chapter 5.7.4** provides information about EFH consultation. BOEM sought EFH consultation under the MSFCMA. On June 1, 2012, NMFS determined BOEM's request for Programmatic EFH consultation was not an appropriate mechanism to evaluate EFH impacts of BOEM G&G activities in the Atlantic OCS based on information available at this time. In response, BOEM has proposed each activity that occurs under this proposed action would receive an environmental review including an EFH assessment from BOEM.
Michael Jasny, NRDC	NGO-E-10	0.85	The National Marine Sanctuaries Act requires agencies whose actions are "likely to injure a sanctuary resource" to consult with the Office of National Marine Sanctuaries ("ONMS").	BOEM understands the consultation process, and as stated in **Chapter 1.6.15**, because the review under this document is programmatic in nature and does not address project-specific information regarding

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			Under the consultation scheme, BOEM is required to prepare a Sanctuary Resource Statement; if ONMS determines that the statement is complete and that injury is indeed likely, it must prepare recommended alternatives to the proposed action, which may include relocation, rescheduling, or use of alternative technologies or procedures. To ensure compliance with the consultation provision, BOEM should keep several critical points in mind. BOEM should not consider itself subject to consultation only if its permitting activities physically injure a marine animal within sanctuary boundaries. The permitting of any seismic survey likely to degrade the acoustic environment of the Monitor or Gray's Reef NMS, or (given the best available science on scuba diver aversion to low-frequency sound) raise noise levels within the sanctuaries above 145 dB (SPL), is subject to consultation under the Act. In addition, we strongly encourage BOEM to tier consultation with the sanctuaries.	potential impacts to sanctuaries, it will not result in a permit application under the NMSA. Our approach to NMFS consultations on a site-specific basis is explained in **Chapters 1.7.5** and **5.7.6**. BOEM has coordinated with NOAA's Office of National Marine Sanctuaries (ONMS) and since NOAA is a cooperating agency on this Programmatic EIS, ONMS also cooperates by provided review, comment, and guidance. Future, site-specific proposals will be reviewed by BOEM to ensure NMSA standards or permit requirements are met and that agreed-upon measures will avoid, minimize, or mitigate potential adverse effects. BOEM is committed to continuing to work with ONMS on future activities.
Michael Jasny, NRDC	NGO-E-10	0.86	The intrusion of oil and gas exploration into the communities of the Atlantic Coast will seriously impact the economies of clean ocean uses. The proposed action will lead to the direct displacement of commercial and recreational fishermen and will likely impact long-term ecotourism and coastal cultural values. Therefore, BOEM has the responsibility to protect the economies and ecosystems of the Atlantic Ocean under a program of improved understanding, stakeholder engagement, and science-based decision making. This DPEIS does not achieve any of these goals, does not represent good ocean governance, and does not represent the use of good science.	The proposed action is only G&G surveys, it does not include any activities related to oil and gas exploration and development. The assessment contained in the Programmatic EIS analyzes the impacts of G&G surveys only. Further, BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre, an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). This program enables multi-use of the ocean. BOEM recognizes the potential for sound to affect fish species important to commercial and recreational fisheries. BOEM incorporated the report, *Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities*, from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). At this workshop, BOEM reached out to fisheries, as well as the Atlantic States Marine Fisheries Commission, which advised this workshop and provided input for the report. BOEM is committed to continuing to reach out to the public, including to commercial and recreational fishermen.
David Phemister, Nature Conservancy	NGO-E-9	0.01	BOEM needs to acknowledge the connection between geological and geophysical activities and future extraction/development activities (oil and gas, renewable energy, and marine minerals) and evaluate whether locations	BOEM was directed by Congress to conduct a Programmatic EIS to evaluate potential significant environmental effects of multiple G&G activities in the Atlantic OCS. The scope of this Programmatic EIS does not include a NEPA analysis that evaluates a specific proposal for oil

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			within the Area of Interest (AOI) are appropriate or inappropriate for both sets of activities. BOEM needs to consider exploration and drilling as closely interconnected activities whenever possible, most especially with regards to spatially explicit avoidance measures within an overall mitigation framework (discussed in more detail under the Mitigation and Amended Alternatives sections below). BOEM can avoid some adverse impacts to marine mammals and other fauna by not permitting exploration activities in areas that are unsuitable for future development.	and gas leasing in the AOI and does not authorize an OCS lease sale. The procedures under the OSCLA to set up a lease sale include a specific NEPA evaluation for that proposed action. A NEPA evaluation for approving the OCS plans that actualize leases for oil and gas exploration and development are also not part of this proposed action. BOEM acknowledges that there are connections between G&G activities and future development locations, but not in a sense that would allow us to define in advance locations within the AOI that are appropriate or inappropriate for both sets of activities as indicated in this comment. Broad scale seismic surveys are needed to help identify prospective locations for oil and gas development. The scope of individual seismic surveys is not determined by BOEM but by the survey operators who have submitted applications based on what they believe industry interest may be, and what data sets they may be able to market. In addition, broad scale seismic surveys provide geological data that helps to identify and map regional structures, even if some of the areas surveyed would not be suitable for future exploration drilling. G&G surveys in support of renewable energy and marine minerals programs would be conducted only at specific sites identified by developers or agencies, and by definition these sites would be at least potentially suitable for the proposed development or use. **Chapter 3.0** identifies the likely depth ranges for renewable energy and marine minerals activities. Finally, HRG site surveys, whether for oil and gas, renewable energy, or marine minerals development, are essential in identifying sensitive benthic communities, archaeological resources, and other features for avoidance. Locations of many such features are not known until a geophysical survey is conducted.
David Phemister, Nature Conservancy	NGO-E-9	0.02	BOEM needs to employ the full hierarchy of mitigation actions in all the alternatives it evaluates to ensure that it avoids, minimizes, and offsets impacts to species and habitats. The DPEIS fails to utilize the full sequence of mitigation actions, and this deficiency means that impacts to both habitats and species, including protected species, will be greater in number and severity than is necessary. In summary, the deficiencies are as follows: Avoidance - While the Conservancy appreciates that the DPEIS does include some spatially explicit avoidance measures, these exclusions areas are currently too small and too narrowly defined. Many more areas merit exclusion from at least some portion of the proposed action. Minimization – By rejecting a full analysis and the incorporation of a number of different technology-based	As summarized in **Appendix C**, the mitigation in the proposed action is extensive and includes both avoidance (e.g., time-area closures, guidance for vessel strike avoidance, and avoidance of sensitive seafloor resources) and impact minimization (e.g., the Seismic Airgun Survey Protocol, HRG Survey Protocol, etc.). Compensatory mitigation is typically the lowest priority in the mitigation hierarchy. The EIS does not include any compensatory (offset) mitigation measures and there is no NEPA requirement to do so. However, each individual survey will be subject to a NEPA analysis that evaluates impacts on a site- and project-specific basis, and that would be the appropriate place to consider the full hierarchy of mitigation actions: avoidance, minimization, and potentially compensatory mitigation as necessary. The comment letter notes that BOEM has included relatively few avoidance areas because the analysis is limited to those impacts

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Name, Organization	ID	No.	Comment	Response
			minimization measures, the DPEIS misses an opportunity to reduce impacts to sensitive resources. Offsets – Lastly, despite the fact the DPEIS highlights a number of unavoidable impacts, including impacts to threatened and endangered species, the document fails to provide any description of appropriate measures to compensate for those impacts.	specifically related to G&G activities and recommends several additional avoidance areas based on sensitivity to future "extraction and construction activities" that may follow. However, the Programmatic EIS rightly focuses on the activities included in the proposed action. Future activities such as oil and gas development would require a separate lease sale EIS, and that would be the appropriate time to consider additional avoidance areas based on the potential impacts of that proposed action.
David Phemister, Nature Conservancy	NGO-E-9	0.03	BOEM should develop additional alternatives that locate different activities within different portions of the AOI and phase in lease and permit requirements based on available technologies and adaptive management. A more diverse suite of Alternatives would recognize that the AOI is very large and quite diverse, the time period covered by this PEIS (2012-2020) is fairly long, and the program areas (oil and gas, renewable energy, and marine minerals) encompassed are highly variable. Thus, BOEM should develop additional alternatives that: Acknowledge that the AOI is not a single, monolithic area, but instead contains a great diversity of human uses and ecological resources. Those uses and many of those resources have defined locations that can be mapped (see our proposed avoidance areas on Map 1-3 as an example). Thus, BOEM should evaluate the appropriateness of geological and geophysical activities in different portions of the AOI based at least in part on the location and compatibility of other uses and ecological resources. Use the full time period of the PEIS to phase in certain requirements based on the availability of new technologies and/or operational changes based on adaptive management (see Monitoring and Adaptive Management section below); Recognize that differing program areas require different sorts of data, distinctions that also can have spatial ramifications.	The AOI is large and ecologically diverse and it is part of BOEM's mission under the OCSLA Section 18(H)(3) to select the timing and location of leasing so as to obtain a proper balance between the potential for environmental damage and the potential for the discovery of oil and gas. A programmatic evaluation looks at the area where proposed impacts could occur without extracting or exempting parcels in areas with special designations. Those areas of special designation have been designated as marine sanctuaries or critical habitat by the agency responsible for making that judgment. Our approach to adaptive management with respect to the conduct of prelease geological and geophysical exploration is expressed in **Chapter 1.7.6** and **Appendix C, Section 7**.
David Phemister, Nature Conservancy	NGO-E-9	0.04	BOEM needs to continue to work hard to close existing data gaps and, wherever possible, make publically available non-proprietary data from geological and geophysical surveys and associated protected species observer programs. As the Conservancy highlighted at some length in our May 17, 2010 comment letter, we remain concerned that BOEM does not have the data necessary for a comprehensive and thorough assessment of environmental impacts associated with geological and geophysical activities in the Mid- and South	A critical part of BOEM's mission is protecting the environment while ensuring the safe development of the nation's offshore energy and marine mineral resources. The Environmental Studies Program within BOEM develops, conducts and oversees scientific research to inform policy decisions regarding development of Outer Continental Shelf (OCS) energy and mineral resources. Research covers physical oceanography, atmospheric sciences, biology, protected species, social sciences and economics, submerged cultural resources and environmental fates and effects. Further information is provided on the

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			Atlantic Planning Areas. As funding for these efforts is obviously a concern, we encourage BOEM to utilize fully its existing authorities (or work with Congress if those are not sufficient) to secure a small portion of any future lease revenue specifically for data collection and analysis efforts. Continued investments in independent research and monitoring through its Environmental Studies program appear to be an especially important effort for BOEM to be able to greatly minimize data gaps in the future.	BOEM website at http://www.boem.gov/Studies/. Nonproprietary data and studies are made publicly available.
David Phemister, Nature Conservancy	NGO-E-9	0.05	BOEM needs to outline a transparent and rigorous adaptive management framework, including the mandated incorporation of new technologies and improved mitigation measures.	A discussion of Adaptive Management is provided in **Chapter 1.7.6** and **Appendix C**, **Section 7**. A discussion of adaptive management is provided that would facilitate changes to existing mitigation measures or the application of new mitigation measures and encouragement of new technologies.
David Phemister, Nature Conservancy	NGO-E-9	0.06	BOEM needs to improve its cumulative impacts analysis so it is clear that moderate to major impacts have not been overlooked. It is unclear to the Conservancy, however, what methodology BOEM used to assign an overall vulnerability ranking to any particular species. The DPEIS reports that the Acoustic Integration Model (Section 2.1.3.2) was used to calculate incidental take in the proposed actions scenarios. However, it is unclear whether this model was used when determining impacts in the cumulative activities scenario. Further, it appears that each impact-producing factors (IPF) included in the cumulative impact scenario for a given species or group of species was assessed one at a time. What seems to be lacking in the cumulative impact scenario is a complete assessment of how all of the IPFs together will impact the viability of the species. The participants in the Okeanos workshop developed new approaches to modeling and mapping cumulative impacts of noise on both marine mammal populations and individuals, and they stressed that once vulnerability scores are assigned for each impact, then vulnerability measures should be "weighted and combined into an overall vulnerability score" (Wright, 2009). The analysis in the DPEIS seems to fall short of this step. Thus, the Conservancy submits that it is very difficult to determine whether or not a number of negligible to minor impacts to a species or group of species add up to a moderate to major cumulative impact. The Conservancy recommends that BOEM either clarify the methodology and analysis in the DPEIS or	The impact analysis in **Chapter 4.2.2** has been revised to address the issue of how all of the IPFs together would affect marine mammals. **Chapters 3.6** and **4.1.3** have been revised to further define the scope of activities included in the cumulative impacts analysis, and the cumulative analysis for marine mammals in **Chapter 4.2.2.4** has been expanded. The AIM© model was not used for evaluating cumulative impacts, only for the activities included in the proposed action. AIM© was not developed for modeling continuous noise signals, or how animal exposure to background or ambient noise levels may affect them. The Okeanos Workshop (Wright, 2009) presents initial recommendations for a framework to assess cumulative impacts of underwater noise, but it is clearly intended as a starting point for further development, not a formal methodology or protocol. The workshop's cover letter states that the participants "began to develop a novel set of tools for assessing the cumulative effects of human activities, including undersea noise from all sources, on cetaceans" and also refers to "this emerging methodology."

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			redo the cumulative impacts analysis consistent with the recommendations and protocols outlined in the report from the 2009 Okeanos workshop.	
David Phemister, Nature Conservancy	NGO-E-9	0.07	The Conservancy strongly supports CMSP as a key tool in the President's vision of a national policy for our ocean, coasts, and Great Lakes and is actively involved in advancing the policy and practice of CMSP. As we have stressed in previous comments to BOEM on proposed programs for oil and gas and various evaluations of wind energy projects, we do not expect BOEM to delay action on this PEIS until the relevant Regional Planning Bodies develop comprehensive regional ocean plans encompassing the Mid- and South Atlantic Planning Areas. We do suggest, however, that BOEM continued to align its planning, review, and leasing activities with the recommendations of the interagency task force, including the twelve national guiding principles for CMSP.	The final recommendations released by the Interagency Ocean Policy Task Force established the direction for improved stewardship of the ocean, our coasts, and the Great Lakes. Regional planning councils have been established to encourage States, Tribes, localities, and Federal agencies to collaborate in an inclusive manner to address issues that regions identify as important. BOEM, as an agency of the U.S. Department of Interior will work to ensure the guiding principles of the CMSP are incorporated into the planning process.
David Phemister, Nature Conservancy	NGO-E-9	0.08	Monitoring and adaptive management As we stated in our May 17, 2010 comment letter, the Conservancy recommends that all alternatives considered in the PEIS stipulate robust monitoring plans to determine actual impacts on marine resources, the effectiveness of mitigation measures, and what steps BOEM needs to take to adaptively manage where and under what conditions geological and geophysical activities occur in the future.	BOEM has added a discussion of Adaptive Management to the Programmatic EIS (**Chapter 1.7.6** and **Appendix C**, **Section 7**). As part of its Adaptive Management program BOEM intends to review the effectiveness of mitigation measures based on monitoring data collected by PSOs during G&G surveys for example. BOEM will use the Adaptive Management process to refine and improve our protective measures.
Scott Kraus, New England Aquarium	NGO-E-13	0.01a	This EA has used inadequate data to estimate the effects of oil and gas seismic operations off the mid-Atlantic on marine mammals. Consequently, it provides completely unreliable estimates of "takes" with no confidence intervals, and makes unwarranted assumptions about animal "takes" and responses to noise, and the consequences of displacement. These unknowns and assumptions could lead to serious problems for several endangered whale species, as well as delays in permitting and construction. The entire draft EA and estimation analyses are dependent upon an extremely sparse dataset. By restricting the marine mammal assessments to the Navy's Nodes database, which is based on data from a very limited number of NMFS shipboard surveys in the area (which are mostly limited to the summer months), there arise several problems. First, there is no scientific basis for extrapolating the modeled marine mammal densities to areas where there are no surveys. Second, the use of the AIM model to extrapolate	BOEM recognizes that limited data are available to estimate marine mammal densities for impact calculations. **Appendix E** has been revised to provide additional discussion of the limitations of the existing data and uncertainty associated with the overall modeling effort. It is agreed that it would be ideal to have marine mammal surveys that have been conducted in all seasons, but the use of habitat modeling to extrapolate survey data to seasons and regions with little or no survey effort is well established (Redfern et al., 2006). BOEM also acknowledges that there are limitations to our understanding of animal movement in the Area of Interest, but recognizes that the best available data were used to approximate the movement of animals, which is a better modeling scenario than stationary animals. The NODE database is an existing compiled dataset that encompasses most of the Area of Interest and has been used in previous impact analyses by the Navy including the EIS for Atlantic Fleet Active Sonar Training. We recognize that there are additional datasets covering portions of the area, and we agree with the observation that "there should be some more advanced thinking and

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			animal movements within the mid-Atlantic region is inappropriate. Third, the extrapolation of primarily warm weather surveys to the winter months is inappropriate. Fourth, the selection of the data for the density model runs eliminates a large collection of datasets for many areas within the mid-Atlantic area. There should be some more advanced thinking and analysis devoted to integrating the multiple datasets available. Also, model results should be presented with confidence intervals around the final numbers... The take-home message from this review of the models and the data is that the approach needs considerable refinement, but mostly it needs some data. BOEM should support the NMFS proposed AMAPPS program to the fullest extent originally proposed, which includes surveys over the entire area in all four seasons.	analysis devoted to integrating the multiple datasets available." That is why BOEM is working in partnership with NOAA, the FWS, and the U.S. Navy to develop better data sets for the future through the AMAPPS program. The data and tools it is developing will be used to support future, site-specific evaluations of individual survey applications. In addition, we recognize that the incidental take methodology has room for refinement – most importantly, the incorporation of new acoustic criteria when they are issued by NMFS. BOEM has added a discussion of Adaptive Management to the Programmatic EIS (**Chapter 1.7.6** and **Appendix C**, **Section 7**) to indicate our commitment to incorporating new information and improving the data and methodologies to support decision-making for individual NEPA evaluations. BOEM does not believe it is realistic to develop confidence limits for incidental take estimates at this time for several reasons. First, incidental take applications and authorizations generally do not contain this information. Second, we do not believe it is appropriate to calculate confidence limits for Level A takes because we expect them to be avoided to the extent practicable through mitigation. As noted in **Appendix E**, we estimated Level A takes without mitigation (other than time-area closures), which is the typical method used in incidental take requests and IHAs. Finally, with respect to Level B harassment takes, we note that the current NMFS criterion for pulsed sources (160 dB re 1 µPa) is widely recognized as a very simplistic predictor of behavioral responses and there is much ongoing research and discussion to develop refined behavioral criteria. Therefore, we believe that calculating confidence limits for numbers of Level B harassment takes would imply a level of quantification and statistical certainty that does not currently exist.
Scott Kraus, New England Aquarium	NGO-E-13	0.01b	**Right Whale Migration**. All of the proposed G&G activity in the mid-Atlantic has the potential to alter the path of right whales migrating southward to the calving grounds (while pregnant), and returning northward in the late winter with their newborn calves. Although the exact path of migration is not known, the limited tagging and sightings data places most right whale records between 5 and 30 miles offshore along the entire mid-Atlantic. Therefore, the expanded time-area closure described in the EA's alternative B is the only reasonable alternative to provide some protection for the most vulnerable component of this population, pregnant females, and mothers with newborn calves	BOEM has identified Alternative B as the Agency's Preferred Alternative. Alternative B includes a 20-nmi closure along the entire Area of Interest to minimize the potential for impacts on right whale migration from seismic airgun surveys. Also, as requested by NMFS, **Chapter 2.1.2.1** has been revised to indicate that if the right whale critical habitat or SMAs boundaries are changed, BOEM would revise the closure areas to align with those boundaries. BOEM has also added a discussion of Adaptive Management to the Programmatic EIS (**Chapter 1.7.6** and **Appendix C**, **Section 7**), and if a compelling reason developed to consider expanding the seaward limit for this area, such as a better understanding of the migration routes for the NARW or other marine mammals, on the basis of adaptive management we would consider it in future decision-making.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Scott Kraus, New England Aquarium	NGO-E-13	0.01c	**Acoustic Disturbance**. The EIS appears to widely underestimate the long distance capability of G & G seismic work to alter the behavior of large whales. The EIS estimates the acoustic level B disturbance levels of boomers, placing the Rmax at slightly over 15 km. Recent analyses of pile driving for wind farm construction off the Scottish coast showed that potential for sound levels high enough to cause behavioral disturbance extended up to 50 km from the construction site (Bailey et al. 2010). Humpback whales song recorded on the Stellwagen Bank National Marine Sanctuary were significantly reduced when animals were exposed to the transmissions of an Ocean Acoustic Waveguide Experiment (peak @400 Hz at ~225 dB source level) about 200 km away from the animals (Risch et al., 2012). Both finback whales (*Balaenoptera physalus*) and blue whales (*Balaenoptera musculus*) have respectively been shown to have both behavioral and acoustic changes in response to low frequency sonar (Croll et al., 2001) and seismic surveys (Di Iorio and Clark, 2010). Castellote et al (2012) showed both displacement and acoustic behavioral changes by finback whales in response to seismic noise levels, and suggested that these behavioral changes could adversely affect reproduction and survival. In addition, there is limited reference to the responses of right whales to low frequency noise (Parks et al. 2007, 2008) and novel sounds (Nowacek, et al. 2004), as well as the potential large scale impacts on right and other whales from increased industrial noise in the oceans (Clark et al., 2007; Tyack, 2008, Nowacek, et al., 2007, and Rolland et al., 2012). These omissions mean that the EIS does not consider the emerging body of literature that suggests significant impacts from anthropogenic noise on marine mammals, and in particular, the effects of louder low frequency noises from seismic exploration on large whales.	Sound profiles from pile driving activities, the Ocean Acoustic Waveguide, and directional low frequency sonar differ from seismic airguns. The analyses within the EIS of potential impacts from proposed activities to marine mammals were based on incidental take estimates that were calculated using currently accepted practices, including current spatial and temporal density estimates and available behavioral information by species, sound source propagation modeling to estimate injurious (180 dB) and non-injurious (160 dB) acoustic threshold radii (integrated to estimate areas). Recent literature suggests that individual mammals, such as baleen whales, may demonstrate behavioral effects during seismic surveys at distances that are greater than the modeled 160-dB radii. These responses indicate an error in sound propagation modeling methods and/or the onset of behavioral response at lower sound levels than 160 dB. References have been added to the EIS in **Chapter 4.2.2**, to consider this emerging body of literature. Additionally, as new information becomes available it may be considered at the site/permit specific level.
Scott Kraus, New England Aquarium	NGO-E-13	0.01d	Cumulative Impacts. The EIS is silent on the cumulative impacts of this and two other major activity expansions in the Atlantic OCS areas. These three activities include 1) alternative energy leasing and construction, 2) Navy activities, including the proposed expansion of operations areas along the east coast of the U.S., and 3) the G & G seismic assessments in the mid and south Atlantic areas. The EIS for each of these projects should include a cumulative (and additive) assessment of all of these activities combined, since it is clear that they will	The Programmatic EIS provides a cumulative impact analysis in **Chapter 4.2.2.4**. The analysis has been revised to address this comment. The cumulative analysis has been expanded to provide a more quantitative consideration of cumulative incidental takes from various activities such as those indicated, including U.S. Navy operations. Also, the impact calculations in **Appendix E** did take into account the possibility of multiple seismic surveys occurring at the same time.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			occur simultaneously. The National Environmental Policy Act requires exactly this kind of analysis. In addition, the EIS indicates that several seismic surveys could be underway simultaneously in the region. If this were the case, the actual potential for displacement and disturbance of marine mammals may be much larger than the EIS suggests. The cumulative impact of multiple seismic surveys are likely to have significant effects on regional populations of marine mammals, and may have serious consequences for right whales (See Stone and Tasker, 2006; Clark et al, 2007;2009; Parks et al, 2007; 2008; Tyack, 2008).	
Scott Kraus, New England Aquarium	NGO-E-13	0.01e	**Mitigation (Appendix C)**. The proposed mitigation plan does not begin to approach minimal standards for scientific observation data collection. Professional survey teams in both aerial and shipboard surveys are usually considered capable of covering approximately one square mile of ocean within a quadrant. For the G & G surveys, two observers on a vessel for mitigation observation is not adequate, since observation hours (especially during the summer months) may be 12 hours or more, and observers need a break at least every two hours. At a minimum, if seismic surveys are to be contingent upon the presence or absence of marine mammals, appropriate scientific survey and observation methods should be employed, calculating the area to be mitigated as a starting point, and then taking into account the sightability of different species, as well as sighting conditions such as height of eye, sea state, and visibility, as well as the limitations of observers. From such calculations, one can determine an appropriate observation strategy for the activity, and then determine the number of observers needed to adequately mitigate the acoustic disturbance. A revision of the mitigation strategy along these lines is critical for G&G surveys, permitting, construction planning, and BOEMs long term planning for offshore development.	Mitigation measures outlined in **Appendix C**, **Section 3.2** for seismic surveys follow current requirements by NMFS for geophysical contractors when conducting seismic surveys within the Gulf of Mexico. These procedures are detailed in the NTL 2012-JOINT-G02 (“Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program”) (USDOI, BOEM and BSEE, 2012a). This NTL clarifies how a geophysical contractor should implement seismic survey mitigation measures, including ramp-up procedures, the use of a minimum sound source, airgun testing and protected species observation and reporting. It is assumed that these regulations will also be utilized for future operations within the Atlantic OCS Planning Areas. Alternative B, BOEM's Preferred Alternative, requires PAM for airgun surveys and use of PSOs and visual observers for acoustic exclusion zone and vessel strike avoidance monitoring. Since the Draft Programmatic EIS was released the Seismic Airgun Survey and HRG Survey Protocols have been clarified. The Protocols specify that PSOs must have completed a training course, and based on our experience with the same requirement used in the Gulf of Mexico, we expect that PSOs would have meaningful field experience. PSOs shall operate under the following guidelines: (1) other than brief alerts to bridge personnel of maritime hazards, no additional duties shall be assigned to observers during their watch; (2) a watch shall be no longer than four consecutive hours; (3) a break of at least two hours shall occur between watches, no other duties shall be assigned during this period; and (4) a PSO’s combined watch schedule shall not exceed 12 hours during a 24-hour period. A minimum of two PSO observers are required for airgun surveys. A minimum of one PSO observed is required for non airgun HRG sources operating at frequencies below 200 kHz observers. For non airgun

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				HRG sources operating at frequencies above 200 kHz visual observers would monitor a vessel strike exclusion zone during transit. Through Adaptive Management as outlined in **Chapter 1.7.6** and **Appendix C**, **Section 7**, BOEM could revise the protocol requirements in the future if new data show that changes are warranted.
Scott Kraus, New England Aquarium	NGO-E-13	0.02	BOEM should support the NMFS AMAPPS and other surveys as needed across the entire oil and gas call region in all seasons,	BOEM is a partner with NOAA, FWS, and the U.S. Navy in conducting AMAPPS program. We agree the data and tools it is developing will be very beneficial to estimating densities of marine mammals to support future, site/permit-specific NEPA evaluations of individual survey applications.
Scott Kraus, New England Aquarium	NGO-E-13	0.03	Use the newly acquired sightings data to support updated modeling efforts to bring the estimates of density and "takes" up to contemporary scientific standards,	The new Atlantic cetacean density data from AMAPPS was not available when the Programmatic EIS was finalized. However, as a partner in the AMAPPS program, BOEM intends to use the density estimates when they become available to support future, site/permit-specific NEPA evaluations of individual survey applications. BOEM has also added a discussion of Adaptive Management to the Programmatic EIS (**Chapter 1.7.6** and **Appendix C**, **Section 7**) to indicate our commitment to improving our future decision-making based on new information and experience.
Scott Kraus, New England Aquarium	NGO-E-13	0.04	Conduct a review of the right whale migratory patterns, and consider additional distance restrictions on the use of seismic activities within 50 km the coast during the migratory season,	BOEM considered additional distance restrictions, but after analysis determined that a 20-nmi time-area closure provides a credible protective measure for NARW and other marine mammal species transiting through to critical habitats at either end of their north-south seasonal migration. Therefore, BOEM decided to keep the 20-nmi time-area closure as proposed for Alternative B. BOEM's resource evaluation staff in their 2011 Atlantic OCS Resource Assessment (USDOI, BOEM, 2012) projected geological play types that would benefit by expansive 2D or 3D seismic surveys along the North Carolina coastal area. Such surveys tend to require long periods at sea to complete and a time-area closure beyond 20 nmi imposes a restriction on access to potential resource area that is not justified on the basis of available information. The 20 nmi zone outward from shoreline and the seasons to which it applied was based on NOAA's vessel speed restriction rule (50 CFR § 224.105). As requested by NMFS, **Chapter 2.1.2.1** has been revised to indicate that if the right whale CH or SMAs boundaries are changed, BOEM would revise the closure areas to align with those boundaries. BOEM has also added a discussion of Adaptive Management to the Programmatic EIS (**Chapter 1.7.6** and **Appendix C**, **Section 7**), and if a compelling reason developed to consider expanding the seaward limit for this area, such as a better understanding of the migration routes for the NARW or other marine mammals, on the basis of adaptive management we would consider it in future decision-making.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Scott Kraus, New England Aquarium	NGO-E-13	0.05	Conduct a true cumulative effects assessment, that includes oil and gas seismic operations, wind farm construction and operations, cable laying operations, and newly proposed navy operation areas, all of which will be occurring in the mid-Atlantic, and where the combined effects will be biologically cumulative and potentially damaging,	**Chapter 4.2.2.4** has been revised to address this comment. The cumulative analysis has been expanded to provide a more quantitative consideration of cumulative incidental takes from various activities such as those indicated, including U.S. Navy operations.
Scott Kraus, New England Aquarium	NGO-E-13	0.06	Develop a scientifically based mitigation plan that has adequate observers, survey coverage, contingencies that account for species differences and sighting conditions,	While mitigation observer data should be conducted using acceptable scientific methods, the purpose of the observation is to implement specific mitigation protocols. This observation must focus on a critical assessment zone and on the species identified to be at special risk of impact. The observer protocols are designed to allow the most effective implementation scenario during full operations and within the constraints of a commercial seismic survey. The GOM observer guidelines (most recently issued as NTL 2012-JOINT-G02, January 1, 2012) provide a baseline for data collection and survey methods. The number, observation schedule and survey area will be determined as part of the permitted mitigation plan for each project and will be based on the mentioned physical and biological parameters necessary for effective monitoring of the expected species. Permitting reviews will take into account appropriate observation standards for each project. Physical conditions that affect sight ability are taken into account in the data collection process. BOEM has also added a discussion of Adaptive Management to the Programmatic EIS (**Chapter 1.7.6** and **Appendix C**, **Section 7**) and would use that process to refine the mitigation protocol if warranted based on new survey data, sighting reports, or other information. In addition, the Programmatic EIS uses the best available information to identify mitigation plans for reducing or eliminating the potential for adverse effects. The Programmatic EIS also notes, where applicable, limits to our scientific knowledge about the effectiveness of certain mitigations. Further, each site-specific permit will require additional analyses to adjust mitigation based on the best available information at that time.
Scott Kraus, New England Aquarium	NGO-E-13	0.07	Use updated data to identify biologically sensitive areas where no G & G activities should occur.	We recognize that additional time-area closures or other mitigation measures may be identified in the future based on new data. Each site-specific permit will require additional analyses to adjust mitigation based on the best available information at that time.

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Name, Organization	ID	No.	Comment	Response
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.01	The words **"negligible," "minor,"** and **"moderate"** indicate value judgments which while they are sometimes backed up through more detailed discussions in Vol. 1 Chapter 4 using citations, these citations do not track consistently and clearly back to the summary impact assessments. We feel that any assessment in the DEIS should be directly backed up with either peer reviewed literature or some other qualified accountability. The words "negligible" and "minor" in the DEIS should be always traceable to peer reviewed papers that substantiate the particulars of the specific evaluation.	NEPA requires consideration of both the context and intensity in determining impact significance (40 CFR § 1508.27). However, there is no quantitative, qualitative, consistent, or agreed-upon measure of adequacy for NEPA with respect to characterizing impacts. Although NEPA does not require it, we chose an approach in **Chapter 4.1.2** and defined significance criteria. Significance criteria are judgmental in nature and are defined by these qualitative descriptors. Each time we have applied them we have explained how we reached each judgment. We have assessed environmental impacts within a context of where they occur and by their intensity and duration. Traceability back to, or reliance on peer reviewed papers for substantiation in all circumstances simply is not possible. The citations for sources we have relied upon are reported in **Chapter 6.0** of the Programmatic EIS. Where we have data or information from refereed journals we use it. Whatever we have relied upon we believe it can be defended. NEPA only requires that the data or information be publicly available, which could include data or information in refereed journals, or it could include information in government reports or reported in official communications of various types.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.02	Concerned about the arbitrary use of impact conventions when evaluating an action for its "Level A" or "Level B" threshold. The current standard is used by National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act (MMPA). It is a blunt metric and could use some refinement, but it is the standard. Using it in parallel selectively substituting it with the "Southall Criteria[1]" is confusing and inconsistent, particularly since the "Southall Criteria" is only an initial scientific recommendation and has not yet gone through an EIS review as would be required under the National Environmental Policy Act (NEPA) to be used as a guiding document for this DEIS. The motivation behind using one or the other is particularly confusing when there is such a disparity between the results. We suggest that historic NMFS standard be consistently used throughout the DEIS until that time when the Southall Criteria is complete and has gone through public review as required by the National Environmental Policy Act (NEPA). In summary, NMFS –MMPA Level A and level B criteria should be used exclusively throughout the DEIS. The "Southall Criteria" should not be used until it is complete and has gone through NEPA review.	The Southall criteria are used for impact analysis in the EIS, along with the current NMFS criteria for Level A and B harassment. NMFS is developing new acoustic criteria and agreed to the inclusion of the Southall criteria for comparative purposes. If in the future NMFS authorizes incidental takes for individual surveys under the proposed action, they would use the Level A and B harassment criteria in effect at that time. BOEM is conducting an impact analysis, not applying for incidental takes based on the Southall criteria. There is no requirement under NEPA for impact criteria to undergo "an EIS review" to be used in an impact analysis. The Southall criteria were developed by a group of experts in acoustics and marine mammal behavior and physiology and were released in a peer reviewed publication that has been widely cited in the scientific literature. As noted in the Southall et al. (2007) paper, the historic NMFS criteria were initially developed before there were studies of temporary threshold shift or other auditory impacts in marine mammals. **Appendix H** includes updated information on studies conducted since the Southall et al. (2007) paper was released. Under NEPA, we are obligated to use the best available science, and we would be remiss to exclude the Southall criteria from consideration on that basis. The Programmatic EIS has been revised to indicate that the Southall et al. (2007) criteria are for "injury" (the terminology used in the Southall paper) rather than labeling them as "Level A harassment."

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				Whether the Southall "injury" criteria should be considered to represent Level A harassment is a regulatory decision that is currently being evaluated by NMFS as part of their acoustic criteria development and is beyond the scope of the Programmatic EIS.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.03	Another conceit appears occasionally throughout the DEIS that "marine mammals within the AOI are familiar with vessel noises, so the effects of vessel noises are expected to be negligible to minor." In fact it has recently been determined that chronic shipping noise induces stress in bowhead whales,[5] so the assumption that animals habituate to vessel noise is patently false and should to be removed from both the marine mammal as well as the fisheries sections of the DEIS until proven to be true. All references to "habituation" should be removed from the DEIS, especially where it is inferred as a mitigation strategy because it is not supported by the literature.	BOEM does not agree that habituation as a concept needs to be removed from the Programmatic EIS. However, BOEM agrees that it is not a mitigation strategy and we have reviewed the impact discussions for marine mammals, sea turtles, and fishes to ensure that a conclusion is not based on an unproven presumption of habituation. It is presumed that mammals within the AOI, particularly within areas such as shipping lanes and nearshore waters adjacent to metropolitan areas, such as ports, are familiar with underwater noise produced by diverse vessels. This statement does not imply mitigation but rather baseline conditions. The small incremental increase in the number of survey and support vessels associated with proposed activities operating within the AOI are not anticipated to significantly impact these resources.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.04	There are serious shortcoming in the entire DEIS; While there are sections throughout the document addressing "Cumulative" impacts of the activities, these are considered as "incremental" impacts rather than synergistic impacts.	**Chapter 3.6** and **Chapter 4.1.3** have been revised to further define the scope of the cumulative impacts analysis, specifically to note that synergistic impacts have been considered in the cumulative impacts analysis. The cumulative impact analyses presented in **Chapter 4.1.3** also originally noted "Cumulative impacts, or the accumulation of effects, can result from one or more processes. These processes, as outlined by NRC (2003), include (1) frequent and repeated impacts on a single environmental resource (i.e., time crowding); (2) high density impacts on a single environmental resource (i.e., space crowding); (3) synergistic impacts attributable to multiple sources on a single environmental resource (i.e., compounding impacts); (4) impacts that become qualitatively different once a resource-specific threshold of disturbance has been reached or surpassed (i.e., thresholds); and (5) the progressive loss of habitat resulting from a sequence of activities, each of which has relatively innocuous consequences, however, the environmental consequences accumulate (i.e., "nibbling"). Synergistic impacts were also addressed for each resource during cumulative impact analysis.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.05	Subjecting entire ecosystems to a chronic assault such as noise, physical disruption, or chemical pollution will at some point cause an irrecoverable instability that will crash the system. In this context the DEIS fails to address anything but the immediate or concurrent impacts of an assault, assuming that once the assault has "moved on" or ceased that it no longer has	BOEM and NMFS agree that there are uncertainties regarding the effects of noise on an ecosystem. BOEM and NMFS use the best available information, in addition to sponsoring research and workshops to address these data gaps, in order to fulfill their missions as regulatory agencies. **Chapter 3.6** and **Chapter 4.1.3** have been revised to further define the scope of the cumulative impacts analysis, specifically to note that

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			a measurable impact. While our ability to account for synergistic impacts is rudimentary at best, precaution and empirical evidence would dictate that we factor in synergistic impacts even while we don't entirely understand them.	synergistic impacts have been considered in the cumulative impacts analysis for each resource. In addition, see comment response NGO-E-4:0.04.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.06	Another assumption that is also found in the DEIS is the assumption that "ramp-up" or "soft start" of seismic surveys are effective mitigation strategies. In fact Jochens et. al. (2008) indicates that there was no avoidance behavior with ramp up in sperm whales. This could be due to a number of factors; one possibility being that animals familiar with the seismic survey pulses did not find suitable respite in swimming away from the source so they just waited it out. Thus the assumption that "ramping up" and "soft starts" constitute an effective mitigation should be withdrawn from the DEIS until proven otherwise. All references to "Ramp-up" and "Soft Start" being used as a mitigation strategy should be either pulled from the DEIS, or included with the caveat that there is no evidence that these techniques are effective (until proven otherwise).	Ramp-up (or soft start) is a standard, widely used part of the mitigation protocol for seismic surveys in the U.S. and internationally. It is required in BOEM and BSEE's Gulf of Mexico seismic survey protocol NTL 2012-JOINT-G02 ("Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program") (USDOI, BOEM and BSEE, 2012a), the International Association of Geophysical Contractors guidelines, and country-specific guidelines in Australia, Brazil, Canada, New Zealand, and the United Kingdom. Ramp up is routinely specified as a mitigation requirement in NMFS IHAs and LOAs for seismic surveys. **Appendix C** of the Programmatic EIS clearly notes that ramp up is used mainly as a "common sense" procedure with little information on its effectiveness. BOEM has added a discussion of Adaptive Management to the Programmatic EIS (see **Chapter 1.7.6** and **Appendix C**, **Section 7**); through the Adaptive Management process, mitigation requirements could be revised if new information indicates that they are infeasible or could be made more effective.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.07	The comment on page xviii in the summary, and in section 2.1.3.5, and 4.2.5.1.4 that "there is no permanent damage in fish ears" is incorrect and based on outdated literature.[12] The citation from Smith et. al. (2006)[13] is work done on a goldfish, a freshwater air-breathing fish that resides in turbid environments. The goldfish has been categorized as a "hearing specialist" due to adaptations that are specific to their environment which have no analogies in open ocean fish. So the comment about "fish not suffering lasting hearing damage" and the associated assumptions should be removed from the DEIS. All references to fish not being subject to permanent hearing damage should be removed from the DEIS along with the consequent assumptions associated with the comment because it is not supported by the literature.	We do not agree with the suggestion to remove all statements about lasting hearing damage and the associated assumptions. The basis for this conclusion is not limited to the Smith et al. (2006) paper cited in the comment. Text has been modified in **Chapters 2.1.3.5** and **4.2.5.1.4** to address this comment. Also see **Appendix J**, **Section 5.2**.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.08	There is also the phrase "No mortality or injury is expected in any case because there has been no observation of direct physical injury or death to fishes from airguns" found in the fisheries impacts sections of the DEIS. This phrase is only partially correct, as there is evidence of physical injury of fishes from airguns in McCauley et. al. 2003. And while there may be no direct evidence of fish mortality from airguns, if fish	**Chapter 4.2.5.1.4** has been revised to address this comment. Although McCauley et al. (2003) did observe impact to fish hearing from seismic noise, there are a number of caveats associated with those findings including that the fish were caged and were unable to swim away from the sound source and video monitoring indicated that the fish would have fled the sound source if possible. Additional information about the issue of "injury" to fishes is presented in **Appendix J**.

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Name, Organization	ID	No.	Comment	Response
			sensory systems are compromised by seismic surveys it may lead to intermediate or long term impacts that are not evident immediately after a survey. In this case an absence of evidence does not indicate an absence of harm.	
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.09	The DEIS treats invertebrates very lightly _ almost dismissively. In section 2.1.3.1 the comment is made that "…limited available data assessing physiological effects or biochemical responses of marine invertebrates to underwater noise indicate that serious pathological and physiological effects are unlikely." This is clearly not the case according to Andre et.al (2006)[15] wherein giant squid mortality was directly correlated to seismic airgun surveys. This is clearly a case where the writers of the DEIS were wrong when they assumed that in a paucity of evidence that the impacts would be "**negligible.**" These findings, along with the prior work of Angel Guerra et.al (2004)[16] should be incorporated into the DEIS section 2.1.3.1 and 4.2.1.2.2, and the assumptions revised to reflect the papers. Also in section 4.2.1.2.2 is after citing Payne (2007)17 the comment is made that "this particular species of lobster was not present in the AOI," thus dismissed. While this species of lobster is not present in the AOI, it stands to reason that other arthropods may suffer the same damage under similar exposures – an "assumption" on our part that holds much more water than the blanket use of goldfish hearing as a proxy for all marine teleost fishes found in the DEIS. Also found in section 4.2.1.2.2 and consistent with worrying convention in the DEIS to conflate an absence of data with an absence of harm is the comment that "The BOEM has determined that incomplete or unavailable data or information on the physiological effects or biochemical response of marine invertebrates in the AOI that results from acoustic noise is not relevant to reasonably foreseeable significant adverse impacts or essential to a reasoned choice among the alternatives." This phrase and the assumptions that it substantiates should be pulled from the DEIS as it is only an opinion and not substantiated by the literature. References to acoustical impacts on marine invertebrates – particularly squid, should be updated and included in the EIS to reflect current state of understanding.[31,32,33,34,35]	**Chapter 4.2.1.2.2** has been revised to address this comment. Also, **Appendix J** discusses the limited available information on sound use by aquatic invertebrates and summarizes potential impacts. BOEM has also incorporated into the Programmatic EIS the report, *Effects of Noise on Fish, Fisheries, and Invertebrates in the U.S. Atlantic and Arctic Oceans from Energy Industry Sound-Generating Activities*, from the BOEM-sponsored workshop in March 2012 (Normandeau Associates, Inc., 2012). This report addressed effects of sound on invertebrates.
Michael Stocker,	NGO-E-4	0.10	Sound propagation and noise attenuation in the ocean is a complex topic. Almost any marine setting will exhibit	The acoustic modeling in **Appendix D** included consideration of parameters such as seasonal sound speed profiles, water depth, and

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Ocean Conservation Research			propagation characteristics that defy our ability to model. This may obviate a need for ongoing monitoring during any potentially noisy operation as a matter of course. In lieu of comprehensive regional and temporal sound propagation models to feed with data we must rely on some stock, simple assumptions. Some simple assumptions are used in the DEIS, but given the scope of the proposed actions both in spatial and temporal terms, the simple models used in the DEIS fail to capture the extents of the impacts. One assumption is that sound will propagate in a hemispherical pattern away from the source until the acoustical energy encounters a boundary. The 'broad brush' attenuation formula for this is: 20log10 (*r*1/*r*2) where *r*1 is the reference distance (usually 1 meter) and *r*2 is the subject distance for evaluation. Once the energy hits the seafloor the energy tends to spread in a cylindrical pattern wherein the attenuation formula is 10log10 (*r*1/*r*2). Because the first boundary encountered is the seafloor, the sound levels at a distance within the depth of the ocean directly beneath the source will be more in line with attenuation at 20 dB log10 of *r*. Far field will be more in line with 10log10 *r*. But there is some continuum between these attenuation conditions, so depending on the distance between the receiver and the source the attenuation factor may be closer to 17 in the "nearish field" and 13 in the far field. Additionally, while it is not mentioned anywhere in the DEIS there is a secondary transmission path in the "mixed layer" above the marine thermocline that behaves as a "surface duct." While the propagation in this transmission path is dependent on the wavelength of the source, the angle of incidence, the depth of the mixed layer, and the surface conditions, the attenuation characteristics are more in consistent with the cylindrical model of 10log10 *r*. (see Urick 1983)[18] Transmission in the surface duct, along with the far-field cylindrical propagation highlights concerns in the "nearish" field pertaining to both required "exclusion zones" and the efficacy of marine mammal observers (MMO). It is already impractical to expect MMOs to effectively spot marine mammals at distances over 1000 meters in calm seas during the day. In these conditions a large airgun array with a source level of 229 dB re:1µPa @ 1m (FN.19) would require 10 km to attenuate to 180dB re:1µPa exposure level. 229 dB – 180 dB = 41 dB _ 10log10 (1/13000) = -41dB MMO effectiveness over	bottom sediment type to characterize the Area of Interest. In developing the propagation model presence and strength of a surface duct, presence of a convergence zone, and bottom bounce pathways were all considered. The modeling used to calculate effect ranges and incidental takes accounts for the reverberation and multipath effects cited in the comment. Please see **Appendix D** and **Appendix E** for a detailed discussion. Also, the 120-dB Level B harassment criterion is not used by NMFS for pulsed sources (such as airguns) in the current regulatory framework. NMFS currently uses 160 dB as the Level B harassment criterion for pulsed sources. For additional information on exclusion zones, please refer to the Final BO (**Appendix A**). Individual operators are required to obtain MMPA authorizations before any activities can be authorized. The MMPA authorizations will further define exclusion zones and may require additional mitigations.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			these ranges is not just impractical, it is improbable. So it is clear that in most situations a large capacity survey cannot avoid subjecting any marine mammal within 10 km to Level A harassment exposures from either the surface ducting or the cylindrical propagation of acoustical energy. If you add the "second hit" from the reflected sound off of the sea bottom, and the direct noise from the hemispherical propagation, the receiver is hit with at least three distinct wave fronts from multi-path sources (all three transmission paths have differing geometrical lengths as well as different transmission speeds due to temperature, pressure, and salinity factors). These three paths need to be integrated into the Sound Exposure Level (SEL) metric in the near-to-intermediate field. Additionally, due to the various transmission artifacts there may be situations in the far field in which the noise from the surveys are not heard as distinct pulses, but as a continuous noise due to reverberation and multipath effects.[20,21,22,23] Because the noise would be continuous it should be mitigated under the 120dB "continuous noise" exposure threshold, particularly since the surveys will likely be occurring around the clock anyway. These considerations preclude the use of large capacity seismic surveys if Level A harassment conditions are to be avoided. Sound propagation models of seismic surveys should account for reverberation and multipath effects in the far field. If the far field noise artifacts are not distinguishable as discrete pulses then the noise criteria should fall under the 120dB mitigation threshold for continuous noise.	
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.11	Regarding the mitigation strategy of separating the survey vessels by more than 40 km: While the model was not clearly articulated it appears that the DEIS used the hemispherical attenuation factor of 20log10 r to derive the 40 km "mitigation" strategy. A more accurate model for this setting is to determine what the exposure level would be at the midpoint (20 km) between the two survey vessels. We assume that a source level of 235 dB (convergence in the far field is not influenced by the directivity of the array). Using the hemispherical propagation model: 20log10 (1/20000) = 86dB → 235 dB – 86 dB = 149 dB re:1µPa Each survey would contribute 149 dB to the system, which at the mid-point between them would yield 152 dB (adding two equal sound levels increases the overall level by 3 dB). But as we know, far field propagation is not	**Chapter 2.2.2.3** states that the 40-km (26-nmi; 25-mi)separation distance was based on an operational limit to eliminate overlapping reflections received from multiple source arrays established. The separation distance under Alternative B was created by rounding up this typical "operational" separation distance to 20 km (10.8 nmi; 12.4 mi), then doubling it. We believe it to be a reasonable and prudent protective measure; however, industry has, in certain areas such as the North Sea, developed timeshare guidelines to address interference problems. BOEM may not apply this specific measure programmatically. Instead, BOEM will consider the value of this measure at the site-specific NEPA and environmental analyses level as well as any new information available at that time. This evaluation will also consider any potential aggregate effects from existing permitted surveys (if any). The calculation of attenuation of the acoustic wave energy due to geometrical

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			hemispherical, rather it is more cylindrical. Using exclusively the cylindrical model: 10log10 (1/20000) = 43 dB → 235 dB – 43 dB = 192 dB re:1μPa Each survey would contribute 192dB to the system, which at the mid-point between them would combine to add +3 dB yielding 195 dB – well above the 180 dB exclusion zone. (These levels would also be significantly beyond the visual reach of MMOs.)	speeding is a very simplified way to generate a rough estimate of the received levels at a distance from the source. The type of spreading loss to consider, spherical or cylindrical, depends on the configuration of the wave front. Near the source, up to the distance equal to the water depth, it would be a hemisphere, at larger distances it would be more like a cylinder. Therefore, it is a common practice to use a combination of spherical and cylindrical spreading models. Consider a 100 m deep environment. At 20-km distance from the source, one can expect the transmission loss due to spreading to be 20*log10(1/100) + 10*log10(100/20000) = -40 + -23 = -63 dB loss, which leads to a received level of 235 dB – 63 dB = 172 dB + 3 dB = 175 dB. Unfortunately, using a simplified method, such as geometrical spreading, to calculate attenuation ignores a number of other factors that influence sound attenuation and that further decrease received levels. More accurate methods, such as the modeling done for this Programmatic EIS, are available. In our experience with many modeling studies and field measurements we never encountered such high levels, as suggested, at that distance. BOEM does not expect concurrent surveys in nearby areas to be a common occurrence.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.12	In Section 2.1.3.1 (associated with chapter 4.2.1) evaluating the impacts of Alternative A, the statement is made regarding the lack of pressure gradient sensors in most marine invertebrates. It is known that many invertebrates have particle motion sensing systems. It is also mentioned that there is limited data on the vulnerability of these sensing systems to mechanical damage, and with this lack of data the writers of the DEIS assume therefore that marine invertebrates are “unlikely” to suffer physiological or pathological impacts from noise exposure. Unfortunately most of the data we do have on the impacts of large vector particle motion on marine invertebrates is limited to intertidal animals and coastal animals such as lobster, shrimp, clams, scallops, and octopus which would have evolved sensory systems adapted to coastal turbulence and crashing waves and thus not necessarily vulnerable to high amplitude, coherent-vector particle motion. But there has been a correlation to squid mortality and damage associated with seismic airgun surveys, so the blanket assumption that damage to marine invertebrates “is expected to be negligible” is an assumption that is not supported by the range of evidence [24]	Text has been added to **Chapters 2.1.3.1** and **4.2.4**, to further discuss impact to invertebrates. However, based on the Significance Criteria definitions for benthic communities included in **Chapter 4.2.1.2**, the impact level is anticipated to range from negligible to negligible-minor. In addition, text addressing particle motion has been added to **Section 7** of **Appendix J**.
Michael Stocker, Ocean	NGO-E-4	0.13	In Section 2.1.3.2 (associated with chapter 4.2.2) regarding the impacts of boomer, chirp, and sub-bottom profilers, and multi-	All of the active acoustic sources and all marine mammal groups were considered in the incidental take modeling in **Appendix E** and evaluated

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Conservation Research			beam depth sounders, the statement is made that "some of [these] are expected to be beyond the functional hearing range of marine mammals or would be detectable only at very close range." With the exception of the multi-beam depth sounders, these other sources would be detectable by odontocetes and should be evaluated for impacts. Boomers, chirp, and sub-bottom profilers, should be more closely scrutinized in terms of their respective impacts on odontocetes.	in the impact analysis. Level A and Level B take numbers were calculated for representative sound sources including electromechanical sources such as boomers, chirp, and sub-bottom profilers and multi-beam depth sounders. Multi beam depth sounders are not the only equipment that may operate at frequencies beyond the functional hearing range of marine mammals; side scan sonars operating at 400 kHz and chirp subbottom profilers operating at 200 kHz would also be above the hearing range of all marine mammal groups (see **Appendix D** for operating frequencies used in the analysis).
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.14	Also in Section 2.1.3.2 the Level B impacts of vessel noise is discounted by the fact that Level B impacts from seismic surveys and other active noise sources have been accounted for. While numerically the exposure levels may have been accommodated in the Level B exposure criteria, this is an over-simplification of the response of animals to increasingly complex noises. It is likely that a fully operating seismic survey with system calibration signals, sea-floor profilers, and various other noises added to the sum of the noises of the vessel would have a more pronounced behavioral impact than the simple exposure impact of each of the sounds separately. It would stand to reason that a complex and varying sound field would have greater impacts than the impacts of just sound type at a specific amplitude – even if each one of them was at or below the Level B harassment threshold. Response to sound quality rather than level alone is substantiated in Frankel and Clark (1998).[25] (This argument appears in section 4.2.2.2 p.4-58 under Vessel Noise Evaluation as well.) A more accurate (but equally simplistic) model would treat each noise source that exceeded the Level B harassment threshold as a separate Level B harassment.	The commenter makes a valid point that complex noises or different noises operating simultaneously may have a different impact on the animal than single source noises. Currently, the scientific community does not understand how these complex noises or different noise sources operating simultaneously impact animal behavior responses. BOEM and NMFS believe that they have utilized the best model and approach to analyze the effects of the various active sound sources on the environment. Sound quality is discussed in this EIS, as the comment noted, in **Chapter 4.2.2.2**. The impact assessments and tools used for those assessments included in the Programmatic EIS are based on NOAA's current acoustic guidelines. When NOAA revises their regulatory criteria, we will adapt to meet new regulatory requirements.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.15	While it is not entirely within the range of our acoustical impacts evaluation, under the same section 2.1.3.2 regarding accidental oil spills that "marine mammals would be expected to avoid areas of heavy fuel sheen" and thus the impacts would be "negligible to minor." Avoidance behavior of oil-sheen waters has not been confirmed and would not necessarily be an evolutionary adaptation. The "avoidance behavior" assumption should be pulled from the DEIS along with the assumptions that the comment substantiates.	This assumption has been deleted from the Programmatic EIS. **Chapter 4.2.2.3** further discusses potential effects of accidental oil spills on marine mammals. BOEM and NMFS agree that there is little data regarding the effects of oil spills on marine mammals and their behavior in the case of an oil spill. However, BOEM and NOAA cite the best available information.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.16	In Section 4.2.2.2.2 "Evaluation" (p.4-52) the comment is made referencing Au and Hastings (2008) that mammalian ears "behaves like an integrator with an integrator time constant," which in the paper is determined to be 100 ms, and through this mechanism a 10ms pulse integrated over 100ms represents a 10dB decrease in exposure (presumably impacts). While this does mathematically work into the "Sound Exposure level" metric[30] this metric is for physiological impacts only, there is no evidence of decreased stress from repetitive exposures of "short duration shocks" over longer pulses.	Integration time is a physiological component that affects the amount of sound energy the ear can process over a given time interval. Because the signal is less than the integration time, the perceived sound level is an average value of the sound pressure received during the integration time. Because this is a physiological description of how the ear processes received acoustic energy, even for behavioral effects and masking, the short duration of the signal will affect the perceived sound level by the animal. The calculation is not intended to address repetitive exposures, but rather to account for how very brief signals will be perceived by an animal.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.17	In the same section, p.4-53 "Level A Incidental Take Estimates" are referenced to Tables 4-9 and 4-10. These tables variously refer to either the "Southall criteria" or the "180dB criteria." The reason for choosing one over the other standard is not clear here, except that the "Southall Criteria" numbers are all significantly smaller. As mention before, the Southall Criteria should not be used until complete and approved through NEPA review.	The text following the citation of **Tables 4-9** and **4-10** has been revised to indicate that the Southall criteria are presented "for comparison" after the estimates using the current NMFS criteria. See the response to comment NGO-E-4:0.02 for an explanation of why the Southall criteria are included.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.18	In this same paragraph regarding the use of "other equipment, including sub-bottom profilers, side-scan sonars, and depth sounders" concurrently with airguns would have no additional impacts because "airguns represent the highest energy source" this "it is reasonable to assume that there would be no additional take from the electromechanical sources operating concurrently." As indicated above it is a faulty assumption based on noise level exposure alone - we can assume that like humans, other animals respond negatively to the complexity of any agonistic signal. Additionally, the noises of the other electromechanical systems are operating across different frequency bands which would not necessarily be masked by the low frequency noise of airguns. Concurrent noise sources are not a set of individual exposures, rather they all contribute to an entire soundscape. These "holo-phonic" impacts will be far greater than individual sound sources or even the sum of concurrent sound sources. In this context a survey operation with two or more boats and an array of profilers and multi-beam sonars should be evaluated across the entire noise spectrum, and over the entire time of the operation. In this context many of these surveys would qualify as "continuous noise sources, and thus subject to the 120dB mitigation criteria. Complex noise exposures should be integrated as a complete	**Chapter 4.2.2.2.2** has been revised to indicate the possibility that sounds emitted by the other electromechanical systems may operate across different frequency bands that would not necessarily be masked by the low frequency band of airguns. The complexity of the integrated sound field or "soundscape" referred to in this comment is not feasible or appropriate to model in a programmatic document since there are so many different possibilities of equipment combinations to be used for various surveys. If appropriate and depending on the acoustic criteria in effect at the time, the sound field from multiple sources could be modeled for individual surveys and use the specific sound sources proposed for the individual survey. The use of the 120-dB continuous noise criterion for Level B harassment is not appropriate for seismic surveys based on the current regulatory framework. NMFS currently uses 160 dB as the Level B harassment criterion for pulsed sources. NMFS is in the process of developing new acoustic criteria for Level A and Level B harassment. BOEM will apply these new criteria once they are finalized.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			sound field over time rather than taken as a set of discrete noise sources. As such most seismic surveys would be considered "continuous noise sources" in the far field and should be subject to the120 dB Continuous Noise mitigation criteria.	
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.19	In the "Conclusion" section the airgun evaluation it is stated from Tables 4-10 and 4-11 that "Incidental take calculations presented in for seismic airgun survey-related noise may be "conservative" because the exposure evaluations "do not consider functional hearing sensitivity ranges for the various species and so assume that all of the species are equally sensitive to received sound frequencies and levels." While it is true that various animals have adapted to their own acoustical niches, we must assume that these animals reside in a complete bio-acoustic habitat with other animals and that the receivers are not just individual subjects in a test environment. It would actually be more realistic to state that the auditory thresholds of odontocetes have been determined by way of captive animals that have been habituated (trained) to respond to operant conditioning and to cooperate with Audio Evoked Potential auditory testing. These individual animals only approximate the hearing responses of wild animals which often respond as a group to sound stimulus and are adapted to be more responsive to environmental sounds.	We believe the referenced sentence in the Conclusions section is reasonable. Considering only the 180 dB and 160 dB criteria, marine mammals could be counted as incidental takes even if the sounds they are exposed to are not within their hearing range. However, the Programmatic EIS recognizes that animals could be indirectly and more subtly affected as indicated in the comment. Within **Chapter 4.2.2.2.1**, Significance Criteria, of the Programmatic EIS, is a subsection titled Stress, Disturbance, and Behavioral Responses that presents a summary of studies relevant to marine mammal hearing capabilities. While the statement suggested in the comment is pertinent to some studies, those represent only a small portion of the information available. In addition, information pertaining to potential differences in hearing responses between captive and trained individuals, and wild animals that may be functioning acoustically as an integral part of a group has been added to **Chapter 4.2.2.2**.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.20	The auditory responses of mysticetes have only been approximated by way of anatomical studies of dead animals and modeled from other vertebrate hearing and thus the auditory threshold models do not clearly represent the entire auditory response capabilities of living baleen whales residing in their natural habitat.	It is certainly correct to note that anatomical studies of the auditory structure of mysticetes are a valuable source of information in helping to understand their hearing capabilities. While direct measurements of the hearing in mysticetes have not been made, there are other sources of information available to help in estimating their hearing range. Please see **Appendix H** for a more complete discussion.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.21	In the same section p.4-55 in is insinuated that animals with differing hearing priorities would have the chance to evade a slow-moving seismic operation to "avoid exposure to injurious sound levels." What is not taken into consideration is the likelihood that most animals are in a particular area because they need to be there – for feeding, community coherence, family bonding, and breeding opportunities. Forced relocation due to exposure to agonistic stimulus undoubtedly increases stress, compromising metabolic, social, and immune system functions.	Text has been added to **Chapter 4.2.2.2** to address this comment.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.22	On p.4.56 referring to the "non-airgun HRG surveys" impacts conclusion section, the statement is made that "Level A take estimates that were calculated utilizing only the 180-dB criterion do not consider functional hearing sensitivity ranges for the various species and so assume that all of the species are equally sensitive to received sound frequencies and levels." This statement appears to be a specious attempt to soft-pedal exposure impacts. The decision to use the "180 dB Criteria" as a mitigation threshold is an accepted, historical standard predicated on a known auditory thresholds found in captive animals. It was chosen as a mitigation threshold after long deliberation. Deconstruction of this standard for the purpose of this DEIS is inappropriate.	BOEM agrees that the 180-dB criterion is the accepted threshold and that is why it was used in developing the take estimates. The statement was made to illustrate the conservative nature of the Level A take estimates as some of the incidental takes are for equipment used during non-airgun HRG surveys that would be outside the hearing range of some species.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.23	On p.4.56 referring to the "non-airgun HRG surveys" impacts conclusion section, the statement is made "assuming selective avoidance of the sound source by individual animals and operations within an open ocean environment" is implied as a mitigation strategy. This is not a mitigation strategy; rather it is why mitigation strategies are required. This statement should be pulled from the DEIS along with the assumptions it purportedly substantiates.	BOEM appreciates the comment and edits have been made to the section. The pre- and during-operation visual monitoring surveys are designed as a mitigation measure. Active avoidance of the sound source by animals may occur but is not mitigation.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.24	In the evaluation of noise impacts from "Vessels and Equipment Noise" p.4-57 that "broadband source levels for most small ships (a category that would include seismic survey vessels and support vessels for drilling of COST wells or shallow test wells) are anticipated to be in the range of 170-180 dB re 1 µPa at 1 m and source levels for smaller boats (a category that would include survey vessels for renewable energy and marine minerals sites) are in the range of 150-170 dB re 1 µPa at 1 m (Richardson et al., 1995)." As these operations are continuous and not periodic or pulse noises the mitigation threshold would be 120dB re: 1 µPa, so the exclusion zone in the loudest instance would be: 180dB – 60dB = 120dB 20log10 (1/1000) = -60dB or 1000 m for spherical propagation, and 13log10 (1/40000) = -60dB or 40 km for far field propagation per our earlier argument.	BOEM agrees that much of the vessel and equipment noise is continuous. However, it is not a source regulated by NMFS and therefore exclusion zones are not incorporated. We have revised the text in question in several locations to include consideration of these sources of continuous noise, and to provide estimates of radial distances and rationale for such calculations. In project-specific cases where vessel and equipment noise may be of concern, BOEM will consider the acoustic effects from these activities in further detail at the site/ permit-specific level.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.25	On p.4-57 is the statement: "Drilling-related noises from semi-submersible platforms in deeper waters ranges in frequencies from 10 to 4,000 Hz, and therefore audible to all cetacean and pinneped species within the AOI. Drilling sound source levels from semisubmersible platforms are estimated at 154 dB re 1	BOEM appreciates the logic provided regarding drilling, semi-submersibles, and thrusters. However, the purpose of this EIS is not to analyze for exploratory drilling or drilling-related noise. The amount of drilling activity expected as part of the scenario in **Chapter 3.0** is very modest – e.g., in the case of COST wells, between 0 and 3 deployments

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			µPa-m. Source levels for drillships have been reported to be as high as 191 dB re 1 µPa during drilling. It is expected that marine mammals would detect drilling-related noises within a radius of audibility." This statement needs to be clarified: Semi-submersible platforms are stabilized by way of thrusters, which have not been characterized in the literature, nonetheless with a source level of 191dB and due to the continuous characteristic of the noise will need to be mitigated at the 120dB exclusion zone, not just "within a radius of audibility." Given: 191dB – 69dB = 120dB 20log10 (1/2850) = -69dB or 2.85 km for spherical propagation, and 13log10 (1/200000) = -69dB or 200 km for far field propagation per our earlier argument. Of course this is a simple model and does not account for frequency-dependent sound absorption over distance, but is also does not account for surface channel propagation or effects of multipath propagation over distance. The appropriate use of the 120dB mitigation threshold would preclude the use of semi-submersible platforms in the Area of Interest for exploratory drilling, and in the future for extraction and production. Semi-submersible drilling platforms and thruster stabilized drilling ships need to be evaluated for noise contribution while in operation and due to the continuous noise characteristic of their thrusters, and need to be mitigated at the 120dB re 1 µPa exclusion criteria.	as shown in **Table 3-9**. A detailed acoustic analysis is not really necessary at the programmatic level based on the level of activity anticipated. In those project-specific cases where drilling operations are proposed and where the sound source and propagation may be of concern, BOEM will consider the acoustic effects from these activities in site/permit-specific evaluations of individual survey applications. Text has been added to the section to note noise attenuation conditions, approximate radial distance, and the fact that BOEM will evaluate project-specific noise sources, as necessary.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.26	NMFS –MMPA Level A and level B criteria should be used exclusively throughout the DEIS. The "Southall Criteria" should not be used until it is complete and has gone through NEPA review.	Please see the response to comment NGO-E-4:0.02. Briefly, there is no requirement under NEPA for impact criteria to undergo "a NEPA review" to be used in an impact analysis. BOEM is conducting an impact analysis, not applying for incidental takes based on the Southall criteria. The Programmatic EIS has been revised to indicate that the Southall et al. (2007) criteria are for "injury" (the terminology used in the Southall paper) rather than labeling them as "Level A harassment." Whether the Southall "injury" criteria should be considered to represent Level A harassment is a regulatory decision that is currently being evaluated by NMFS as part of their acoustic criteria development and is beyond the scope of the Programmatic EIS.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.27	Sound propagation models should include provisions for surface duct transmission paths in seismic surveys, and thruster-stabilized platform and drillship operations.	The presence, or absence, of a surface duct is an important aspect of the propagation component in acoustic modeling, and has been addressed in **Section 5.1.1** of **Appendix E**. Platform and drillship operations are not included in the modeling as they are beyond the scope of this EIS.
Michael Stocker, Ocean	NGO-E-4	0.28	Exposure to the same seismic signal that arrives at the receiver as multiple signals due to time domain differences in direct,	Please see **Appendix D** and **Appendix E** which address all of these factors in their discussion of sound propagation.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Conservation Research			reflected, surface, and SOFAR ducting should be considered separately and figured into the overall Sound Exposure Level (SEL) metric.	
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.29	Expecting MMOs to effectively find marine mammals at night or in exclusion zones greater than 1000 meters is impractical even in calm sea states. Seismic survey operations should be limited to times and conditions in which MMOs can actually locate marine mammals within the prescribed exposure-dependent "exclusion zone".	BOEM agrees that PSOs cannot always effectively monitor an exclusion zone if visibility is limited, zone size is large, or sea states are high. The airgun survey protocol specifies that operators cannot initiate start-up procedures at night or when they cannot visually monitor the exclusion zone for marine mammals and sea turtles if the minimum source level drops below 160 dB re 1 μPa. In addition, Alternative B, which has been identified as the Agency's Preferred Alternative, includes the required use of PAM at all times for airgun surveys. Additionally, if BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility for non-airgun HRG surveys using sources operating at or below 200 kHz, effective monitoring technologies would be required which could include shipboard lighting, enhanced vision equipment, night-vision equipment and/or PAM. These techniques help locate animals when visual conditions are not ideal. Prohibiting all survey operations at night is not feasible based on the operational requirements for broad scale surveys that may require months of 24 hour days to complete.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.30	Under any airgun operation the noise propagation models used in the Final EIS should be verified in the field with acoustical monitoring both in the near and far fields until there is confidence that the EIS models represent the actual noise propagation in the field.	The Seismic Airgun Survey Protocol has been revised to require that operators establish an exclusion zone for each survey. The zone shall be calculated independently, be based on the configuration of the array and the ambient environment, but shall not have a radius of less than 500 m (1,640 ft). In some cases, field verification or modeling may be conducted for non-airgun HRG acoustic sources. Please refer to **Chapter 2.0** and **Appendix C** for the clarified mitigation requirements.
Michael Stocker, Ocean Conservation Research	NGO-E-4	0.31	It appears from the forgoing that neither Alternative A nor Alternative B will meet safe exposure criteria established under the Marine Mammal Protection act, and will cause significant habitat and wildlife damage. This should be avoided.	BOEM has cooperated with NMFS during the preparation of the Programmatic EIS to ensure that resources under its jurisdiction would be adequately protected. BOEM has concluded its Section 7 Consultation under the Endangered Species Act with NMFS and FWS to ensure that the proposed action would not jeopardize the continued existence of a listed species or destroy or adversely modify critical habitat (see **Appendix A**). Because Incidental Take under the ESA is only issued for ESA-listed marine mammals once the requirements of Section (101)(a)(5) of the MMPA have been met, seismic surveys that could affect ESA-listed marine mammals shall not commence until such time that FWS and/or NMFS have issued the appropriate MMPA ITA and coordinated its requirements with those in any existing or new ESA Incidental Take Statement. Additional mitigation measures can be applied by NMFS and/or FWS and are not limited to the mitigation

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
				measures identified for the alternatives framed for this Programmatic EIS, or to how mitigation measures are defined in it. Based on the mitigation measures included in the proposed action as well as the coordination and consultation process outlined in **Chapter 5.0**, BOEM expects that significant habitat and wildlife damage as indicated in this comment would be avoided.
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.01	The Sierra Club, the oldest environmental organization in the United States, opposes any and all plans to undertake seismic testing along the Atlantic coastline, which would lead to future oil and gas exploration and extraction.	Comment noted.
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.02	Seismic testing would have a detrimental impact on a number of endangered and threatened species as well as any living marine creature, plants and animals.	BOEM has addressed potential impacts on threatened and endangered species as well as other marine life in the Programmatic EIS, which has also been reviewed by NMFS and FWS to ensure it adequately addresses impacts to marine resources under their jurisdiction, including threatened and endangered species. To comply with Section 7 of the Endangered Species Act, BOEM prepared a Biological Assessment that was submitted to NMFS and FWS to initiate consultation. NMFS has prepared a Biological Opinion that evaluates whether listed species are likely to be adversely affected and specifies reasonable and prudent measures to minimize impacts on listed species. NMFS will also review during the permitting process for site-specific activities. FWS concurred with BOEM's determination in the Biological Assessment that the proposed action would have no effect or would not be likely to adversely affect all the federally listed species and potentially affected critical habitats under FWS jurisdiction (**Appendix A**).
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.03	The pressure disturbance of sound waves which travels through a medium by means of particle-to-particle interaction, will distorts sonar communications between whale species as well as dolphins.	**Appendix H** has been revised to provide a discussion of the potential for impacts to marine mammals from particle motion. Because particle motion attenuates more rapidly as it leaves the source than pressure does, after a relatively short distance (within one wavelength of the sound) it will have attenuated substantially and continue to decline at a rapid rate with distance from the source. Any effect as a result of exposure to particle motion (as well as its detection) is very likely to only occur very close to a source.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.04	Right Whales are considered surface feeders. The physical waves of seismic testing would destroy the whales' food source as well as their communication. The Right Whale migrates from Florida all the way north to Nova Scotia, Canada each year. Scientists who have dedicated most of their professional careers to studying these mammals do not know their location at any given point and time. Those individuals involved in "seismic testing" hardly could know!	North Atlantic right whales feed on zooplankton, and seismic surveys are not expected to have significant impacts on these populations. Also, the main feeding grounds for the NARW are located offshore Canada and the northeastern U.S., which are outside the Area of Interest. Although the location of individual right whales may not be known, surveys have documented the population distribution, migratory corridors, and principal feeding, breeding, and nursery areas. That information provided the basis for NMFS to designate Critical Habitat and identify SMAs. The time-area closures included in Alternatives A and B prohibit seismic airgun surveys in these high use areas during the times when right whales are known to be present and will minimize the chance of exposing right whales to high sound levels from seismic surveys. In addition, each seismic airgun survey would use trained PSOs to look for right whales and other marine mammals.
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.05	(In addition to North Atlantic Right Whales, Loggerhead turtles, and Atlantic Sturgeon) seismic testing and possibly later drilling and installing platforms for oil and gas extraction will impact the entire sea life along the path of the Gulf Stream. One has to understand the movement of the water current along the eastern coastline; such as the Corio lis force, the surface water, which moves at faster pace than the Thermohaline circulation, the "Global Conveyor Belt," which comprises nearly 90 per cent of ocean waters and constitutes the deep water currents (at a depth of 400 m). Not only does any seismic testing interrupt the feeding sources for marine life, it would certainly also destroy Critical Habitat they need to survive. Seismic induced waves inflict heavy damage on the marine environment. It would bring loss of spawning areas and water pollution. One has to remember that the fishing industry makes their living on the seas and brings valuable foods to the nation's tables.	The proposed action evaluated in the Programmatic EIS includes G&G surveys, not oil and gas drilling or platform installation. If Congress directs BOEM to assess the impacts from opening the Area of Interest to oil and gas lease sales, the environmental issues raised by those activities would be addressed at that time in multiple future NEPA evaluations. Potential impacts on critical habitat are evaluated in the Biological Assessment and the Biological Opinion (**Appendix A**). Potential impacts on fisheries resources and Essential Fish Habitat are evaluated in **Chapter 4.2.5** and potential impacts on Commercial and Recreational Fishing are evaluated in **Chapters 4.2.7** and **4.2.8**, respectively.
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.06	Only in the late 1960s was the dumping by the US military of thousands of canisters of chemical weapons into the waters of the East Coast halted. Records show that the military disposed of WMDs for decades, from 1944 to 1970. Off the coast of New Jersey the military dumped containers of mustard gas and nerve gas, off Virginia and South Carolina canisters of arsenic trichloride, white phosphorus, mustard gas and lewisite. When in 1987 hundred of dolphins washed ashore in Virginia and New Jersey beaches with burns similar to mustard gas exposure, a marine mammal specialist believed chemical	We agree that OCS activities must avoid the potential to disrupt ordinance or WMD sites, the locations for which may be poorly documented. These hazardous wastes may be introduced to the biosphere by natural container deterioration that cannot be avoided, but that is likely to result in slow and gradual leakage. The means by which a sudden and high concentration of toxins may be released would be as the result of direct contact or disturbance of the bottom. The proposed activities in this Programmatic EIS are G&G surveys and some limited drilling of stratigraphic wells. Bottom disturbances that are proposed in a permit application would require shallow hazard bottom surveys to

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			weapons dumped in the ocean by the US Army killed these animals. It is a real possibility that any seismic activity will speed up the breakdown of those aged containers and cause leakage. Not only will any dispersal of such toxic chemical cause great harm to marine life, it may also cause major injury, such as severe spastic paralysis and even death if the respiratory muscles become paralyzed in those human workers. To take it one step further: will the American consumer put seafood on their table contaminated with arsenic and other toxic substances?	identify potentially sensitive biologic communities or cultural resources such as shipwrecks as a condition for permit approval. These surveys are fully expected to be able to identify suspect bottom types having a topographic or magnetic signature suggestive of materials disposed on the sea bottom. Such areas may be investigated by remote vehicles or avoided altogether. We do not find credible a claim that seismic impulses have the ability to damage the integrity of ordinance or WMD that has been disposed on the bottom.
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.07	The beaches of New Jersey are their treasure and need to be protected. In addition to loss of tourism in case of a disastrous accident, property values along the eastern seaboard, and particularly to New Jersey, would be astronomical.	The proposed action does not include activities offshore New Jersey. The Programmatic EIS has evaluated the potential impacts from an accidental event, specifically accidental fuel spills as discussed in **Chapter 3.5.2.1**. The Programmatic EIS notes that, based on USCG spill statistics, the likelihood of a spill would be remote and the likely spill volume would be small. The analysis in **Chapter 4.2.9.3** concludes that the potential impacts on recreational resources would be negligible to negligible-minor depending on spill location and the meteorological and oceanographic conditions at the time. In any case, it is unlikely that an accidental spill from activities within the Area of Interest would affect beaches in New Jersey.
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.08	Even if there were to be no seismic testing at the New Jersey coast at the present time, this state and its tourism trade and fishing industry would be impacted by any unforeseen future oil spill, if later drilling was approved along the coastline of Virginia and the Carolinas.	The Programmatic EIS evaluates potential impacts of G&G surveys. Impacts of future activities such as oil and gas exploration and production would require multiple future NEPA evaluations.
Margit Meissner-Jackson, Sierra Club, Ocean County Group	NGO-L-4	0.09	With the ever-increasing evidence of sea level rise along the nation's shorelines one wonders why there is still the push for more oil and gas exploration. There needs to be exploration of alternative energy sources. For your office to claim that you are involved in developing "Renewable Energy Programs" sounds irresponsible. Are you aware that a possible renewable power source is available without damage to marine life and industry? The Gulf Stream transports ca. 1.4 petawatts of heat which is the equivalent of 100 times the world energy demand.	The Programmatic EIS has been written to evaluate the impacts of G&G surveys falling under three programs: oil and gas, renewable energy, and marine minerals. BOEM's Renewable Energy program (http://www.boem.gov/Renewable-Energy-Program/index.aspx) includes studies of the potential development of hydrokinetic energy from waves and ocean currents (such as the Gulf Stream). Any surveys proposed to harness the energy of the Gulf Stream would be evaluated on a site-specific basis in future NEPA documents.
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.01	In particular, we are concerned that the draft PEIS underestimates the risks that seismic activities, especially deep penetration seismic air gun surveys, pose for the critically endangered north Atlantic right whale (*Eubalaena glacialis*). Section 101 of the MMPA provides a mechanism for allowing the incidental (not intentional) taking of "small numbers" so	BOEM has conducted ESA consultation with NMFS to ensure that the proposed action would not jeopardize the continued existence of threatened or endangered species (including the NARW) or destroy or adversely modify critical habitat. The Biological Opinion is presented in **Appendix A** and includes NMFS' reasonable and prudent measures, terms and conditions, and conservation recommendations. Further

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			long as the taking has no more than a "negligible impact" on such species. "Incidental take" authorizations require that regulations be promulgated outlining the (i) permissible methods and the specified geographical region of taking; (ii) the means of effecting the least practicable adverse impact on the species or stock and its habitat and on the availability of the species or stock for subsistence uses; and (iii) requirements for monitoring and reporting. The MMPA does allow takes for those marine mammal species protected as threatened or endangered under the Endangered Species Act (ESA) so long as the taking remains small in number and has a negligible impact on a listed species. The Biological Assessment (BA) prepared by BOEM, with the input from NMFS, has concluded that proposed seismic activities are likely to adversely affect all of the endangered whales found in the proposed activity area, including the critically endangered North Atlantic right whale. The BA concludes that mitigation measures required by BOEM will "be effective in avoiding Level A harassment of North Atlantic right whales by active acoustic sound sources to the maximum extent practicable." However, there is a significant difference between avoiding all adverse effects altogether and avoiding adverse effects to the maximum extent practicable. The former guarantees that harm will not come to any individual right whale, the latter only reduces the risk to individual right whales. Thus, while BOEM may not expect that Level A take, i.e. injury or mortality, will occur, BOEM cannot guarantee that its actions will not jeopardize the North Atlantic right whale. Therefore, SCB disagrees that BOEM has done everything possible to mitigate the impacts of these proposed seismic activities. The critically endangered North Atlantic right whale is particularly vulnerable to masking effects from seismic air gun surveys given the acoustic and behavioral characteristics of its calls. The exposure levels implicated in all of these studies above are lower than the threshold used to evaluate air gun behavioral impacts in the DPEIS. Repeated insult from seismic air gun surveys would occur on top of already high levels of background noise. For individual right whales, and cumulatively for the species, these activities represent jeopardy for the species continued existence.	information about the coordination between MMPA authorization and ESA requirements is provided in **Chapter 1.6.7**.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.02	SCB notes that BOEM has the authority to impose whatever mitigation measures it deems necessary to fully protect the right whale. For example, BOEM could prohibit all seismic activities in the entire South Atlantic planning area when right whales are on their calving and nursing grounds each winter. Such a prohibition would be much more effective than closing only 4% of the project area at certain times of year. Substantially more significant mitigation measures are required because of the extraordinarily wide geographic scale that the impacts of seismic surveys can be felt at by the large baleen whales.	BOEM understands the need to protect the critically endangered NARW. BOEM has conducted Endangered Species Act consultation with NMFS to ensure that the proposed action would not jeopardize the continued existence of threatened or endangered species (including the NARW) or destroy or adversely modify critical habitat. The Biological Opinion is presented in **Appendix A** and includes NMFS' reasonable and prudent measures, terms and conditions, and conservation recommendations. BOEM will consider the Programmatic EIS and ESA findings, as well as other analyses, prior to making any decisions on permitting seismic activities in the Mid and South Atlantic Planning Areas. In addition, BOEM has the authority to impose mitigation measures it deems necessary for the protection of marine mammals that are reasonable and physically and economically feasible. The mitigation measures included in this Programmatic EIS have been developed in conjunction with regulatory agencies, such as NMFS, that have jurisdictional authority. Additionally, in the future each applicant will be required to obtain Incidental Take Authorizations under MMPA, as necessary, in conjunction with BOEM authorization. Prohibiting all seismic surveys in the South Atlantic Planning Area (e.g., to a distance of 350 nmi [643 km; 403 mi] offshore) during the right whale calving and nursery season is not warranted based on the available information about the distribution of right whales. The time-area closure developed for Alternative B encompasses the area designated as right whale critical habitat, as well as the SMAs identified by NMFS regulations and DMAs when they become established. BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat or SMAs (e.g., if they are expanded farther offshore).
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.03	The Programmatic EIS Contains Procedural Shortcomings That Limit the Ability to Review the Underlying Scientific Conclusions Regarding the Impacts of G&G Activities on Marine Mammals. The draft PEIS contains a significant procedural shortcoming, namely it fails to consider a sufficient number of meaningful alternatives discussed in the draft EIS. SCB is concerned that BOEM imprudently eliminated from further consideration several significant alternatives to the proposed action in the draft EIS, leaving the existing document with no meaningful consideration of practical alternatives (other than no-action) to the proposed action. Instead, the EIS only provides two substantive choices: G&G activities throughout the South and Mid-Atlantic OCS and the same with	BOEM evaluated a reasonable range of alternatives in the Programmatic EIS, including three alternatives (A, B, and C) that were analyzed in detail and other alternatives that were eliminated from detailed study with a discussion in **Chapter 2.5** of the reasons for eliminating them (40 CFR § 1502.14). We developed the range of alternatives based on the underlying purpose and need. The construction of our alternatives followed the simple premise that to be a valid alternative it would have to fulfill the purpose and need for the proposed action and be economically feasible and technically viable. Alternatives recommended by the commenter, such as "only conducting G&G in the mid-Atlantic" or "only conducting G&G in areas over 20, 50, or 100 miles from shore" do not meet the Agency's purpose and need as presented in **Chapter 1.4**. In addition, they do not serve any specific purpose in mitigating impacts.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			a little bit more mitigation. As has been upheld in several courts, “the existence of a viable but unexamined alternative renders an environmental impact statement inadequate.” As a result, an agency must “look at every reasonable alternative, with the range dictated by the nature and scope of the proposed action and sufficient to permit a reasoned choice.” SCB is concerned that BOEM did not consider other macro-level options for where and when (both seasonally and over subsequent years) G&G activities might take place. For example, BOEM did not consider in its draft EIS an option for only conducting G&G in the mid-Atlantic or only conducting G&G in areas over 20, 50, or 100 miles from shore. BOEM also eliminated from detailed consideration the possibility of requiring non-air gun acoustic surveys in the Atlantic OCS despite the fact that “some air gun alternative technologies are available now or in the next 1-5 years.”[26] Even if these technologies are not yet perfected, requiring their use in the Atlantic could provide the needed incentive for industry to improve these technologies to the point that they are comparable to traditional seismic air gun surveys. Overall, given the exceptionally high level of marine mammal take anticipated, the failure of BOEM to consider additional options in the PIES beyond (1) conducting seismic throughout the South and Mid-Atlantic planning areas and (2) no G&G seismic activities anywhere does not appear to represent a sufficiently broad range of alternatives, making the PEIS inadequate. Therefore, SCB recommends that BOEM reconsider its overall approach in the PEIS, and in regard to G&G seismic activities, include more detailed hypothetical periods of inactivity to allow marine mammal populations to recover from adverse impacts from G&G seismic activities and fully integrate a research and monitoring program to determine how well the various mitigation measures are working. This should involve comprehensive impact studies before, during and after any seismic activities and an adaptive management program to adjust future G&G activities as more is learned about the impact of such activities on marine mammal populations. Given the uncertainties involved regarding the cumulative impact of anthropogenic activities in the marine environment, the PEIS should have discussed in detail any seismic program alternatives that include a more precautionary approach for undertaking these G&G activities.	In contrast, the time-area closures included in Alternatives A and B were based on avoidance of impacts to NARWs and nesting sea turtles in specific areas that are either protected by laws and regulations (right whale critical habitat and SMAs) or documented as high use areas (sea turtle nesting in Brevard County, Florida). BOEM considered expanding the time-area closures based on areas likely to be of interest to industry as well as information made available since release of the Draft Programmatic EIS that includes BOEM’s 2012 Atlantic resource assessment (USDOI, BOEM, 2012) and NOAA’s cetacean stock assessment. Because BOEM believes Alternative B will provide adequate protection, BOEM has determined that the extent of the closure will remain at 20 nmi from shore.. BOEM has revised the Programmatic EIS to note that these time-area closures would align with any future changes in right whale critical habitat or SMAs (e.g., if they are expanded farther offshore). BOEM has revised and updated the discussion of non-airgun alternatives in **Chapter 2.5.6** and **Appendix C**, **Section 6**. However, as stated in **Chapter 2.5.6.8**, we found that the alternative of requiring non airgun sources would not meet the Agency’s purpose and need because none of the non airgun alternatives currently are economically feasible or technically viable for commercial deployment; all of them being in various stages of development. We do seek an orderly transition by industry toward alternatives to the impulse airgun and permitting incentives are worthy of consideration. Incentives may take the form of selective lifting of certain mitigation measures in the seismic protocol, or operating in an area or at a time that airguns are not permitted. The ability of BOEM to compel an applicant to deploy a specific technology they may not consider as adequate to their purpose has not been tested. BOEM has added a discussion of Adaptive Management to the Programmatic EIS (**Chapter 1.7.6** and **Appendix C**, **Section 7**). As part of its Adaptive Management program, BOEM intends to review the effectiveness of mitigation measures based on monitoring data collected by PSOs during G&G surveys. BOEM will use the process to refine and improve our protective measures.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.04	Second, the draft PEIS states that the review of G&G activities "is programmatic in nature and therefore will not result in an application for an ITA under Section 101(a)(5) of the MMPA." With respect to the ESA, the draft PEIS states that a BA will eventually be provided to the NMFS so that the consultation between the two agencies can begin. However, there is no indication as to whether the BO will be completed prior to the completion of the final PEIS. BOEM states that, instead, the draft PEIS "will serve as a reference for environmental documentation regarding future site-specific actions. Such future documentation will tier off this document in a similar fashion to that under NEPA." As a general practice, it is acceptable for an agency to use programmatic documents as a reference for future, site-specific environmental analysis. As will be discussed in greater detail below, there are significant concerns for the cumulative impact that G&G activities will have on north Atlantic right whales in specific and other endangered marine mammals in general. Therefore, tiering site-specific actions to this larger PEIS presents the risk that the best available science will be lacking in both the PEIS and future, related environmental analyses.	The BA and BO have been included in **Appendix A** of the Programmatic EIS. The discussion of cumulative impacts in **Chapter 4.2.2.4** has been revised to better address impacts to species of concern such as the right whale and other marine mammals.
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.05	By moving forward with the PEIS without the benefit of the NMFS' input, BOEM undermines the ability of the public to comment on the adequacy of proposed mitigation measures. This lack of meaningful review is especially troubling given that the PEIS acknowledges that "incidental take was not modeled for Alternative B" with respect to the effectiveness of mitigation for the north Atlantic right whale. If BOEM and NMFS are only approximating how effective mitigation might be for right whales, then it is difficult to imagine how the public could adequately comment on the proposed mitigation in the PEIS either. Because of these shortcomings, SCB recommends Alternative C as the only alternative in the PEIS that is sufficiently precautionary to fully protect endangered species in the Atlantic Ocean.	As a cooperating agency NMFS has played a significant role in the development of the Programmatic EIS. A team of NMFS personnel has reviewed and commented on several versions of the document prior to its release to the public. In addition, BOEM has conducted Endangered Species Act consultation with the NMFS to ensure that the proposed action would not jeopardize the continued existence of threatened or endangered species (including the NARW) or destroy or adversely modify critical habitat. The Biological Opinion is presented in **Appendix A** and includes NMFS' reasonable and prudent measures, terms and conditions, and conservation recommendations. SCBs support for Alternative C is noted.
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.06	Finally, SCB is concerned that BOEM has not undertaken enough of an effort to address areas where there is a lack of information regarding the impacts of seismic air gun survey activities. NEPA regulations set out an "ordered process" for an agency preparing an EIS in the face of missing information.[31] When there is incomplete information relevant	The Programmatic EIS uses all relevant and available information in its analysis of impacts to marine mammals. The requirements of 40 CFR § 1502.22 for the treatment of incomplete and unavailable information have been met in this Programmatic EIS. BOEM acknowledges that there is incomplete or unavailable information for marine mammals as indicated in **Chapter 4.2.2.1**; however, the information identified as

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			to reasonably foreseeable significant adverse impacts that is essential to a reasoned choice among alternatives, an agency must obtain and include the missing information in the EIS if the overall costs of obtaining it are not exorbitant.[32] The CEQ's regulation furthers NEPA's purpose of ensuring that agencies make "fully informed and well-considered decisions," by ensuring a "widespread discussion and consideration of the environmental risks" of a project.[33] The PEIS does not fully address data gaps that may be critical to the survival and recovery of endangered whales in the Atlantic. SCB believes that given these uncertainties, especially as they may apply to the North Atlantic right whale, that seismic activities should not be permitted at this time, given the large gaps in BOEM's knowledge and information about these key scientific issues.	incomplete or unavailable is not "essential to a reasoned choice among alternatives" (40 CFR § 1502.22). Under NEPA, it is the task of the implementing agency to make this determination, subject to the additional consultations that are required by law. **Chapter 4.2.2** reports what we know about the marine mammals that use the AOI and further supporting information is provided in **Appendix H**. Additional information specifically addressing the NARW was provided in the Biological Assessment (see **Appendix A**).
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.07	SCB hopes that BOEM and NMFS will carefully consider the cumulative impacts of preexisting stressors on north Atlantic right whales as it weighs future seismic activities.	BOEM has considered the cumulative stressors to the critically endangered NARW in the Programmatic EIS and will continue to do so in future, site-specific evaluations.. While the Programmatic EIS addresses this issue, the main vehicle for addressing this concern is the Endangered Species Act consultation process. BOEM has completed that process, and the outcomes can be found in **Appendix A**.
Brett Hartl, Society for Conservation Biology	NGO-E-12	0.08	SCB is very concerned that the conclusion regarding the significance of the impacts of seismic activities does not represent a meaningful, scientific statement because impacts must be evaluated on a species-by-species basis, not in the aggregate. Given that the PEIS provides predicted Level A and Level B take for all relevant species within the Atlantic planning areas, BOEM should also be able to assess whether or not such take reaches a particular threshold of significance by the definitions it has provided. Stating that the impacts to marine mammals will be moderate masks the gravity of the potential takes of all of the threatened, endangered and depleted marine mammals in the proposed activity area. SCB requests that BOEM provide supplemental information addressing whether anticipated take will result in major or moderate impacts for each ESA-listed or MMPA-depleted species.	An extensive modeling effort was done to quantify levels of impact to each marine mammal species. The results of that effort, which includes take estimates for each species, can be found in **Appendices D** and **E**. While the modeling takes into account many variables regarding marine mammals, geographic area, and seasonal changes in conditions, assessing an impact level for each species would require a number of assumptions about the surveys. The level of survey effort for the proposed action is based on received permit applications, what will actually occur may vary. For that reason, this programmatic analysis has assessed impact at the resource level, in this case for marine mammals rather than each species. Additional analysis for each site-specific action will analyze impacts in greater detail as more specific information is made available.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
General Public (sorted by Last Name)				
Peter L. DeFur	P-E-244	0.01	Scallop and surf clam grounds are two of the most important fishery resources; as such, no exploration work should be conducted on such sites, and the oil and gas industry must fund research on the impact of any and all exploration activities prior to the initiation of any exploration work. If any work is carried out near trawling areas, a vessel or commercial expert fisherman must be hired to guide them clear of schools of fish that must be avoided with a wide area of clearance.	The Programmatic EIS does not involve oil and gas exploration, only G&G survey activities. Avoidance of specific fishing areas such as scallop beds or surf clam grounds would be considered by BOEM during evaluation of individual survey applications that involve bottom-disturbing activities. BOEM does not expect that oil and gas or renewable energy facilities or marine minerals borrow sites would be located within such areas.
Peter L. DeFur	P-E-244	0.02	In short, there has simply not been enough study done to examine the long-term effects of the noise produced by air guns on the animals found in the Mid- and South Atlantic region, but the results we do have are distressing.	The Programmatic EIS analyzes potential impacts on marine life of the Mid- and South Atlantic Bights using the best available data. BOEM and NMFS continue to fund research and sponsor workshops to address data gaps.
Lorraine Fleming	P-PHWDE-2	0.01	I'm wondering if you have had the benefit of Delaware's marine spatial planning document? The -- this was a one-year study by graduate students primarily working under Dr. Jeremy Firestone in our University of Delaware' College of Earth, Ocean and Environment.· It was partly funded by the Sea Grant program. Anyway, there was a workshop in November, much like this one, to pick up on information that they might have missed, that people there -- and there were a lot of professional, technical people in attendance. And there were two staff people from your agency there, and I hope you're all talking to each other.	BOEM has reviewed the document. It should prove particularly useful to future site-specific analyses.
Monty Hawkins	P-E-235	0.01	Regarding your agency's assumption that hard-bottom reef doesn't exist in the Mid-Atlantic Bight, please see the following http://www.youtube.com/watch?v=G3nGYeXvkxE for professional video footage. First minute is stills of impacted reef, rest is HD video of a very typical biotic assemblage of MAB hard-bottom reef.	Text has been revised in **Chapter 4.2.1.1.1** to reflect the natural and man-made hard-bottom of the Mid-Atlantic Bight.
Monty Hawkins	P-E-235	0.02	From your agency's report: ".Compared to the South Atlantic Bight, Mid-Atlantic Bight hard bottom habitats are sparsely distributed over the shelf and are composed of bare rock, gravel, shell hash, and artificial structures rather than limestone outcrops covered by algae, sponges, and soft corals.." Presumably, your BOEM's seabed charting will reveal hard bottoms – it's not bare: In fact, its Essential Fish Habitat.	BOEM recognizes that hard bottom habitat exists in the Mid-Atlantic Bight. As discussed in **Chapters 3.5.1.8** and **4.2.1.2.2**, BOEM requires site-specific information regarding potential sensitive benthic communities (including hard/live bottom areas, deepwater coral communities, and chemosynthetic communities) prior to approving any G&G activities involving seafloor disturbing activities or placement of bottom founded equipment or structures in the AOI.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Monty Hawkins	P-E-235	0.03	You might also review http://www.youtube.com/watch?v=-cMC8JVa2Bk&feature=related & http://www.youtube.com/watch?v=n77WF9XQRJM&feature=related for my personal video work. Please know I support both renewable energy development & oil exploration. However, the scientific bog of poor research pertaining to hard-bottom reef fish habitat must be replaced with far better ecological study.	Text has been revised in **Chapter 4.2.1.1.1** to reflect the occurrence of natural and man-made hard-bottom of the Mid-Atlantic Bight. In addition as discussed in **Chapter 4.2.1.2.2**, BOEM require site-specific information regarding potential sensitive benthic communities (including hard/live bottom areas, deepwater coral communities, and chemosynthetic communities) prior to approving any G&G activities involving seafloor disturbing activities or placement of bottom founded equipment or structures in the AOI. This information will identify the location of hard-bottom communities and provide data for mapping of these communities.
Doug Nowacek, Duke University Marine Laboratory	P-E-246	0.01	The take calculations presented in the Programmatic EIS vastly underestimate the numbers of takes that will potentially occur. These calculations were estimated using the criterion of 160 dB RMS received level of seismic pulses. Page xiv in the Summary states, '…Level B harassment (as defined by the 160-dB zone), which could extend up to 15 km (9.3 mi) from a large airgun array and up to 3 km (1.9 mi) from a small airgun array, depending on the geographic location and season modeled.' However, behavioral harassment from a large airgun array could extend much further than 15 km for several reasons. First, some of the most sensitive animals (e.g. beaked whales and harbor porpoises) will experience harassment at levels well below 160 dB. Second, Nieukirk et al (2012) recorded airgun signals out to almost 4000 km away from their source. The received levels of these signals were well below 160 dB, but, as Nieukirk et al. observed, their time and frequency characteristics could interfere with the acoustic lives of some cetaceans. Specifically, the communication signals (e.g. song) of fin, sei, minke and other baleen whales could be masked at levels not far above baseline ambient. Third, unlike the Gulf of Mexico, most of these animals will be naïve to this type of stimulus, making it highly unlikely that they will have habituated to the sound. For these and other reasons, BOEM's 160 dB is not scientifically supportable.	The acoustic exposures and resulting take estimates utilized the 160-dB rms criterion for potential behavioral reactions (MMPA Level B incidental harassment) that is currently accepted by the Federal regulatory agency, National Marine Fisheries Service. The data were also analyzed using the Southall et al. (2007) criteria in case the regulatory agencies update their requirements. The discussion in **Chapter 4.2.2** has been expanded to better address this issue. **Section 4.2.2** of **Appendix H** discusses the issue of auditory masking due to anthropogenic noises.
Doug Nowacek, Duke University Marine Laboratory	P-E-246	0.02	Visual observation alone is an inadequate mitigation tool and must be complemented by passive acoustic monitoring. Barlow and Gisiner (2006) estimated the ability of visual observers to detect beaked whales, for example, is highly dependent on weather conditions. Even in excellent conditions, only 23% of Cuvier's beaked whales were detected on the survey track line by the most experienced scientific observers;	BOEM agrees with this comment and has identified Alternative B, which requires PAM for airgun surveys, as the Agency's Preferred Alternative. Additionally, if BOEM authorizes nighttime operations or if operations continue during periods of reduced visibility PAM or other effective monitoring technologies (e.g., shipboard lighting, enhanced vision equipment, or night –vision equipment) would be incorporated into the Seismic Airgun Survey Protocol for non- airgun HRG sources below

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			less experienced marine mammal observers were considered to have roughly a 2% chance of detecting beaked whales on the track line. It is not surprising that such animals are missed given that they spend most of their time below the surface, but Barlow and Gisiner (2006) also noted that the encounter rate decreases by 101 as sea conditions go from sea state 1 to 5. This is particularly problematic as seismic surveys can occur in almost any sea conditions. In the proposed Alternative A, passive acoustic monitoring (PAM) is described as optional, which is both naïve and inappropriate. PAM has been demonstrated as a reliable and important tool for mitigation of many species during seismic surveys conducted elsewhere in the world's oceans. No observational technique is perfect but visual and acoustic methods combined have complementary strengths. Without PAM, how will any near-source mitigation occur at night? In the fog? In poor weather conditions? Indeed, for operations at night or in poor visibility conditions, governments of other countries require the use of PAM (e.g., Greenland, Canada).	200 kHz to improve detection of marine mammals and further reduce potential impacts to the NARW and other marine mammals.
Doug Nowacek, Duke University Marine Laboratory	P-E-246	0.03	The treatment of the subject of noise-related stress in marine mammals is completely inadequate in the PEIS. The cumulative, synergistic, and chronic effects of elevated noise levels, including those from both "intermittent" and continuous sounds, have been demonstrated to be detrimental to humans and other mammals, affecting hormone systems as well as behavior (Otten et al 2004; Warner and Heimstra 1971), including recent findings specifically for marine mammals (Rolland et al. 2012; Wright and Highfill 2007). The PEIS devotes only four sentences to this subject, even as it acknowledges that vast numbers of such intermittent sounds will be introduced into the marine environment.	**Chapters 3.6.11** and **4.2.2.4** have been revised to provide an expanded discussion of this subject.
Doug Nowacek, Duke University Marine Laboratory	P-E-246	0.04	Given the distances at which impacts will occur and the potential for significant cumulative impacts on a population level, it is imperative that BOEM establish time-area closures and prescribe measures that reduce or cap activities. Remarkably, the PEIS makes no systematic effort to identify important habitat or to propose any time-area closures for species other than the North Atlantic right whale. BOEM should engage in that effort and release its findings for additional public and scientific comment.	The Programmatic EIS identifies critical habitat for threatened and endangered species (see **Appendix A**) and presents extensive information about the habitat requirements of marine mammals, sea turtles, fishes, and other marine life (see individual resource sections in **Chapter 4.0**). The Programmatic EIS also identifies EFH and HAPCs, as well as other MPAs (see **Chapter 4.2.11**). In addition, BOEM has consulted with NMFS and FWS under the ESA and the MMPA, and will consult with ONMS (NOAA) as required by the NMSA at the site-specific level per NMFS's request. All of these processes help to ensure that marine life is protected to the greatest extent practicable by

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				providing measures that reduce harm to marine life and possibly limit activities if warranted by data and analyses as the activities move forward. At the programmatic level, BOEM identified time-area closures for the NARW and sea turtles as appropriate for inclusion in the action alternatives.
Doug Nowacek, Duke University Marine Laboratory	P-E-246	0.05	We support Alternative C given the risk to marine species from G&G activities. However, given the huge spatial extent of the proposed action, the lack of information about potential effects on cetaceans, the naïveté of the animals involved, and the presumed duration of activities, we believe that a carefully controlled, scientific approach should be used to examine the potential effects of the proposed activities in the event that BOEM decides to allow oil and gas exploration. Specifically, we believe that an opportunity exists to conduct an experiment in which a certain area (or areas) are closed to seismic exploration, so that we can compare the behavior of cetaceans in areas that are exposed to such sounds with their behavior in areas without exposure. The first task would be to determine how big an area would need to be closed (see comments above). We recommend the Cape Hatteras Special Research Area (Figure 1), established by the National Marine Fisheries Service due to the high density of cetaceans along the shelf break off Cape Hatteras, as a perfect starting point for such an experimental approach.	Through its Environmental Studies Program, BOEM has sponsored research on impacts of seismic surveys in the GOM and expects to conduct additional research in the Atlantic if the proposed seismic surveys go forward. BOEM is also currently working with NMFS to conduct the Atlantic Marine Assessment Program for Protected Species (AMAPPS) to assess the distribution of marine mammals and other protected species. A discussion of the Cape Hatteras Special Research Area has been added to the Programmatic EIS, and it has been added to **Figure 4-4**, which shows other Habitat Areas of Particular Concern.
Ruth Ann Purchase	P-PHWDE-3	0.01	First of all, there's a request that complete disclosure of all lobbying activity on this subject, as well as international corporations' funding of academic research, of all the offshore research, especially the validity of mitigation measures. The public would like to see who is pushing for this to be done, and who is funding the research itself, who funds the academic laboratories that are doing the research, since we understand that so much of the motivation comes from people who do want to make profit from this work.	The proposed G&G surveys included in the proposed action and the required mitigation activities would be funded by the geophysical companies that apply for survey permits. Research on mitigation is being conducted by many individuals and organizations, including BOEM and NMFS.
Ruth Ann Purchase	P-PHWDE-3	0.02	From the organizations that I participate in, we have understood that many environmental scientists, especially international scientists, are definitively declaring that there is no energy requirement for an increase in natural gas or oil.· And that if the current level of funding dedicated to this particular project alone were dedicated to energy efficiency and energy reduction, less polluting and less damaging processes would develop, which would be more in alignment with the general international environmental recommendations.	Comment noted.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Ruth Ann Purchase	P-PHWDE-3	0.03	The most valuable cultural resources that would be disturbed are not related to modern shipwrecks or tourism, but the ancient cities of the original places – of the original people, and sacred places, which some believe have an ancient wisdom understood, and which modern science ignores, which may be why we're in the dangerous situation we're in today.	**Chapter 1.6.11** discusses the consultation requirements under the National Historic Preservation Act (NHPA). For specific activities included in the proposed action, BOEM will make a determination as to whether the actions could affect historic properties, either those in the National Register of Historic Places or that meet the criteria for listing. If it is determined the action could affect such properties, BOEM will identify the appropriate State Historic Preservation Officer/Tribal Historic Preservation Officer to consult with during the process. Consultation is expected to result in a Memorandum of Agreement outlining agreed-upon measures that the Agency will take to avoid, minimize, or mitigate adverse effects.
Ruth Ann Purchase	P-PHWDE-3	0.04	I would like to know personally if here's anyone here in the room that can answer the question, I would like an answer tonight to be able to take back to people, about the process for disclosure of who's funding the research, and·especially the mitigation aspect, and how Native Americans are being included in the process of evaluating the damages that would be done.	The proposed G&G surveys included in the proposed action and the required mitigation activities would be funded by the geophysical companies that apply for survey permits. Native Americans may be included in the NHPA consultation process for individual survey activities as described in the preceding response. If it determines that a specific proposed action could affect historic properties, BOEM would identify the appropriate State Historic Preservation Officer/Tribal Historic Preservation Officer to consult with during the process. The United States has a unique legal relationship with Indian tribal governments and recognizes Indian tribes as domestic dependent nations under its protection. As domestic dependent nations, Indian tribes exercise inherent sovereign powers over their members and territory. The United States works with Indian tribes on a government-to-government (G2G) basis to address issues concerning Indian tribal self-government, tribal trust resources, and Indian tribal treaty and other rights. BOEM generally does not formally consult with Indian tribal governments for a programmatic EIS because of the broad scope of the proposed actions discussed in the Programmatic EIS, and the lack of a specific Federal action on which to consult. The G2G consultations are further complicated at this stage by the scope of geological and geophysical activities that span three program areas: oil and gas, renewable energy, and marine minerals. While certain analyzed activities are common for all three program areas, others are limited to a specific program area (e.g., seismic surveys using airguns are typically only used in the oil and gas program area). Furthermore, while the Programmatic EIS discusses a range of proposed activities with a range of potential impacts, BOEM will not know the exact nature of an action until it is proposed and evaluated by the bureau. Finally, BOEM has already initiated and held G2G consultations with Indian tribal governments under its Renewable Energy Program area for the Mid-

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
				Atlantic, Rhode Island, and Massachusetts Wind Energy Areas. While there are no Indian tribal government lands on the Outer Continental Shelf in the Atlantic, BOEM does recognize that the proposed actions analyzed in the Programmatic EIS, as well as the potential impacts from these proposed actions, may be of interest to Indian tribes. As seen in **Chapter 5.4**, the Draft Programmatic EIS was sent to federally-recognized tribes in the Atlantic Region that BOEM identified as having tribal or ancestral lands bordering the Atlantic. This action in and of itself does not constitute consultation, but does illustrate a good-faith effort on the part of BOEM to inform Indian tribal governments of the proposed actions. In anticipation of interest by tribes concerning the possibility of future G&G activities in the Atlantic, BOEM is developing a strategy to communicate potential impacts from proposed actions and to provide opportunities for G2G consultation.
Mark Swingle, Virginia Aquarium & Marine Science Center	P-E-190	0.01	We support Alternative C – No Action for Oil and Gas, Status Quo for Renewable Energy and Marine Mineral G&G Activity.	Comment noted.
Mark Swingle, Virginia Aquarium & Marine Science Center	P-E-190	0.02	The DPEIS accurately indicates that there is a very wide range of possible behavioral responses to sound exposure, given that the sound is audible to the particular animal. However, your point that the following list is increasing in severity, but decreasing in likelihood, is questionable when the sound exposure is of the scale involved with seismic exploration: none observable – animals can become less sensitive over repeated exposures; looking or increased alertness; minor behavioral responses such as vocal modifications associated with masking; cessation of feeding or social interactions; temporary avoidance behavior (emerging as one of the more common responses); modification of group structure or activity state; habitat abandonment; and/or injury and/or death via direct response or possibly exacerbated by physiological factors. Southall et al. (2007) found that sounds of 120-150dB can trigger behavioral changes that are not necessarily minor, and occur far from noise sources. Baleen whales response to multiple pulsed sounds (e.g. airguns) showed avoidance, brief cessation of reproductive behavior, aggressive behavior (e.x. tail/flipper slapping, jaw clapping, abrupt directed movement), and brief and extended changes in vocalization. These types of reactions for sounds between 120-150 dB were documented in approximately 60% of baleen whale studies observed in this	Analyses of potential impacts from proposed activities to marine mammals were based on incidental take estimates that were calculated using currently accepted practices, including current spatial and temporal density estimates and available behavioral information by species, sound source propagation modeling to estimate injurious (180 dB) and non-injurious (160 dB) acoustic threshold radii (integrated to estimate areas). Recent literature suggests that individual mammals, such as baleen whales, may demonstrate behavioral effects during seismic surveys at distances that are greater than the modeled 160-dB radii. These responses indicate an error in sound propagation modeling methods and/or the onset of behavioral response at lower sound levels than 160 dB. References have been added to the EIS, where appropriate, to identify this issue. BOEM is undertaking this NEPA process because currently there is no programmatic NEPA coverage for permitting G&G activities in Atlantic OCS waters for all three program areas overseen by BOEM (oil and gas, renewable energy and marine minerals). Because of the level of potential activity in all three program areas, BOEM's proposed action is seeking to gather the most up-to-date and best available scientific information available in order to carry out any G&G activity in a sound manner. BOEM further anticipates that as G&G activities move forward and take place on the Atlantic OCS, an adaptive management plan will be put in place (see **Chapter 1.7.6** and **Appendix C**, **Section 7**) in order to

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			study. Foraging disruption is the behavioral impact most likely to affect long-term health of individuals or populations. Jochens et al. (2008) found that whales may remain at the surface when exposed to sound levels of 160 dB, and may not dive to feed until the sound exposure stopped. The study also found that no tagged whale made a deep dive closer than 4 km from the array. The authors found that a 20% decrease in overall foraging activity is likely to occur near airguns. Additionally, no observable response from a particular individual or group of animals does not necessarily mean the sound is having no effect. Tyack (2008) points out that in addition to acute behavioral responses there is significant risk to populations of marine mammals from less visible effects of chronic exposure. There is risk that this level of seismic surveys will have an impact on marine mammals. The degree of this effect is currently unquantifiable and not fully understood. Since we believe that there is no immediate need for these surveys to take place, it would be irresponsible for BOEM to approve the proposed Action.	continuously review and revise existing mitigations (NTLs, stipulations, conditions) applicable to all lessee/permittees operating on the OCS so that all of the marine environment is adequately protected.
Mark Swingle, Virginia Aquarium & Marine Science Center	P-E-190	0.03	Species density estimates and acoustic modeling were used to report the number of takes per grid block throughout the survey area for all marine mammal species (Section 4.2.2.2). Based on these take estimates, the PEIS reports that the proposed Actions, "would result in negligible or minor impacts to marine mammals" (Sections 4.2.2.2 and 4.2.2.3). According to Section 1.6.7 of the DPEIS, the take data reported will be used to "serve as a reference for environmental documentation regarding future site-specific Actions." Overall, we recognize the efforts the BOEM has made to compile species density data and model the effect of acoustics on protected species. However, we assert that the baseline density data used may be a gross underestimate of actual density due to the lack of sufficient marine mammal sighting data, on a regional and seasonal scale, throughout the proposed G&G survey area. One of the assumptions of the complex acoustic modeling effort used in this study was "animal density estimates would use the best available data, specified by location and season, for the modeling effort." Additionally, the report states that "the AIM (acoustic integration modeling) was used to estimate the impacts per survey block for each species, based on the typical planned geometry for each type of survey in each modeled area	The U.S. Navy's Operating Area Density Estimates (NODE) data are currently the best available data for estimating marine mammal densities in the Mid/South Atlantic Planning Areas. BOEM has used these data within the analyses contained within this Programmatic EIS. The data are also used as part of the marine mammal take estimations via the Acoustic Integration Model (AIM©). BOEM does agree and recognize that there are data gaps in marine mammal density information for these areas. As such, we have partnered with NOAA and other organizations to fund projects to improve biological information on protected species in the U.S. Atlantic. Two notable programs include: • Atlantic Marine Assessment Program for Protected Species (AMAPPS) – This is an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals (cetaceans and pinnipeds), marine turtles, and sea birds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters. The project will also collect similar data at finer scales at several sites of particular interest to NMFS and BOEM. Importantly, AMAPPS also seeks to assess the population size of surveyed species at regional scales and develop models and associated tools to translate these survey data into seasonal, spatially explicit density estimates incorporating habitat characteristics (see http://www.nefsc.noaa.gov/read/protspp/mainpage/AMAPPS/). index.html and http://boem.gov/uploadedFiles/BOEM/Environmental_

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
			where the surveys would be conducted, using the appropriate thresholds for that species." Therefore; the potential physiological and behavioral impacts to marine mammals in this study are being based on a model that relies on accurate animal density estimates. The density estimates were developed as the NAVY Operating Area Density Estimates (NODE) in 2007 (U.S. Dept. of the Navy. 2007). These density estimates were based on the NMFS Southeast Fisheries Science Center (SEFSC) shipboard surveys conducted between 1994 and 2006. Virginia falls under the jurisdiction of NOAA Northeast Fisheries Science Center. While SEFSC surveys do occasionally cover Virginia waters, these efforts are generally limited, conducted on a very broad scale, and usually species specific (most surveys have focused on bottlenose dolphins, *Tursiops truncatus*). The DPEIS identifies Zone 20 extending across the continental shelf from Cape Lookout to the Delaware Bay, including Virginia waters. Many of the species have zero or near zero reported average densities (4.2.2.2), but have regular presence in Virginia stranding and sighting records (Table 1 provided). Humpback whales (*Megaptera novaeangliae*) and bottlenose dolphins are of particular interest, because both our sighting reports and our stranding data are inconsistent with these densities (Figure 1 provided). The DPEIS reports a zero density of humpback whales and a 0.00002 density of fin whales (*Balaenoptera physalus*) in Zone 20; however, using photo-identification techniques, VAQF has documented a minimum of 57 humpback whales and 5 fin whales in near-shore Virginia ocean waters from December 2011 through February 2012. In addition, the DPEIS reports a density of 0.1816 bottlenose dolphins in Zone 20. During 2011, a total of 14,576 km of aerial survey transits resulted in 346 bottlenose dolphin group sightings within Zone 20. The groups ranged in size from 1 to 65 animals and totaled 2,010 individuals (Figure 1 provided). As these examples show, lack of formal survey data from the mid-Atlantic region resulted in a model with large areas of zero and near zero density, despite extensive anecdotal stranding and sighting records. The lack of robust (e.g. consistent and fine scale), yearlong, comprehensive data causes several problems when researchers calculate abundance estimates. First, the lack of yearlong survey data limits researcher's ability to calculate abundance over a	Stewardship/Environmental_Studies/Gulf_of_Mexico_Region/Ongoing_Studies/AT-10-x11.pdf). • BOEM, working with NOAA, has developed the Multipurpose Marine Cadastre, an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system framework (see http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Multi-Purpose-Marine-Cadastre-Map-Viewer/Index.aspx). Ultimately, NEPA requires that Federal agencies use the best available information in environmental impact statements, which BOEM has done. BOEM will continue to monitor the results of AMAPPS and other relevant studies (i.e., NOAA Sound and Cetacean Density Mapping) to ensure any updated data are considered as they become available to support future, site-specific evaluations of individual survey applications.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
			population's entire habitat. Second, visual line-transect data are subject to perception and availability bias, and should not be used to calculate abundance without appropriate methodology to allow for bias correction. However, the NODE density model cited in the DPEIS assumes an availability bias, or g(0), of 1 which underestimates the species density by assuming that there are no animals under the surface of the water (U.S. Dept. of the Navy. 2007b). Finally, survey design of multiple efforts must be conducted from similar platforms using comparable methodology to allow for data compatibility. Existing regional sighting datasets cannot be pieced together to calculate wide-scale population and abundance estimates. The sighting data used in the analysis suffers from these biases and the presence or absence of species in the DPEIS should not be predicted using uncorrected sighting data. Furthermore, marine mammals and turtles, as well as avian species, are migratory animals that have seasonally specific habitats. These habitats have vast ecological ranges, crossing multiple political boundaries, and animals may change behavioral patterns in response to anthropogenic activities. Robust distribution and abundance estimates for migratory marine species must be available on temporal and spatial scales that incorporate all ecological niches for these species. Currently, these data are not available for appropriate EIS or environmental NEPA analyses. There are critical gaps in density data available for marine species population assessments of cetaceans, including critically endangered right whales and other ESA whale species, as well as for endangered sea turtles, shore birds and waterfowl in the mid -Atlantic region. The last comprehensive, year-long marine mammal and sea turtle surveys of the Atlantic coast were the Cetacean and Turtle Assessment The density estimates used in the DPEIS report are in no way an accurate representation of animal density in Virginia waters and therefore it is not sensible to use the results of this model for our area. It would be careless to base a study on noise that has the potential to cause direct behavioral and physiological impacts to marine mammals, including impacts that could lead to death, on a biological model using such limited data. It is important that BOEM work with other federal agencies and NMFS to fill these data gaps and re-create the acoustic model used to predict take numbers, prior to issuing an environmental impact finding for the seismic surveys.	

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
Mark Swingle, Virginia Aquarium & Marine Science Center	P-E-190	0.04	The seismic surveys proposed in the G&G DPEIS are not necessary for development of the WEAs given that BOEM is already authorized to move forward with the less invasive side-scan surveys that meet the needs of benthic studies for wind tower construction.	The comment is essentially reiterating the recommendation that BOEM select Alternative C, which would maintain the status quo for renewable energy and marine minerals surveys while not allowing G&G surveys for oil and gas development. Alternative C is addressed and evaluated in **Chapter 2.0**.
Ginger Taylor	P-PHWNC-43	0.01	Will BOEM post the comments and transcripts in verbatim on websites so all us citizens would have the benefit of them? … I think the fair thing to do for your agency is not -- drag us citizens through the knothole of a FOIA request and volunteer to post -- and volunteer to post it. I've worked with other Federal agencies on DIS and EIS matters, and they do that. Please post it on a website and make it available to all of us.	BOEM has posted the public meeting transcripts, comment letters, emails, and mailed comment sheets on the Programmatic EIS website at http://www.boem.gov/oil-and-gas-energy-program/GOMR/GandG.aspx. The Final Programmatic EIS includes an appendix that addresses all of the comments received during the public comment period for the Draft Programmatic EIS.
Ginger Taylor	P-PHWNC-43	0.02	The second administrative comment is the fact that for several years the US Navy considered construction of a 23 square mile sonar range in the Onslow Bight off the general Morehead City area. There was extensive research done on fish and marine mammal and sea turtle movement through that area and the impact of -- of sonar type systems, of scrubee (phonetic) and explosives on those creatures. Well, the Navy decided not to build that range there, but that data exists. Have you made yourself available of that research?	Information developed by the U.S. Navy for their Environmental Impact Statement was evaluated for use in this Programmatic EIS and incorporated where appropriate.
Ginger Taylor	P-PHWNC-43	0.03	Under Alternative B, you mentioned sea turtles nesting on the Central Florida coast.· Extensive numbers -- I don't know how many hundreds of sea turtles of all species in the Atlantic range nest on the North Carolina coast from Hatteras southward. It's not just a Central Florida issue.	**Chapter 4.2.3.1** discusses the range and distribution of sea turtle species including nesting beaches. Although nesting can occur along most of the shoreline from Virginia to Florida, the highest numbers by far are found in the Broward County area. For that reason mitigation measures focused on that area and this area was included in Alternative B for additional closures. The entire range and distribution of sea turtles were considered in the impact analysis included in **Chapters 4.3.2.2** (Alternative A), **4.3.3.1.2** (Alternative B), and **4.4.3** (Alternative C).
Ginger Taylor	P-PHWNC-43	0.04	You mentioned the Northern Right Whale spawning off Florida. They also spawn off the Southeastern North Carolina coast, not in the numbers they do off Florida, but they give birth -- I'm not -- sorry -- spawn – they calve off the Southeastern North Carolina coast.	As noted in **Figure 2-1**, the U.S. SMAs, several locations are identified, including the area off of North Carolina, are identified as Migratory Route and Calving Grounds. As illustrated in **Figures 2-2** and **2-3**, these areas would be exclusion areas for airgun surveys during these critical times.
Vicki Weeks, Weeks Consulting	P-PHS-1	0.01	As we look at this specific study, I noticed that most of the survey was focused on the seismic airgun but I also notice that electromagnetics are basically involved and in terms of marine mammal navigation I believe we've seen some substantial scientific evidence showing that marine mammals use magnetic orientation in their navigational and biological processes and I don't see that that was at all addressed here. In terms, that's pretty much your operational events.	While magnetotelluric surveys are passive measurement of the Earth's electromagnetic fields, controlled source electromagnetic surveys do induce a low frequency (around 1 Hz) and low voltage electromagnetic signal into the upper layers of the seafloor via a dipole towed just above the seafloor. The signal attenuates rapidly in seawater to a level much below the Earth's magnetic field within meters of the source; therefore, further analysis was not performed.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued)

Name, Organization	ID	No.	Comment	Response
Vicki Weeks, Weeks Consulting	P-PHS-1	0.02	As we talk about the marine mammal population here with regard to this specific seismic exploration, I also noticed that it was no mention of the sea turtles here on Tybee and Coastal Georgia, which I believe we do have a fairly substantial population in this area.	**Chapter 4.2.3.1** provides information on sea turtle populations and discusses nesting along the southeastern U.S. coast including Georgia. **Figure 4-14** shows densities of sea turtle nesting by county, including five Georgia coastal counties. Loggerhead turtles are the most common sea turtle species nesting in Georgia. The relative percentage of total loggerhead nesting in Georgia is 1.5%, compared with approximately 80% in Florida. Nesting of other sea turtle species in Georgia (green and leatherback) is considered to be uncommon.
Vicki Weeks, Weeks Consulting	P-PHS-1	0.03	I know that the coastal bottom dolphins are not listed as a threatened or endangered species, but they are in terms of the tourism in this area, a key draw to people coming to visit the area.	All marine mammals that might be found in the proposed Area of Interest, including a number of species of dolphin, are discussed in **Chapter 4.2.2**.
Vicki Weeks, Weeks Consulting	P-PHS-1	0.04	And when you talk about the incidental taking, the killing is one level of impact but there is also the behavioral changes and those behavioral changes can be substantial to these populations of other marine mammals that are really crucial to our tourism industry here.	A complete discussion of behavioral as well as potential injurious impacts resulting from the use of active acoustic sound sources can be found in **Chapters 4.2.2.2** and **4.3.2.2**. Both Level A (Injury) and Level B (Behavioral Harassment) criteria have been used throughout the Programmatic EIS to calculate the take numbers and for evaluation of impacts.
David K. Wiles	P-E-33	0.01	I found several of the methodological calculations disingenuous. Perhaps the best illustration is the sea turtles at the Archie Carr preserve and the convoluted logic that reduced their 'take' impact to Minor for the entire AOI. The logic that adding the Archie Carr preserve, a relatively small area south of the designated underwater area of G&G interest (less than 5% of total area) for Alternative B compensation in an 'impact' to the total area is an excellent illustration of a series of small mistakes sweeping on to a grand fallacy. The BEOM proposal notes that 25% of all loggerhead turtles are found on the Preserve but, to me, this seems to indicate that the sea waters along the entire Florida coast are affected as these marine mammals swim toward the nesting area. Have BEOM officials thought of currents and tides and waves in their consideration of overall water mass? There is some discussions of 'near shore' and deep water in terms of hatchlings and various species of sea turtles but where is the argument to justify downgrading risk from Moderate to Minor? If the Archie Carr Preserve turtles had contained 75% of all loggerheads would this have reduced the 'risk' to this marine sea turtle even more? To Negligible as far as seismic air gun effect? I would discount Alternative B on the misrepresentation of 'near shore waters off Brevard County' alone.	Alternative B includes a time-area closure of near-coastal waters offshore Brevard County, Florida during the sea turtle nesting season (May 1 through October 31). As discussed in **Chapter 4.3.3.1.2**, potential impacts to sea turtles under Alternative B were reduced from moderate to minor (in comparison with Alternative A) because of the decreases in potential disturbance to dense aggregations of turtles offshore Brevard County. A time-area closure in a relatively small area can change overall impact conclusions if the closure area (and season) consists of a preferred feeding, breeding, or nesting area. The closure area consists of highly used nesting beaches, including a small portion of the Archie Carr NWR, which supports 25% of all loggerhead nesting in the U.S. as noted in **Chapter 4.2.3.1.1**. The seasonal airgun exclusion area extends out to 11 km from shore in the area where a large number of sea turtles mate and rest during the nesting season. The Programmatic EIS evaluates impacts with respect to context and intensity as required by NEPA regulations (40 CFR § 1508.27) as explained in **Chapter 4.1.2** (for all resources) and **Chapter 4.2.3.2.1** (for sea turtles). The impact ratings (negligible, minor, moderate, and major) are provided to summarize the impact analysis and to aid in comparing alternatives. One can disagree with the ratings for individual resources. However, BOEM believes that the change in impact rating for sea turtles under Alternative B is reasonable based on the potential impacts that would be avoided in this area.

Table L-6. Comment Summary and Response Table for Comments Requiring Detailed Technical Response (continued).

Name, Organization	ID	No.	Comment	Response
David K. Wiles	P-E-33	0.02	Two other areas of policy consideration where Alternative B seems particularly weak are the distances imposed for concurrent seismic testing and the 'guidance' from NASA and military operations. The Alternative B proposes a 25 nautical mile distance between concurrent seismic air gun testing. Yet the logic behind such a stipulation demonstrates such distance is speculation and hope. In reality, concurrent testing is likely to be the current best practice of oil and gas explorers of about 9.5 nautical miles. In other words, Alternative B is unenforceable in any practical way.	This Alternative B requirement for separation between simultaneous seismic surveys would be enforced by BOEM through the requirements in the permits that would be issued to operators for each specific survey. Based on the number of small number of applications received by BOEM to date and the large size of the survey area proposed by each operator, the separation distance is reasonable and achievable. Additional guidance regarding NASA and military coordination has been added to **Chapters 2.1.2.8**, **3.8**, and **3.9**.
David K. Wiles	P-E-33	0.03	A final question about the actual implementation of Alternative B would be the relationship of BEOM and NASA or various branches of the military (Navy, Coast Guard) in terms of 'guidance' given one another, especially in the 'closed' seasons. The navy wants an underseas weapons training facility based out of Jacksonville/Mayport Florida that contains much of the water properties as the BEOM exploration. NASA space mission activities also use the Atlantic waters off the eastern seaboard. I believe much of Alternative B calculation of Negligible or Minor 'risk' and 'impact' are problematic to coordination with other agencies and political interests in the use of USA waters.	One of the 13 resource areas addressed in the Programmatic EIS, Other Marine Uses, addresses the potential for conflict among Federal agencies or branches of the military. For Alternative B, that discussion can be found in **Chapter 4.3.12**. BOEM has been in contact with NASA and branches of the military regarding the proposed action, and their input led to changes in **Chapter 2.1.2.8**. They will be consulted during future evaluations of site-specific actions. A new Section has been added to discuss NASA coordination. Reference **Chapter 5.7.7**.
Received After Close of the Public Comment Period				
Oceana and International Fund for Animal Welfare	N/A	N/A	North Atlantic Right Whales (NARW) are present throughout the year off the Virginia coast. NARW were detected outside the bounds of the proposed time-area closure. This new information demonstrates that the assumptions under which the Draft EIS "analyzed impacts, proposed alternatives, and adopted mitigation measures are not justified, and constitutes significant new information for purpose of NEPA. Accordingly, it is now necessary for the Bureau to re-scope the issues and alternatives, and develop a new Draft EIS for public comment prior to advancing further with the Atlantic seismic exploration program." (This comment and associated information was presented to BOEM over one year after the comment period closed.)	The information provided with this comment is based on data that were presented to BOEM's Deputy Director and other key staff on December 6, 2013; however, the data have not yet been finalized, published, or peer-reviewed. The analyses within the Draft and Final Programmatic EIS's currently acknowledge that NARWs can be found outside of the NARW closure areas and throughout the AOI (**Chapter 4.2.2.1.1**). BOEM still believes, based on the best available information at this time, that the 20-nmi NARW closure area provides effective protection to the core migratory areas and NARW critical habitat. Within this final Programmatic EIS, BOEM also added a Level B harassment buffer to the 20-nmi time-area closure, critical habitat, SMAs, and DMAs. Based on the acoustic propagation modeling described in **Table D-22** of **Appendix D**, this may add an additional buffer to the 20-nmi, ranging from 4 km to 15 km. BOEM will continue to analyze the best available information on NARW distribution and seasonality during the site-specific reviews.

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APPENDIX M

SUMMARY OF PENDING ACTIONS AND CHANGES

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1. ENDANGERED AND THREATENED SPECIES: DESIGNATION OF CRITICAL HABITAT FOR THE NORTHWEST ATLANTIC OCEAN LOGGERHEAD SEA TURTLE DISTINCT POPULATION SEGMENT (DPS) AND DETERMINATION REGARDING CRITICAL HABITAT FOR THE NORTH PACIFIC OCEAN LOGGERHEAD DPS

The U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) have recently proposed terrestrial (i.e., nesting beaches) and marine critical habitat designations, respectively, for the Northwest Atlantic Ocean Distinct Population Segment (DPS) of loggerhead sea turtle. The FWS proposed terrestrial critical habitat (nesting beaches) in proposed rulemaking issued on March 25, 2013 (*Federal Register*, 2013a). NMFS proposed critical habitat for the Northwest Atlantic Ocean loggerhead turtle DPS, which includes individuals found within the Area of Interest (AOI), on July 18, 2013 (*Federal Register*, 2013b). This proposed designation includes 36 marine areas consisting of a combination of four critical habitat types: nearshore reproductive habitats, winter areas, breeding areas, and migratory corridors. The general location of nesting beaches identified by FWS is shown in **Figure M-1**; detailed maps of the 36 areas are provided in the FWS proposed rule announcement (*Federal Register*, 2013a). Marine areas within the AOI proposed for critical habitat designation by NMFS are shown in **Figures M-2** through **M-8**.

Four important habitat types associated with the proposed critical habitat designation have been defined as follows:

- **Nearshore Reproductive Habitat:** These units are those directed at conserving hatchling swim frenzy and internesting turtle habitat directly off high density nesting beaches and beaches adjacent to them, as defined by FWS in their proposed rule to designate critical habitat for the loggerhead sea turtle (*Federal Register*, 2013a); this habitat extends from the shoreline (Mean High Water) seaward 1.6 km (1 mile).
- **Winter Habitat:** The physical and biological factors (PBF), water temperature primary constituent elements (PCE), and Gulf Stream boundary PCE of the winter habitat for loggerhead sea turtles; the best available data indicate that the area south of Cape Hatteras is an important winter concentration area, especially for turtles from the Northern Recovery Unit and other Recovery Units that may forage in northern waters.
- **Breeding Habitat:** The PBF of a concentrated breeding habitat and the associated PCE of high concentrations of reproductive male and female loggerheads (which facilitates breeding for individuals migrating to that area); two concentrated breeding habitats were noted by NMFS, with the first location off southern Florida, from the shore out to the 200 m (656 ft) contour in between the Marquesas Keys and the Martin County/Palm Beach County line, while the second area is located in the nearshore waters just south of Cape Canaveral, Florida, the latter of which are within and immediately adjacent to the southern portion of the AOI.
- **Constricted Migratory Habitat:** NMFS identified two migratory corridors that are constricted in width, as indicated by both the width of the continental shelf and available satellite tracks, and thus more vulnerable to perturbations than other migratory areas along the continental shelf; these migratory corridors occur off the coast of North Carolina and Florida; the primary impact to the functionality of the identified corridors as migratory routes for loggerhead sea turtles would be a loss of passage conditions that allow for the free and efficient migration along the corridor. The loss of these passage conditions could come from large-scale and or multiple construction projects that result in the placement of substantial structures along the path of the migration, or other similar habitat alterations, requiring large-scale deviations in the migration movements.

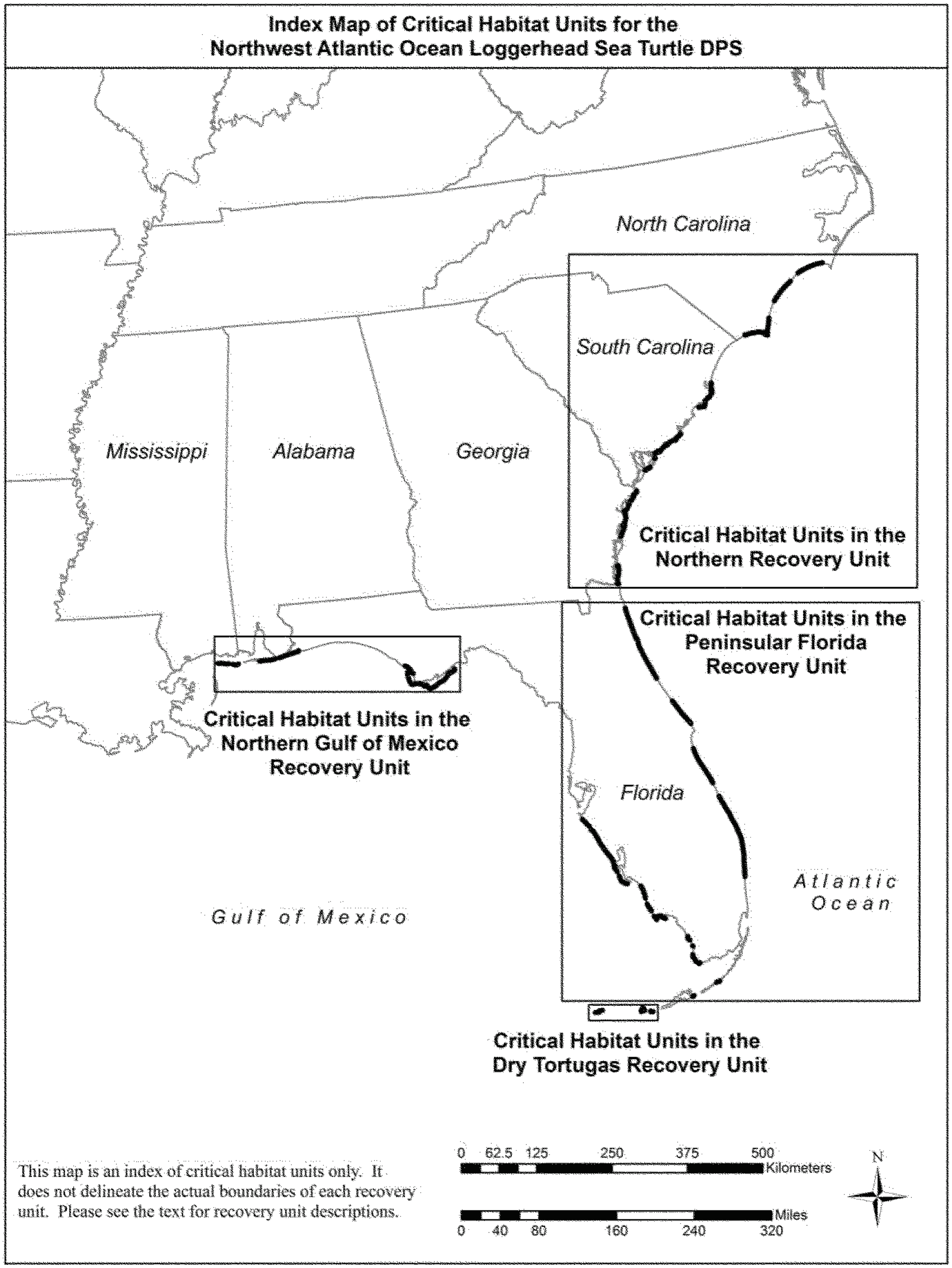

Figure M-1. Index Map of Terrestrial (nesting beaches) Critical Habitat Units (from *Federal Register*, 2013a).

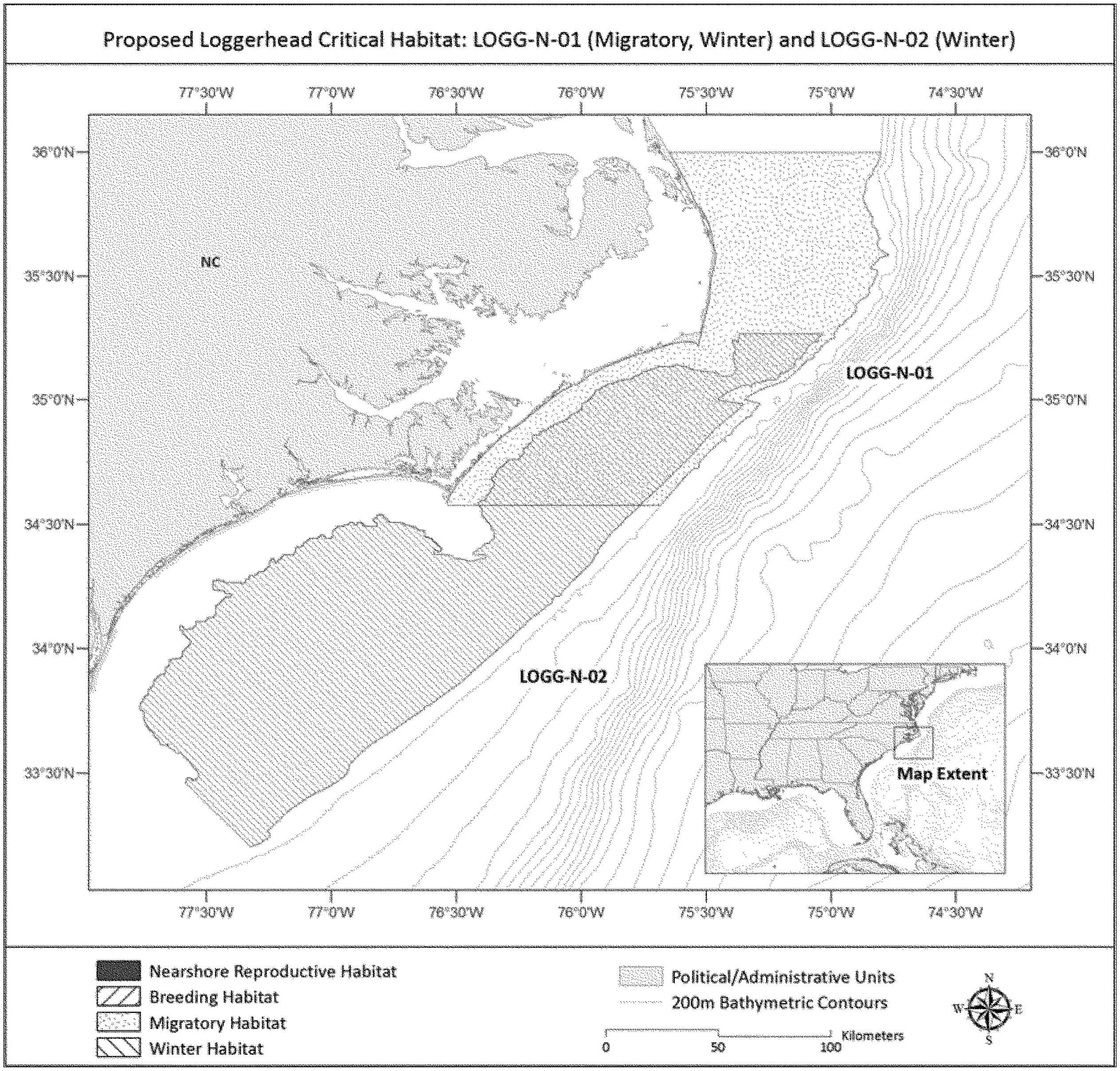

Figure M-2. Proposed Critical Habitat (migratory and winter habitat) off North Carolina (from *Federal Register*, 2013b).

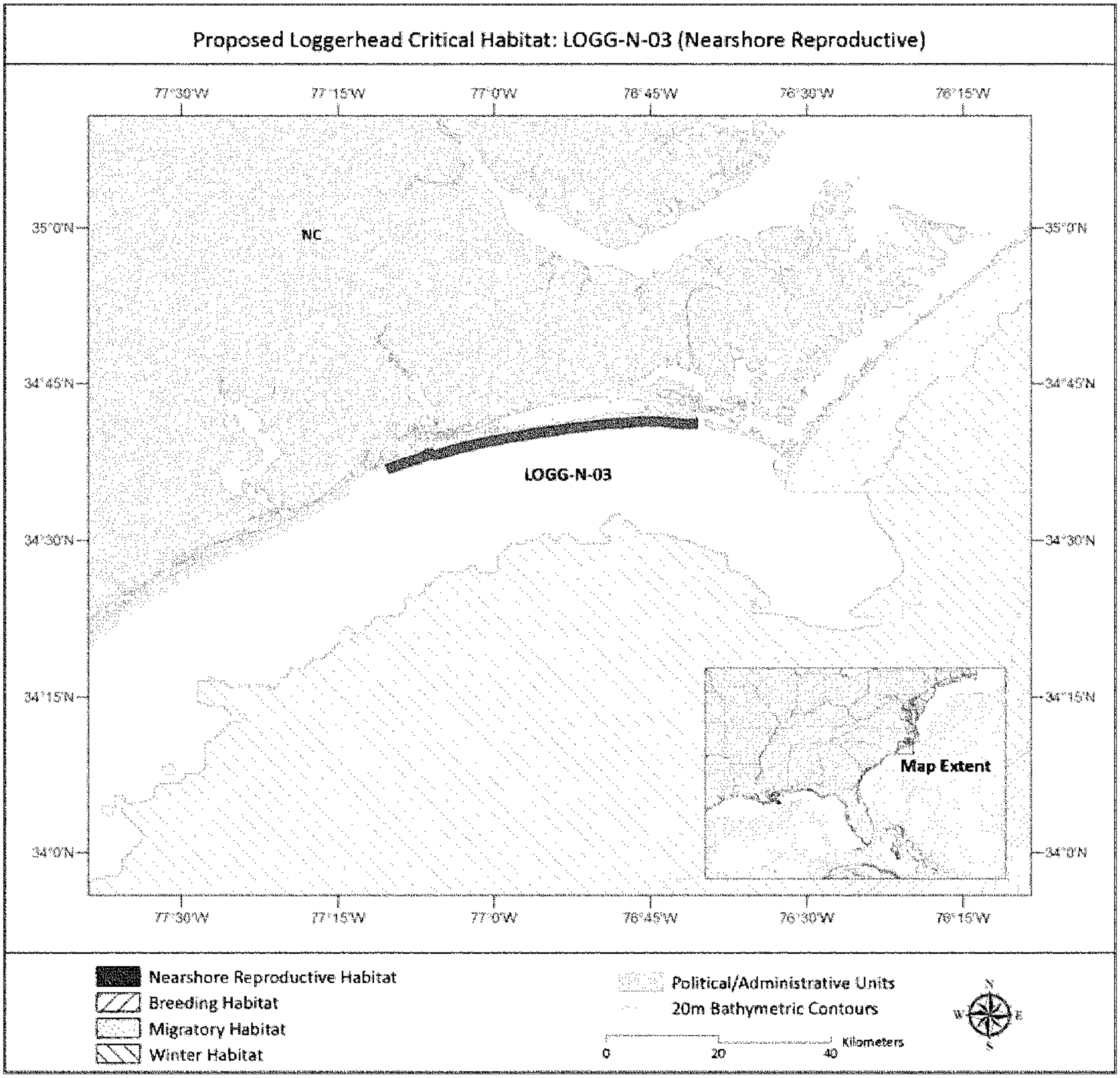

Figure M-3. Proposed Critical Habitat (nearshore reproductive habitat; N-03) off North Carolina (from *Federal Register*, 2013b).

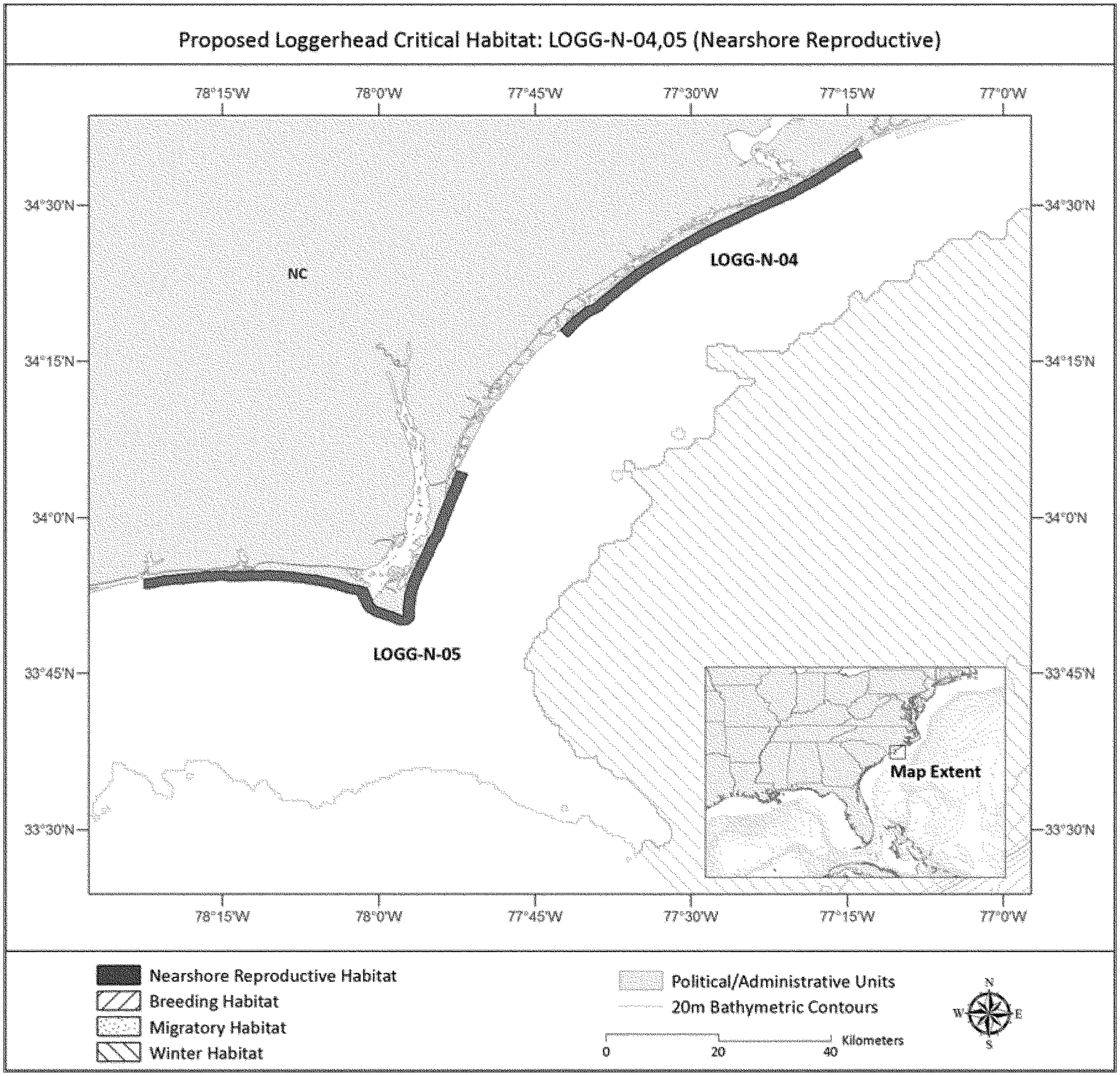

Figure M-4. Proposed Critical Habitat (nearshore reproductive habitat; N-04 and N-05) off North Carolina (from *Federal Register*, 2013a).

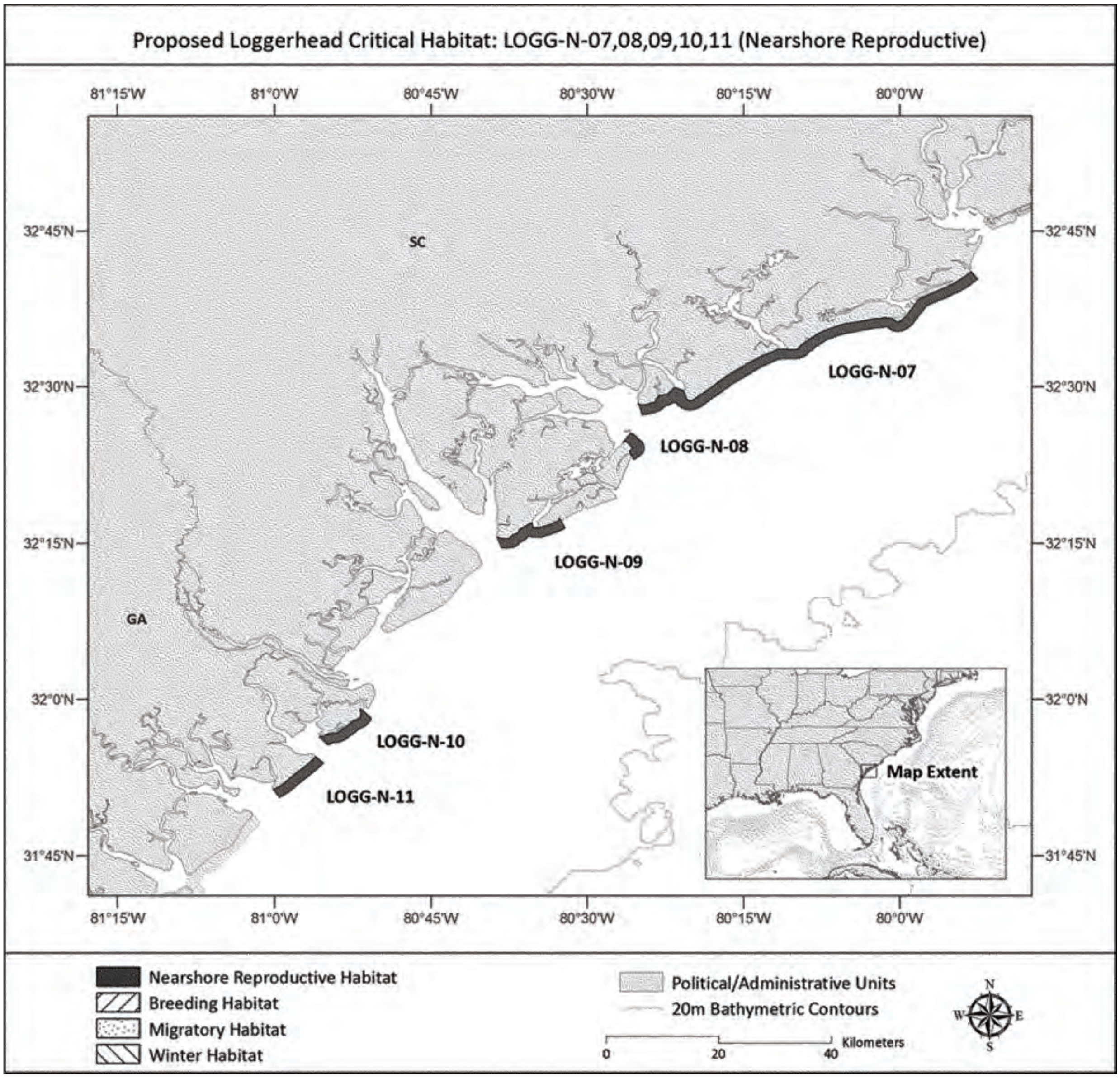

Figure M-5. Proposed Critical Habitat (nearshore reproductive habitat; N-07 through N-11) off South Carolina and Georgia (from *Federal Register*, 2013b).

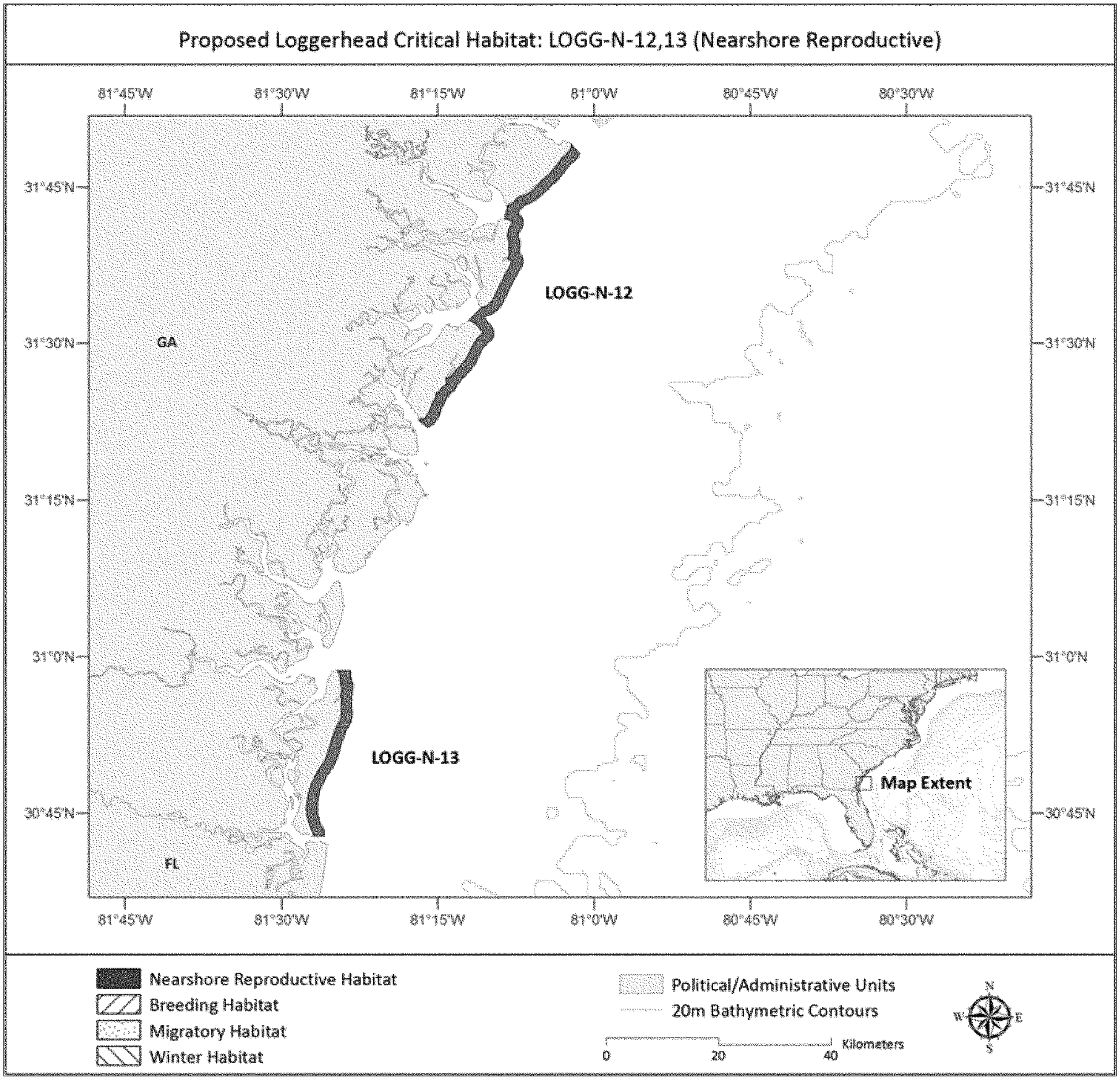

Figure M-6. Proposed Critical Habitat (nearshore reproductive habitat; N-12 and N-13) off Georgia (from *Federal Register*, 2013b).

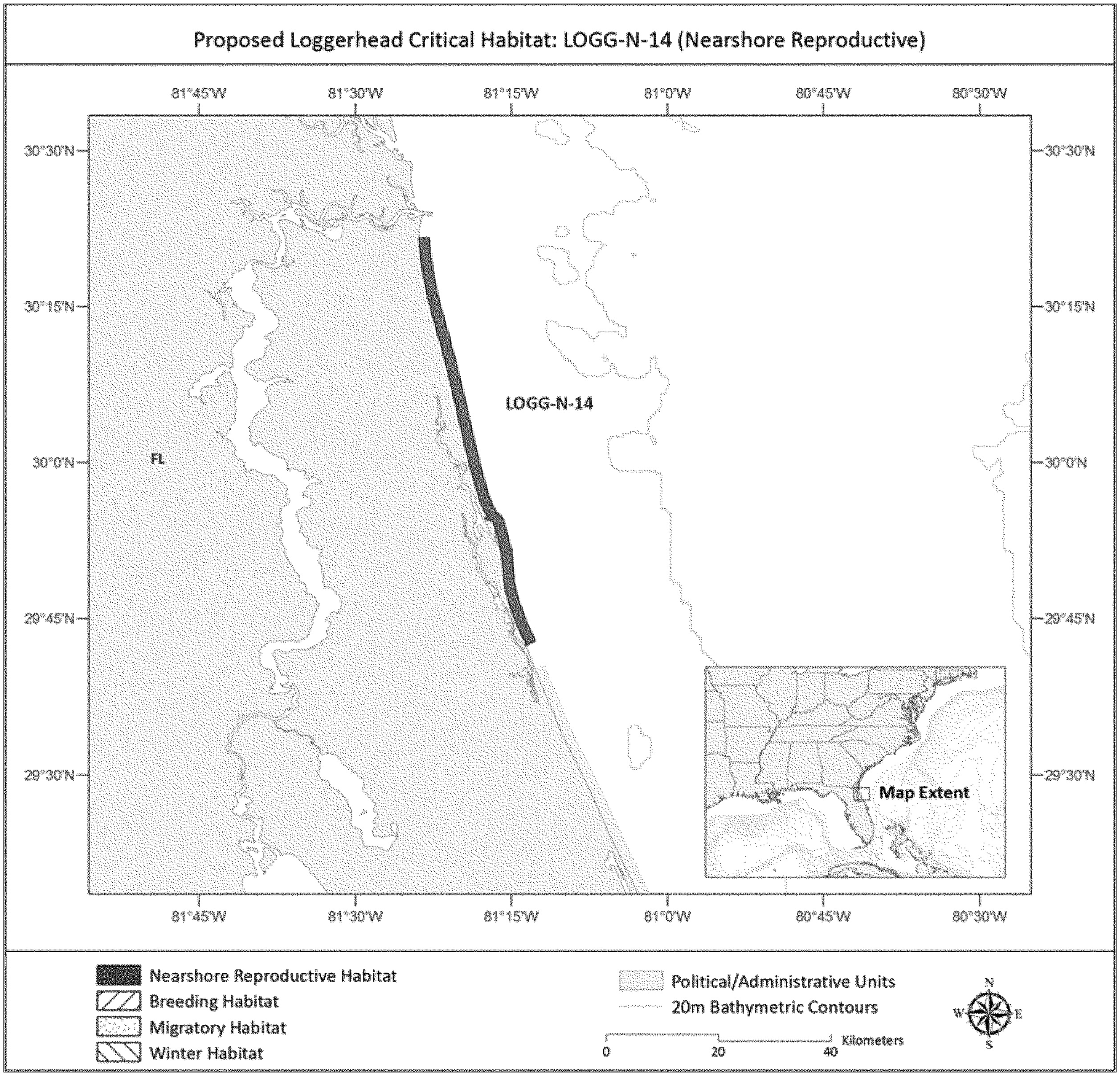

Figure M-7. Proposed Critical Habitat (nearshore reproductive habitat; N-14) off Florida (from *Federal Register*, 2013b).

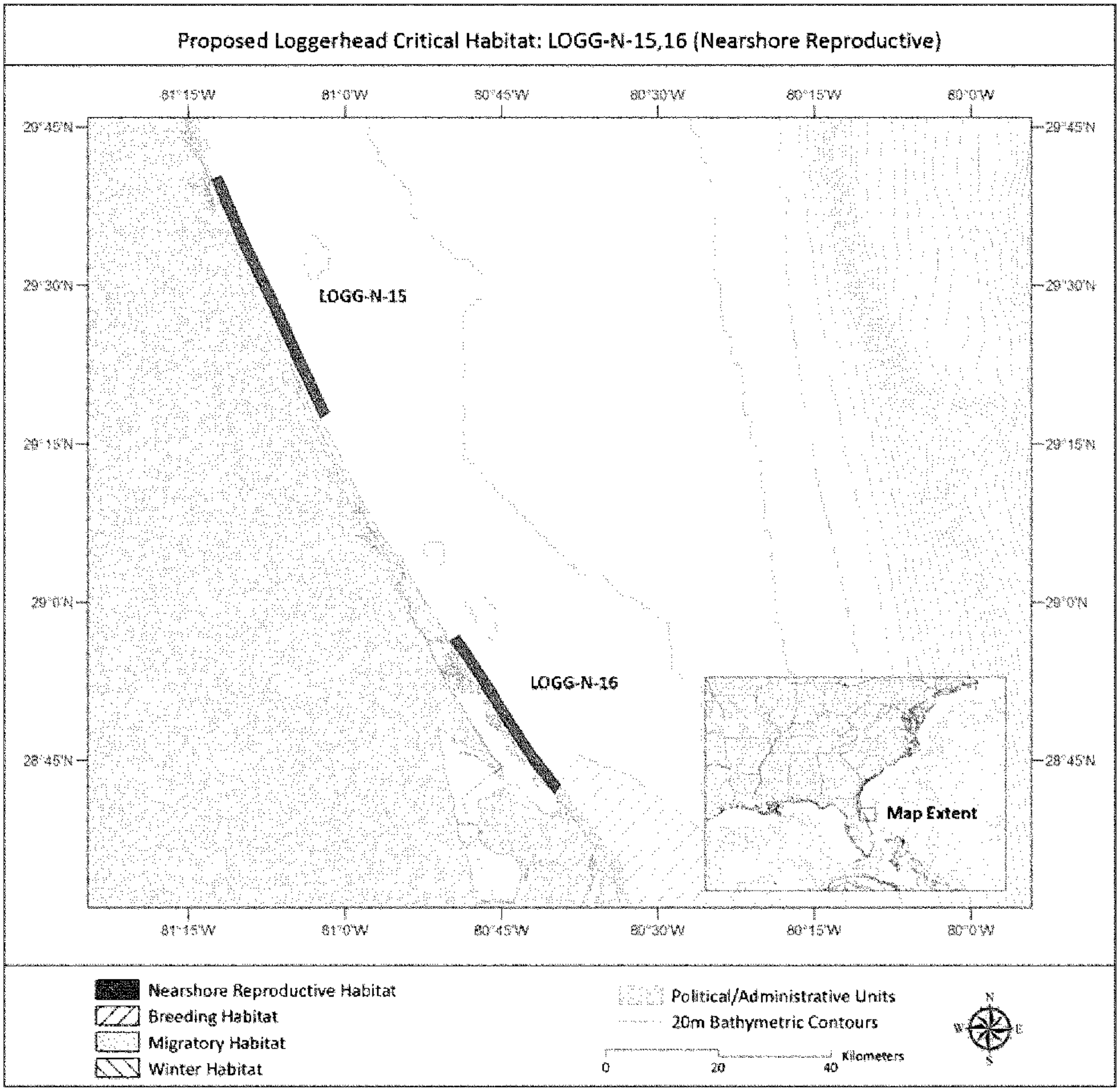

Figure M-8. Proposed Critical Habitat (nearshore reproductive habitat; N-15 and N-16) off Florida (from *Federal Register*, 2013b).

The numbers of critical habitat types within the AOI by State are shown in **Table M-1**.

Table M-1

Northwest Atlantic Ocean Loggerhead Sea Turtle Distinct Population Segment Critical Habitat Types within the Area of Interest

Critical Habitat Type	State			
	North Carolina	South Carolina	Georgia	Florida
Nearshore Reproductive Habitat	3	4	4	5
Winter Habitat	1	-	-	-
Breeding Habitat	-	-	-	1
Constricted Migratory Habitat	1	-	-	1
Total	5	4	4	7

A wide variety of activities may affect the proposed critical habitat and may be subject to the Endangered Species Act (ESA) Section 7 consultation process when carried out, funded, or authorized by a Federal agency. These include (1) nearshore and in-water construction, dredging, and sediment disposal, such as construction and maintenance of offshore structures such as breakwaters, groins, jetties, and artificial reefs; construction and maintenance of transportation projects (e.g., bridges) and utility projects; dredging and sediment disposal; and channel blasting; (2) fisheries management, such as Federal commercial fisheries and related activities; (3) oil and gas exploration and development, such as decommissioning of old oil and gas platforms, construction of nearshore oil and gas platforms, and oil and gas activity transport in the nearshore environment; (4) renewable energy projects, such as ocean thermal energy, wave energy, and offshore wind energy; (5) some military activities, such as in-water training and research; and (6) aquaculture, such as marine species propagation (*Federal Register*, 2013b).

The marine critical habitat designation was proposed on July 18, 2013, and is undergoing a 40-day comment period that ends on September 16, 2013.

2. ENDANGERED AND THREATENED WILDLIFE; 90-DAY FINDING ON PETITIONS TO LIST THE DUSKY SHARK AS THREATENED OR ENDANGERED UNDER THE ENDANGERED SPECIES ACT

NMFS announced a 90-day finding on petitions to list the dusky shark (*Carcharhinus obscurus*) range-wide or, in the alternative, the Northwest Atlantic and Gulf of Mexico population of the dusky shark as a threatened or endangered DPS under the ESA, and to designate critical habitat concurrently with the listing. NMFS made two determination regarding the dusky shark, including (1) that the petitions present substantial scientific or commercial information indicating that the petitioned action may be warranted for the Northwest Atlantic and Gulf of Mexico population of dusky shark and (2) that the petitions fail to present substantial scientific or commercial information indicating that the petitioned action may be warranted for the dusky shark range-wide. Therefore, NMFS conducted a status review of the Northwest Atlantic and Gulf of Mexico population of dusky shark to determine if the petitioned action is warranted. To ensure that the status review is comprehensive, they solicited scientific and commercial information pertaining to this petitioned species from any interested party; the comment period closed July 17, 2013 (*Federal Register*, 2013c).

3. MARINE MAMMAL STOCK ASSESSMENTS

Marine mammal stock assessments were used throughout this Programmatic Environmental Impact Statement (EIS) for information about the affected environment with respect to marine mammals present in the AOI (Waring et al., 2010). At the time that the Programmatic EIS was being prepared, the 2010 stock assessments were the most current information; however, they are updated regularly by the National Oceanic and Atmospheric Administration (NOAA). Individual surveys that require Marine Mammal Protection Act authorizations should access the most current stock assessments for this coordination with the Bureau of Ocean Energy Management (BOEM) and NMFS available at http://www.nefsc.noaa.gov/nefsc/publications/tm/tm223/index.html.

4. MARINE MAMMAL ACOUSTIC THRESHOLD CRITERIA

At present, NMFS specifies that marine mammals exposed to pulsed sounds with received levels exceeding 180 or 190 dB re 1 μPa (rms) for cetaceans and pinnipeds, respectively, are considered to exceed Level A (Injury) levels. NMFS also specifies that cetaceans and pinnipeds exposed to levels exceeding 160 dB re 1 μPa (rms) are considered to exceed Level B (Behavioral Harassment) criteria.

Over the past several years, NMFS has been working to develop new acoustic criteria. NMFS provided a draft version of the new criteria for a Federal agency review and comment period. This document outlined new Level A criteria for all sources and new Level B criteria for seismic surveys (mainly airguns). BOEM provided comments on this draft version of the criteria, including noting additional information BOEM needed to evaluate the methodology. Further, this version did not contain NMFS's plan for implementing any new criteria. These new criteria will address permanent threshold shift (PTS) from all underwater sound sources and temporary threshold shift (TTS) for both impulsive and continuous noise sources (behavioral responses).

As of the publication of this Final Programmatic EIS, the criteria still remain in draft form. BOEM continues to provide NMFS with comments, as requested. However, analysis of the criteria within this Programmatic EIS is not possible given the uncertainty that still remains on the final content of the new acoustic criteria.

However, if NMFS finalizes new criteria, BOEM will evaluate the criteria in the context of any site/permit-specific analysis under the Outer Continental Shelf Lands Act and National Environmental Policy Act. NMFS will also apply any new criteria at this site/permit-specific level through any undertaken MMPA authorization process.

5. CETACEAN DENSITY AND DISTRIBUTION MAPPING GROUP (CETMAP)

The Cetacean Density and Distribution Mapping Group (CetMap) and the Underwater Sound Field Mapping Group (CetSound) were convened starting in 2011 with a stakeholder symposium held in 2012. NOAA led these efforts and was supported by BOEM and the U.S. Navy. The objectives of the CetMap effort were to create regional cetacean density and distribution maps that are time- and species-specific, using survey data and models that estimate density using predictive environmental factors. This information will also identify known areas of specific importance of cetaceans, such as reproductive and feeding areas, migratory routes, and areas in which small or resident populations are concentrated. CetSound focused on creating mapping methods to depict the temporal, spatial, and spectral characteristics of underwater noise. The CetMap and CetSound data and products relevant to the Atlantic OCS were not available prior to the release of the Draft Programmatic EIS and have not become available during the 18-month period following the close of the 90-day public comment period and the finalization of the Programmatic EIS (see http://www.st.nmfs.noaa.gov/cetsound/).

6. BOEM-FUNDED ENVIRONMENTAL STUDIES

BOEM is also working with NOAA and other organizations on two programs to improve biological information on protected species in the U.S. Atlantic. They are as follows: (1) the Atlantic Marine Assessment Program for Protected Species – an effort to collect broad-scale data over multiple years on the seasonal distribution and abundance of marine mammals, marine turtles, and seabirds using direct aerial and shipboard surveys of coastal U.S. Atlantic Ocean waters; and (2) the Multipurpose Marine Cadastre – an integrated marine information system that provides legal, physical, ecological, and cultural information in a common geographic information system (GIS) framework. BOEM continues to consider other opportunities to improve knowledge of the biological baseline as well as opportunities to develop a long term monitoring program during individual, site-specific analyses (see http://www.boem.gov/Environmental-Stewardship/Environmental-Studies/Current-Research.aspx).

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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 the 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 communities.

The Bureau of Ocean Energy Management Mission

The Bureau of Ocean Energy Management (BOEM) promotes energy independence, environmental protection, and economic development through responsible, science-based management of offshore conventional and renewable energy.