OCS EIS/EA
BOEM 2017-051

Gulf of Mexico OCS
Proposed Geological and Geophysical Activities

Western, Central, and Eastern Planning Areas

Final Programmatic Environmental Impact Statement

Volume II: Figures, Tables, Keyword Index, and Appendices A-D

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

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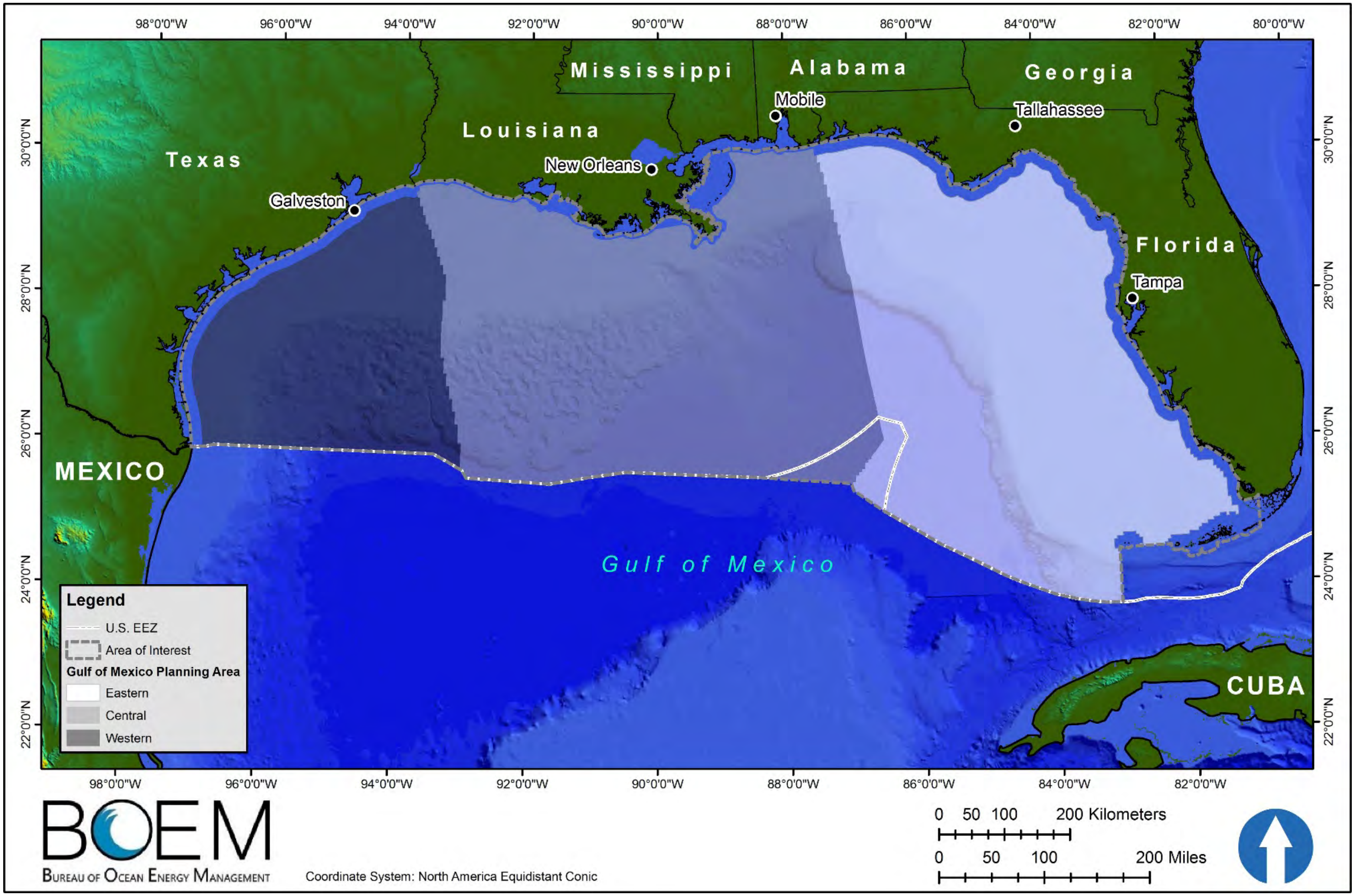

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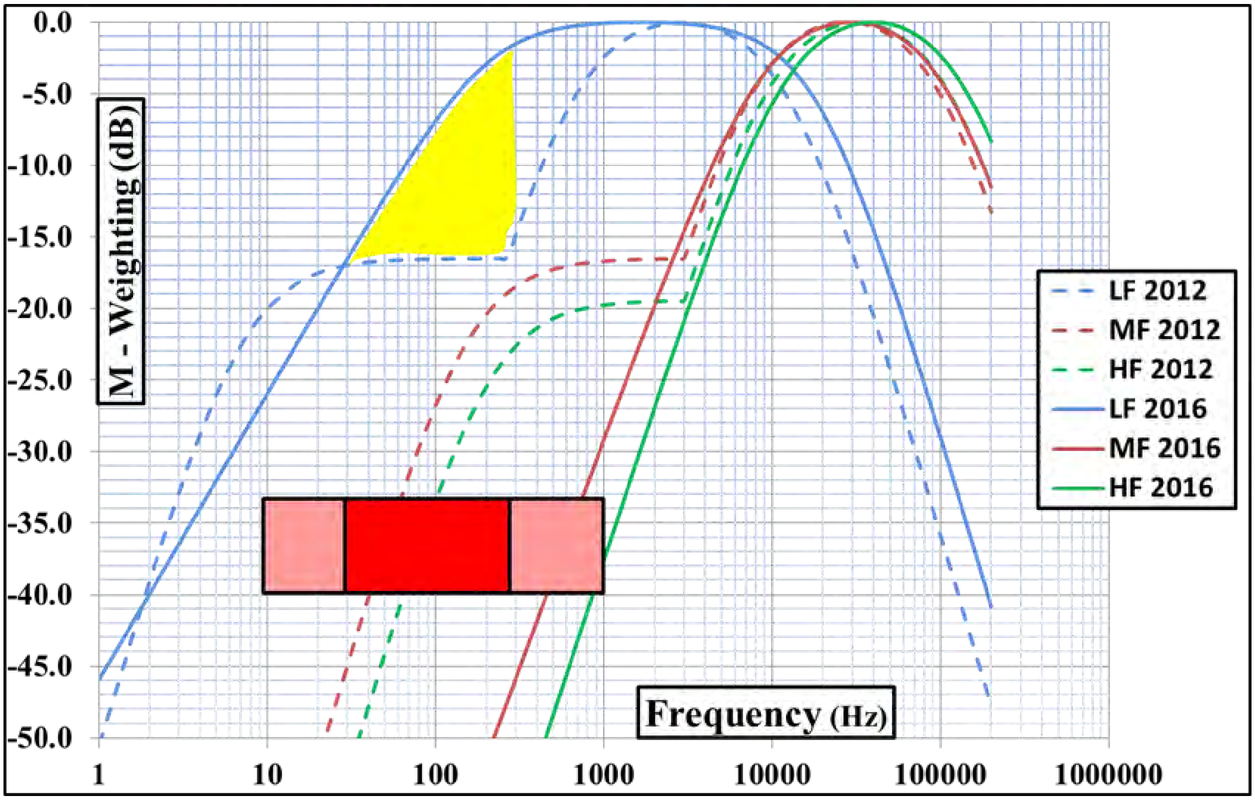

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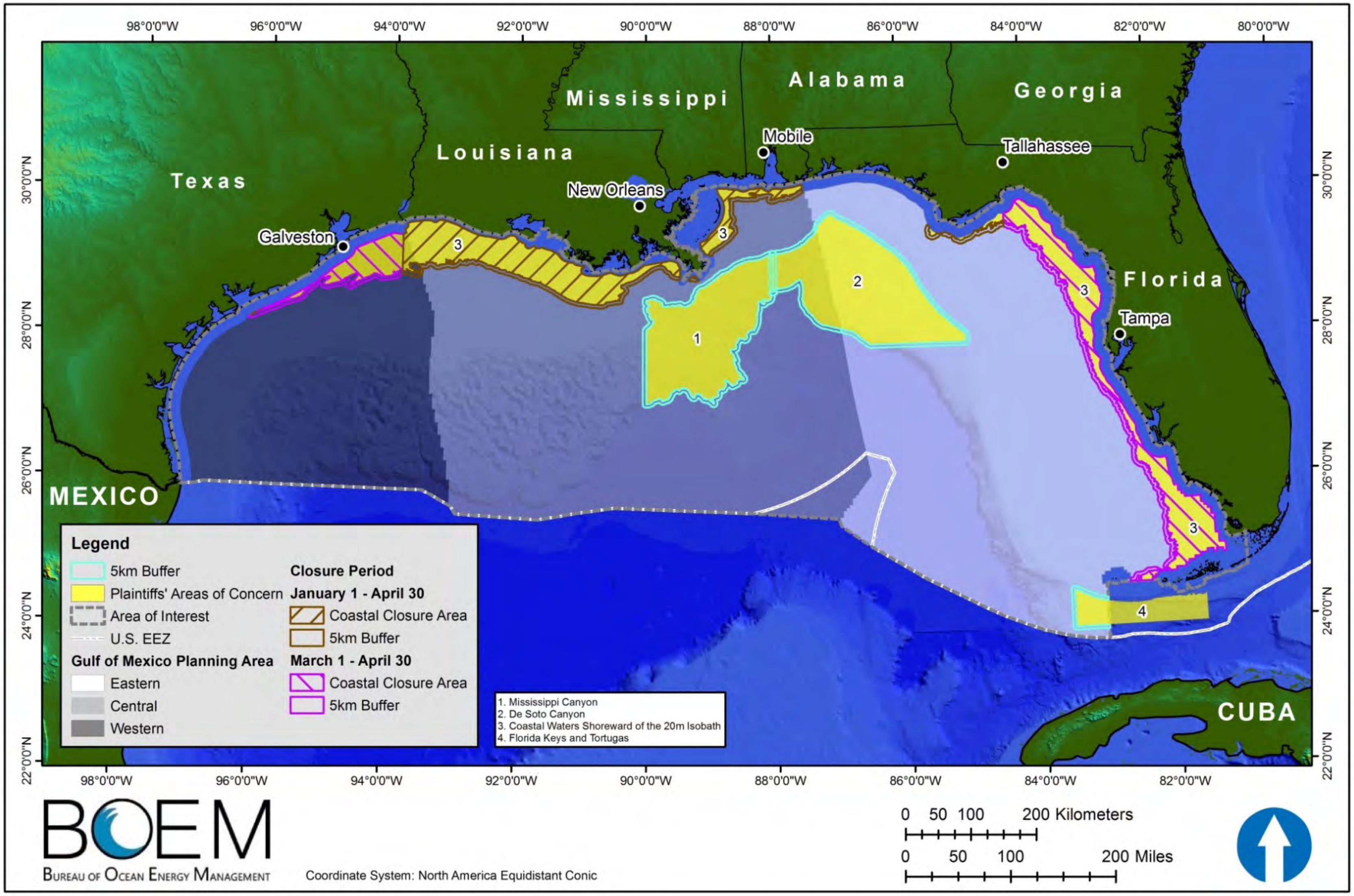

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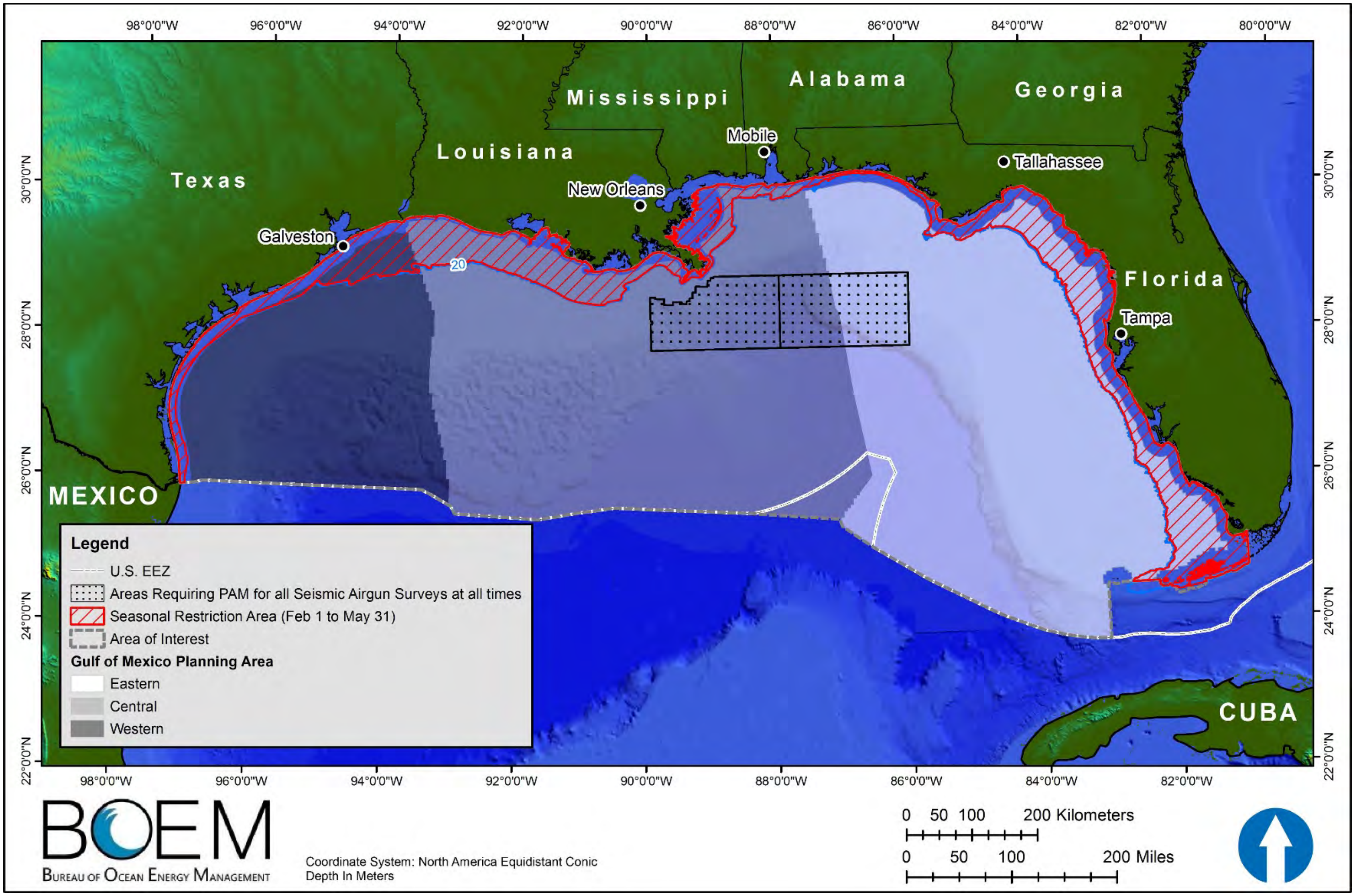

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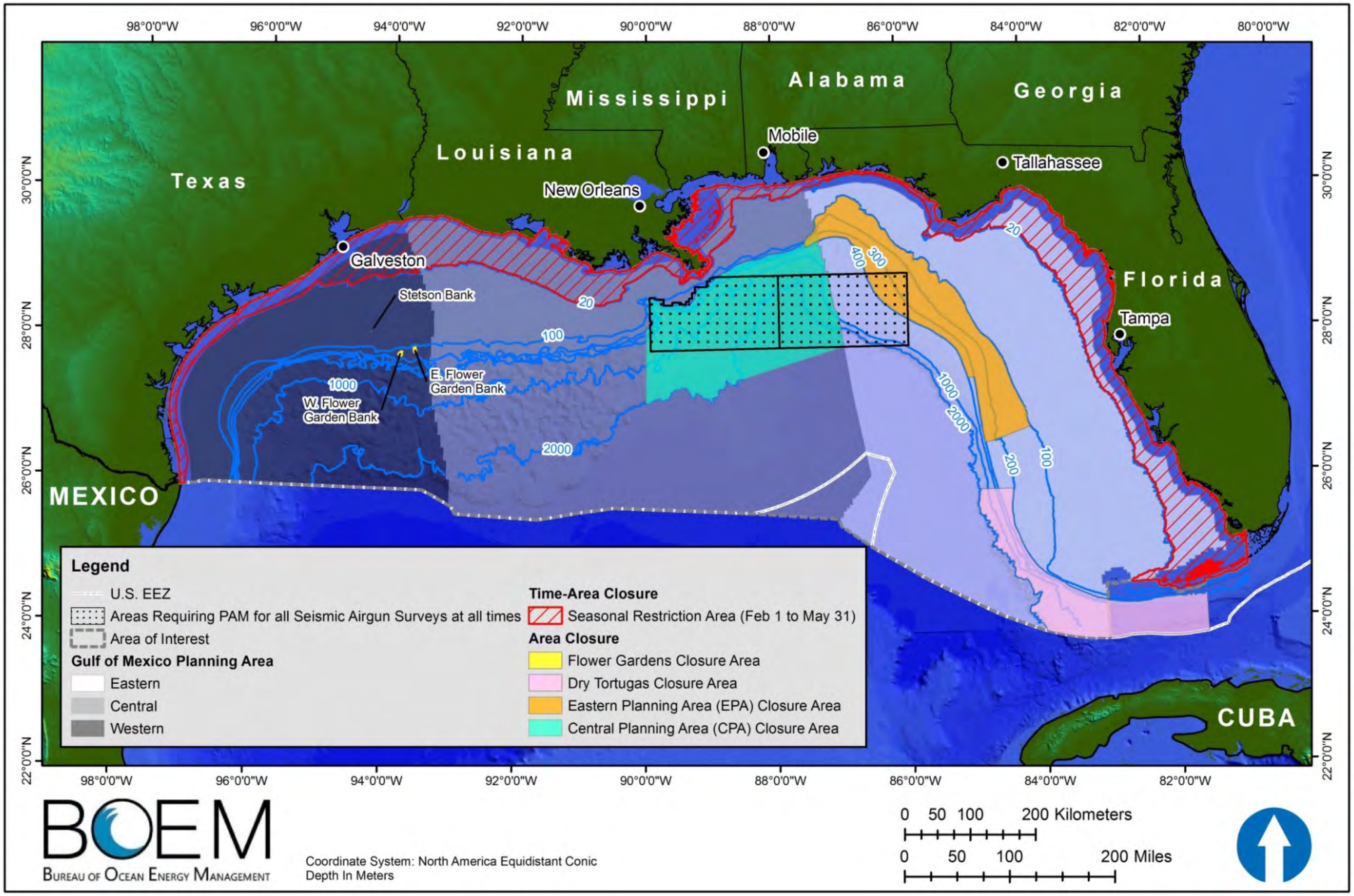

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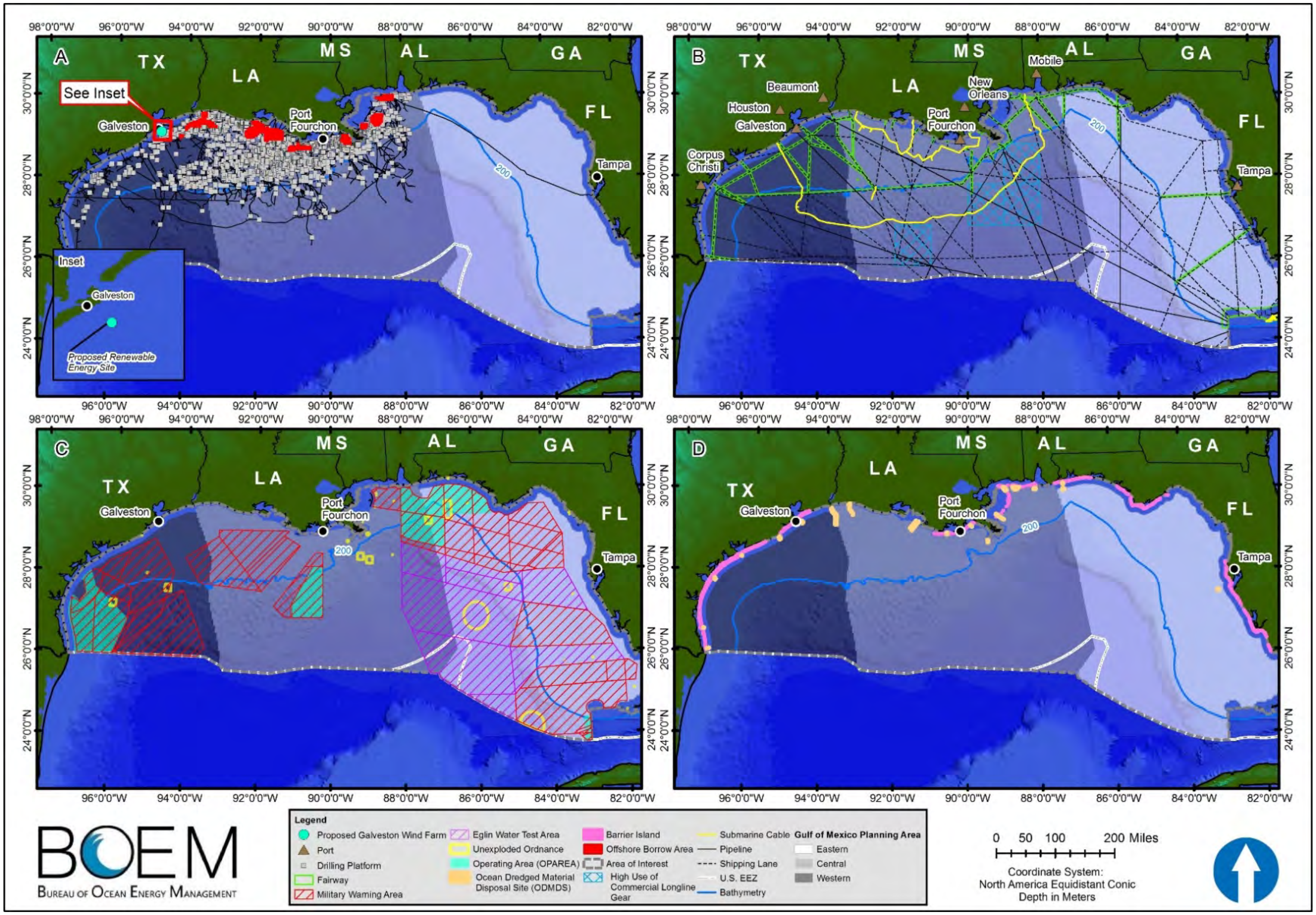

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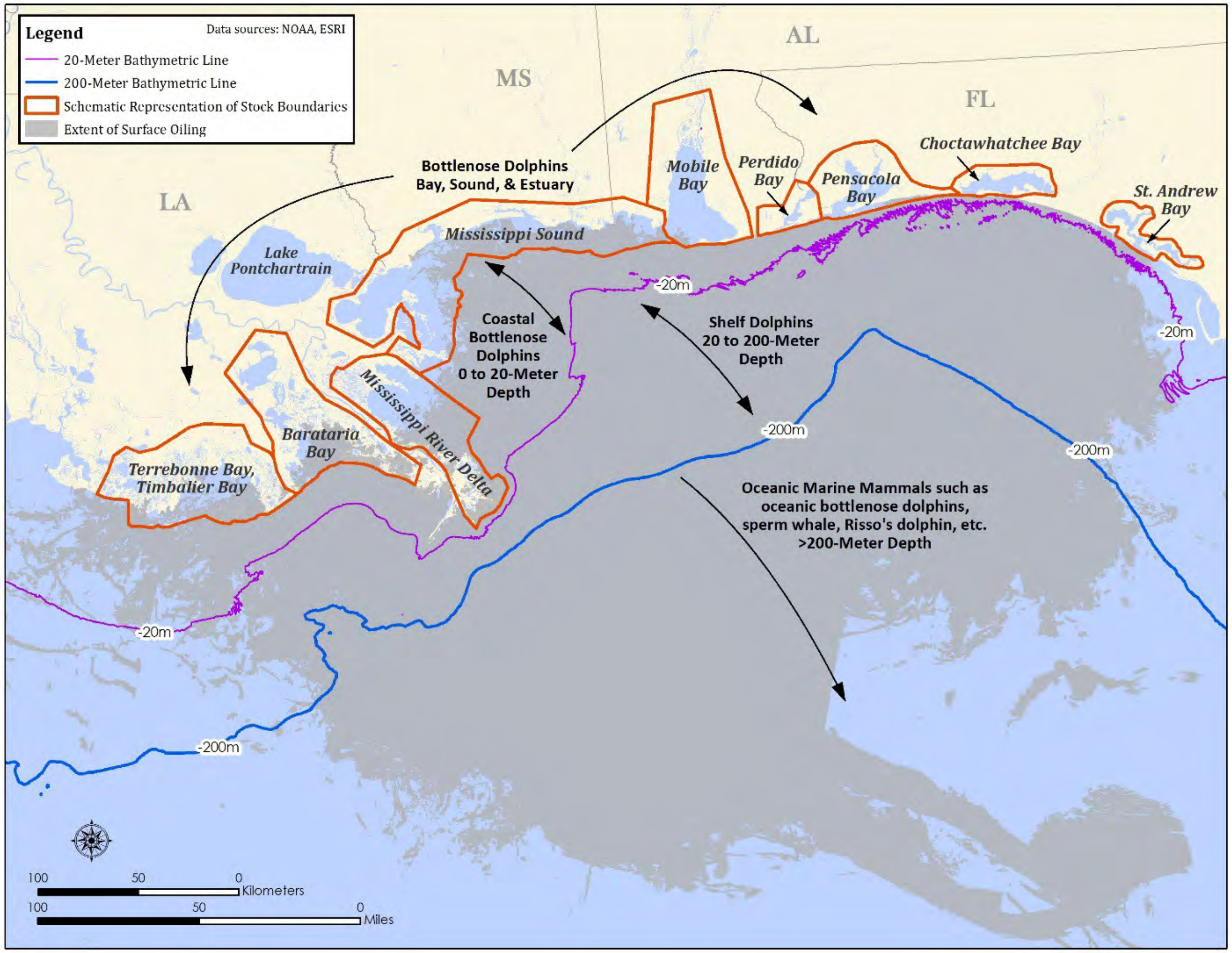

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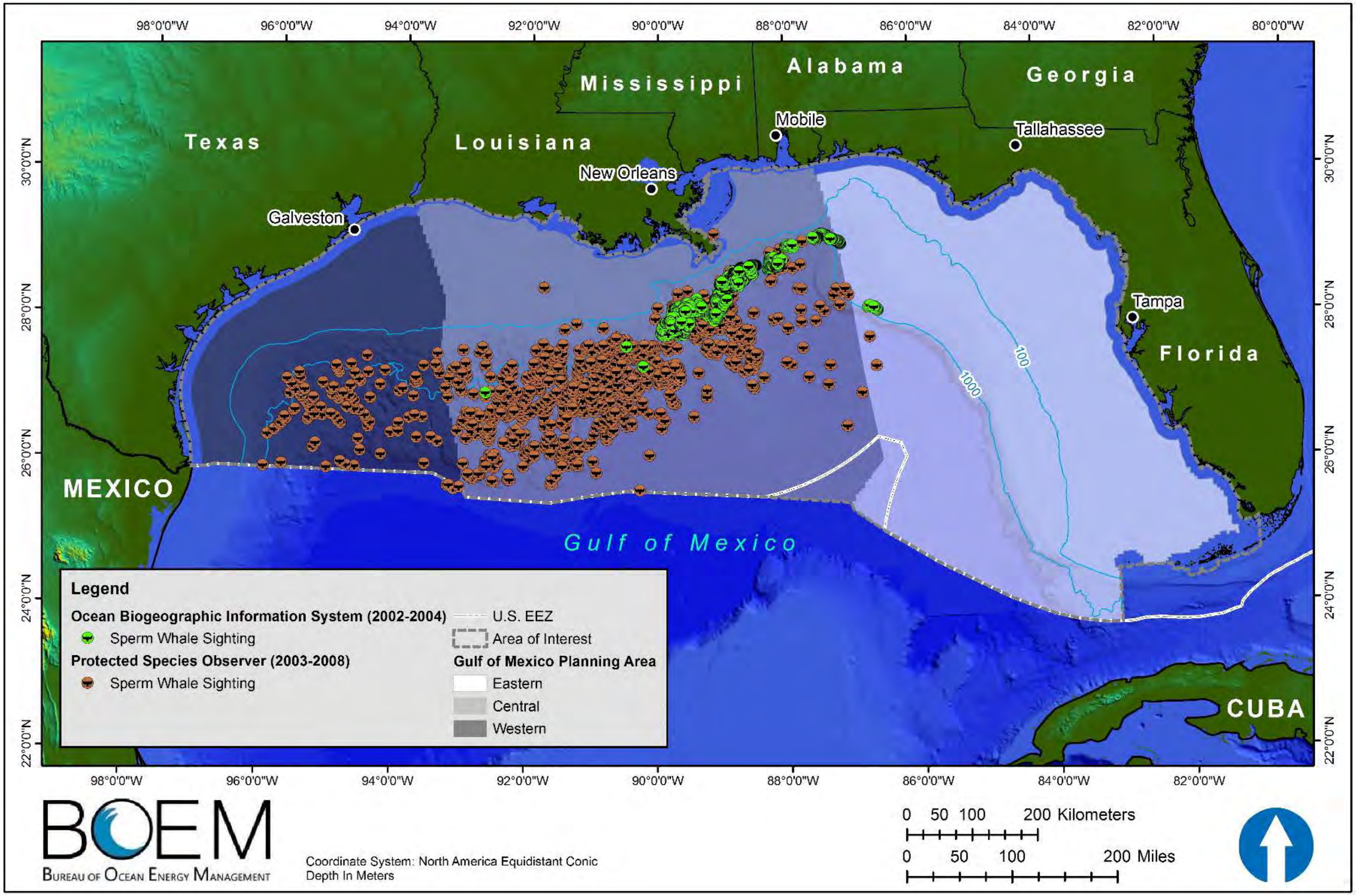

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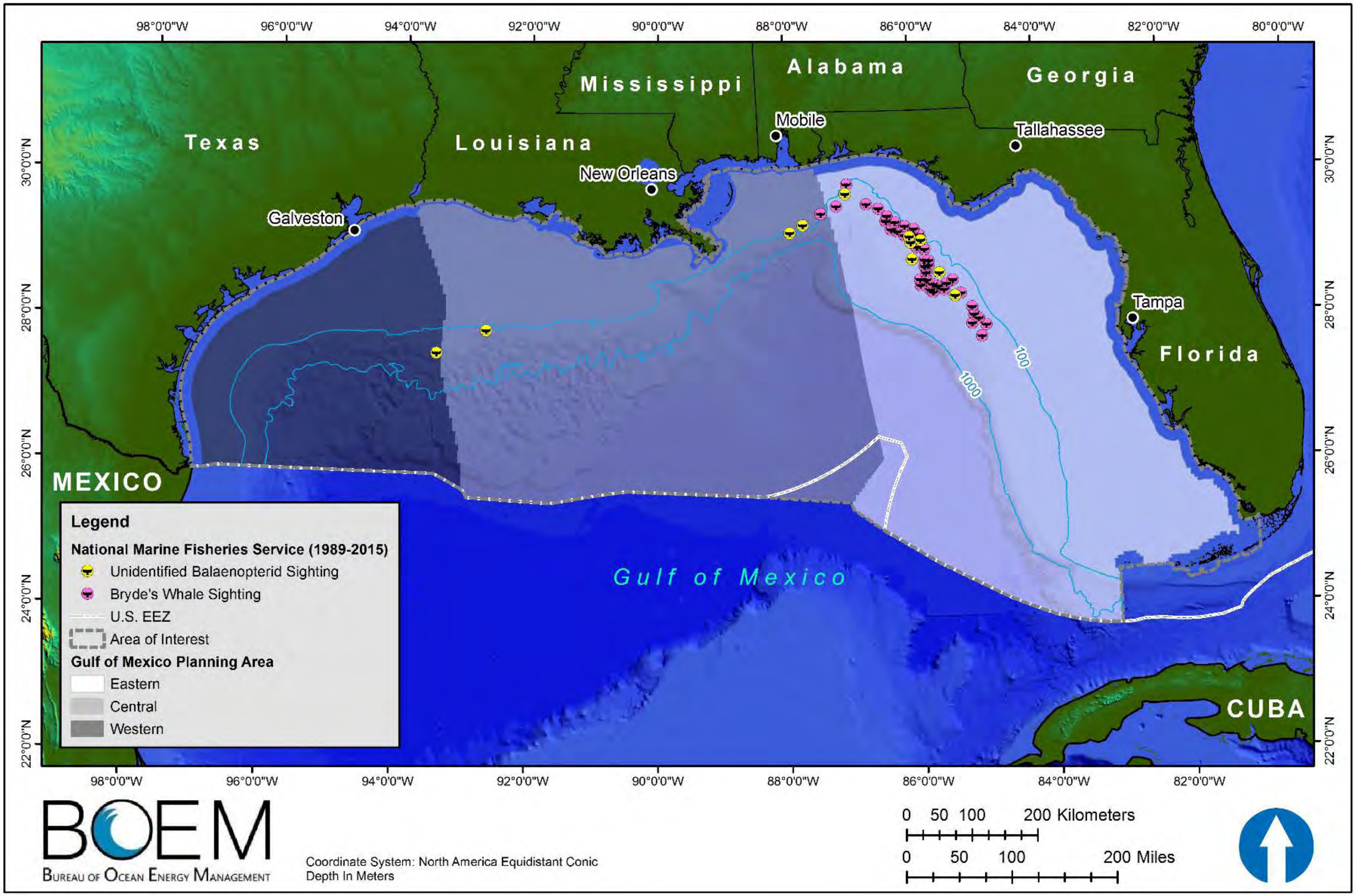

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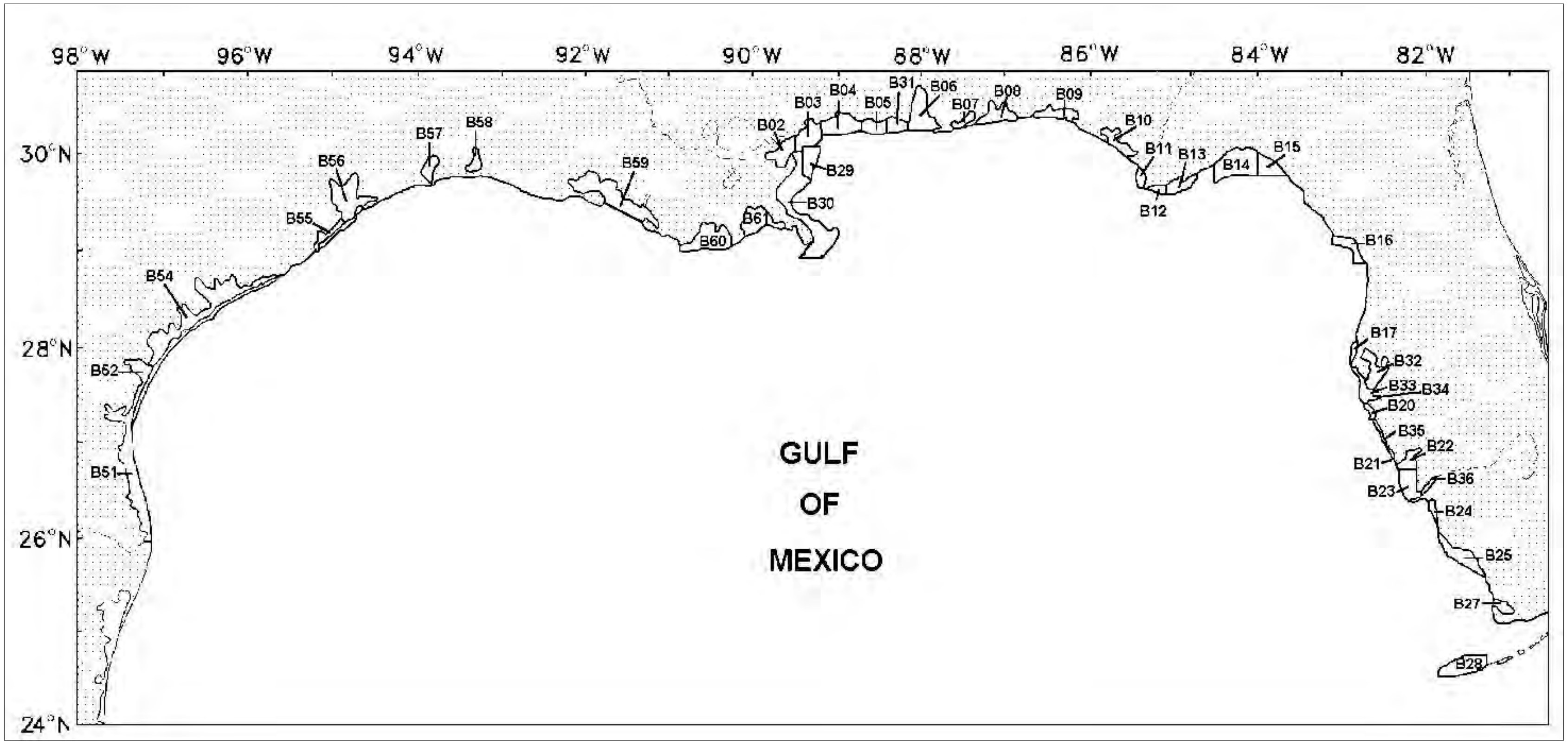

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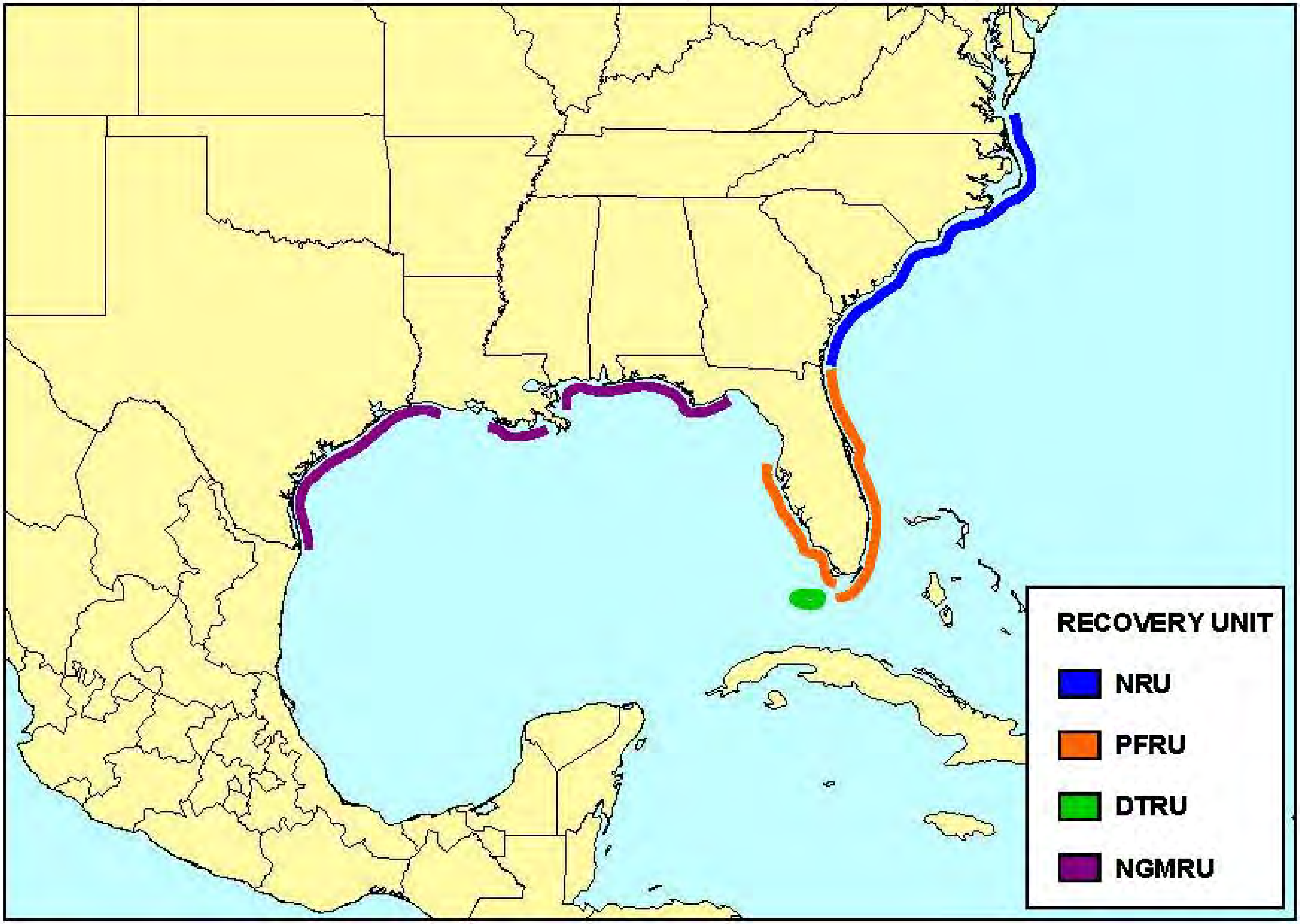

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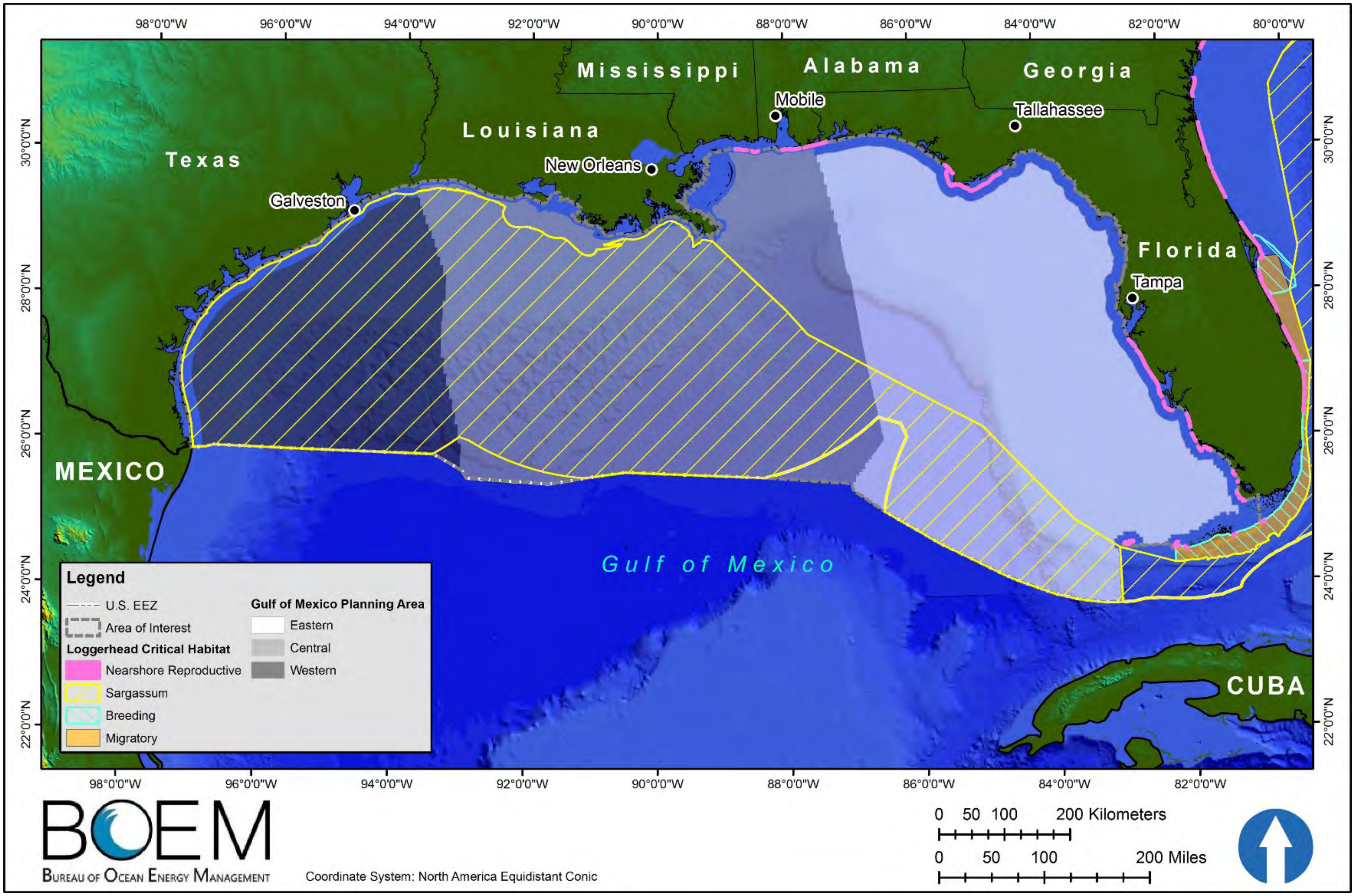

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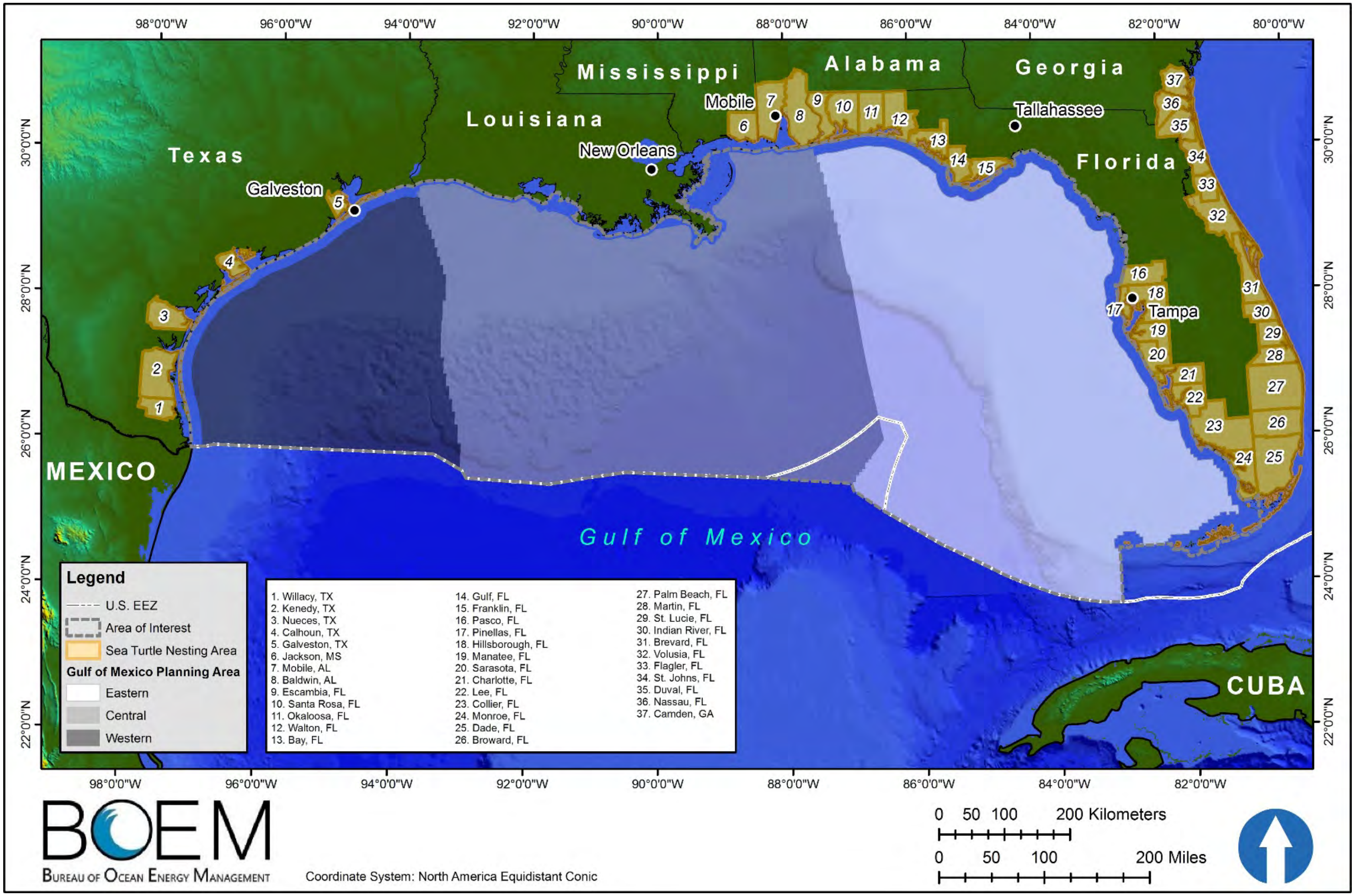

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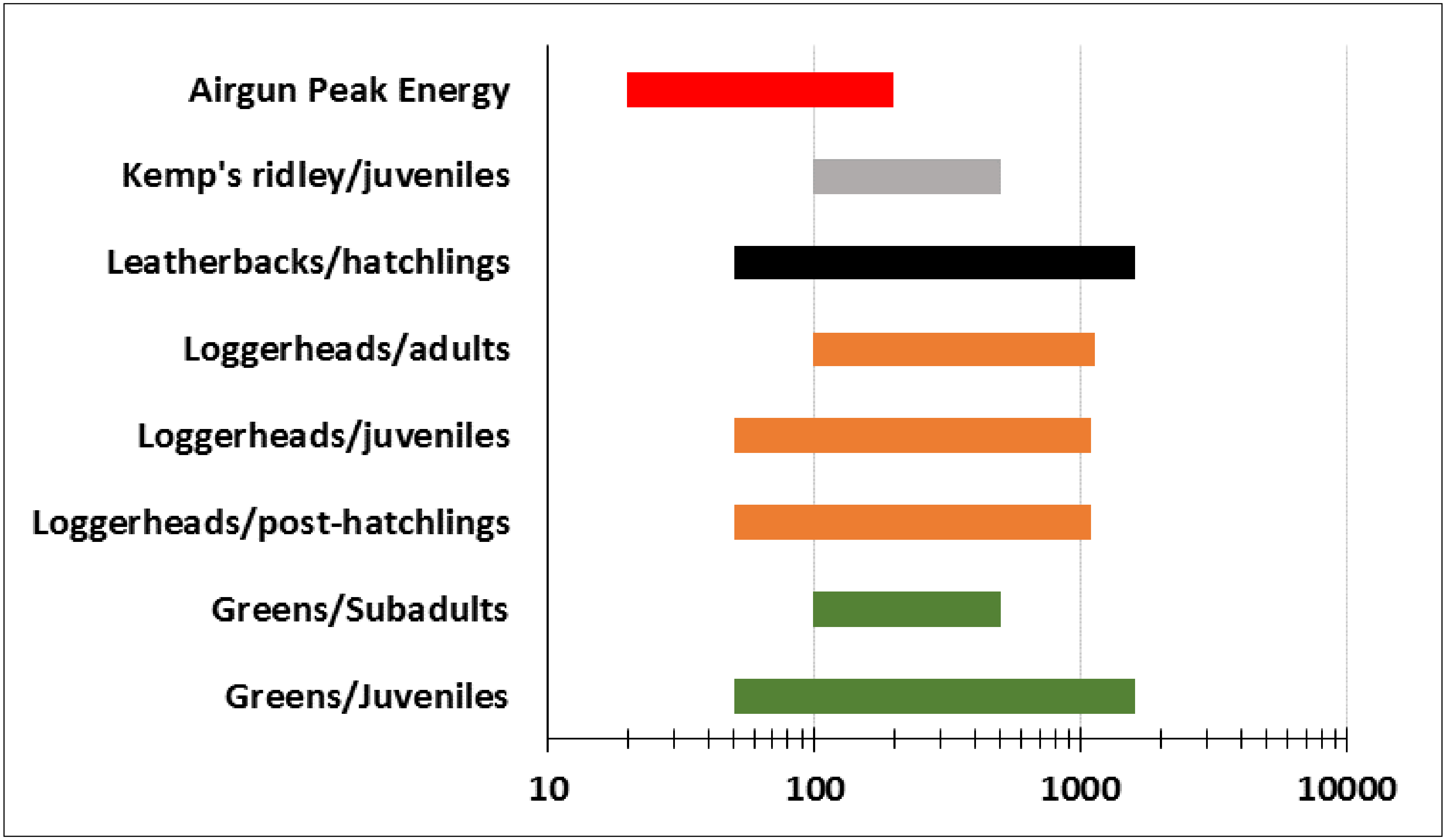

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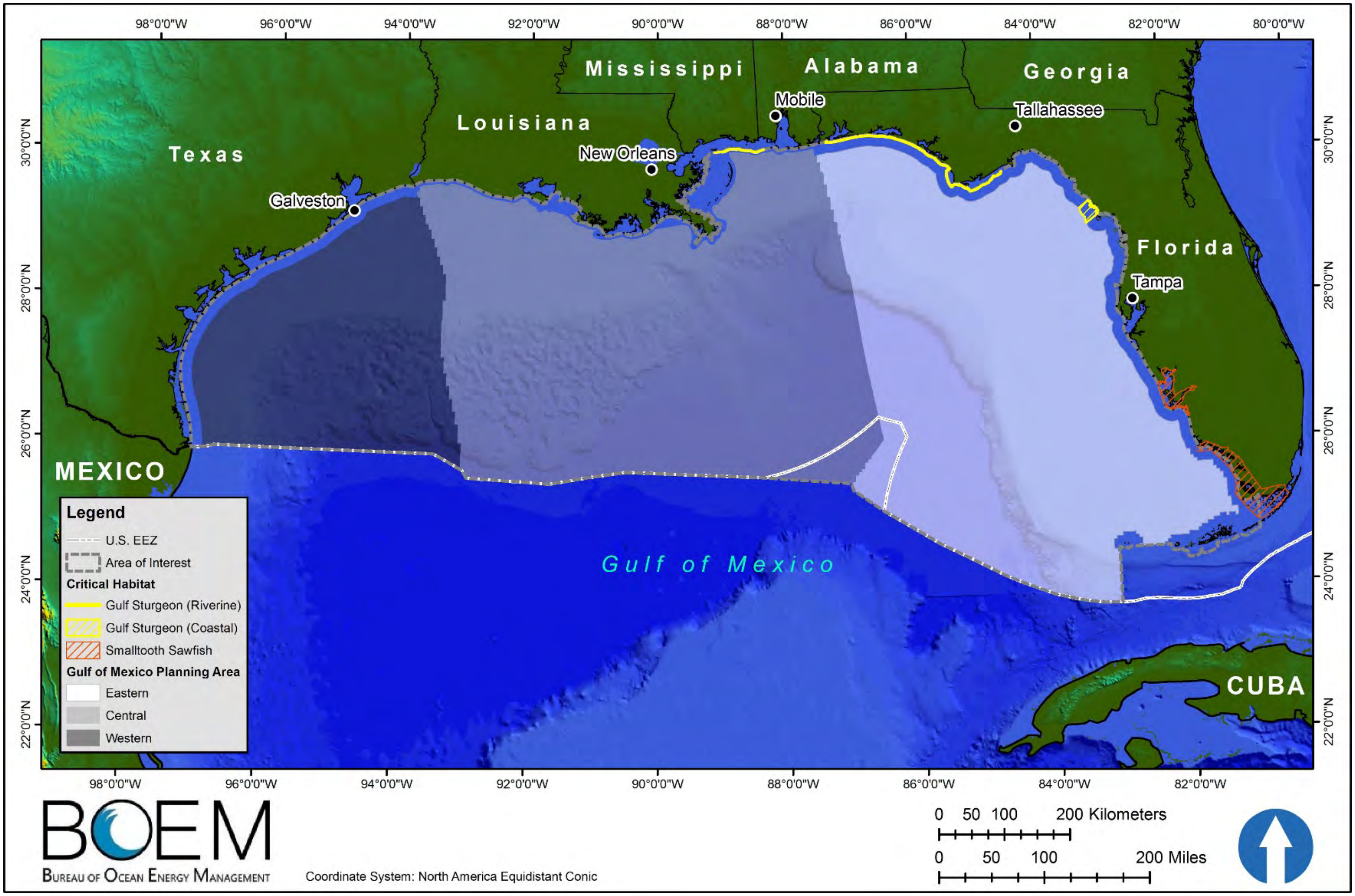

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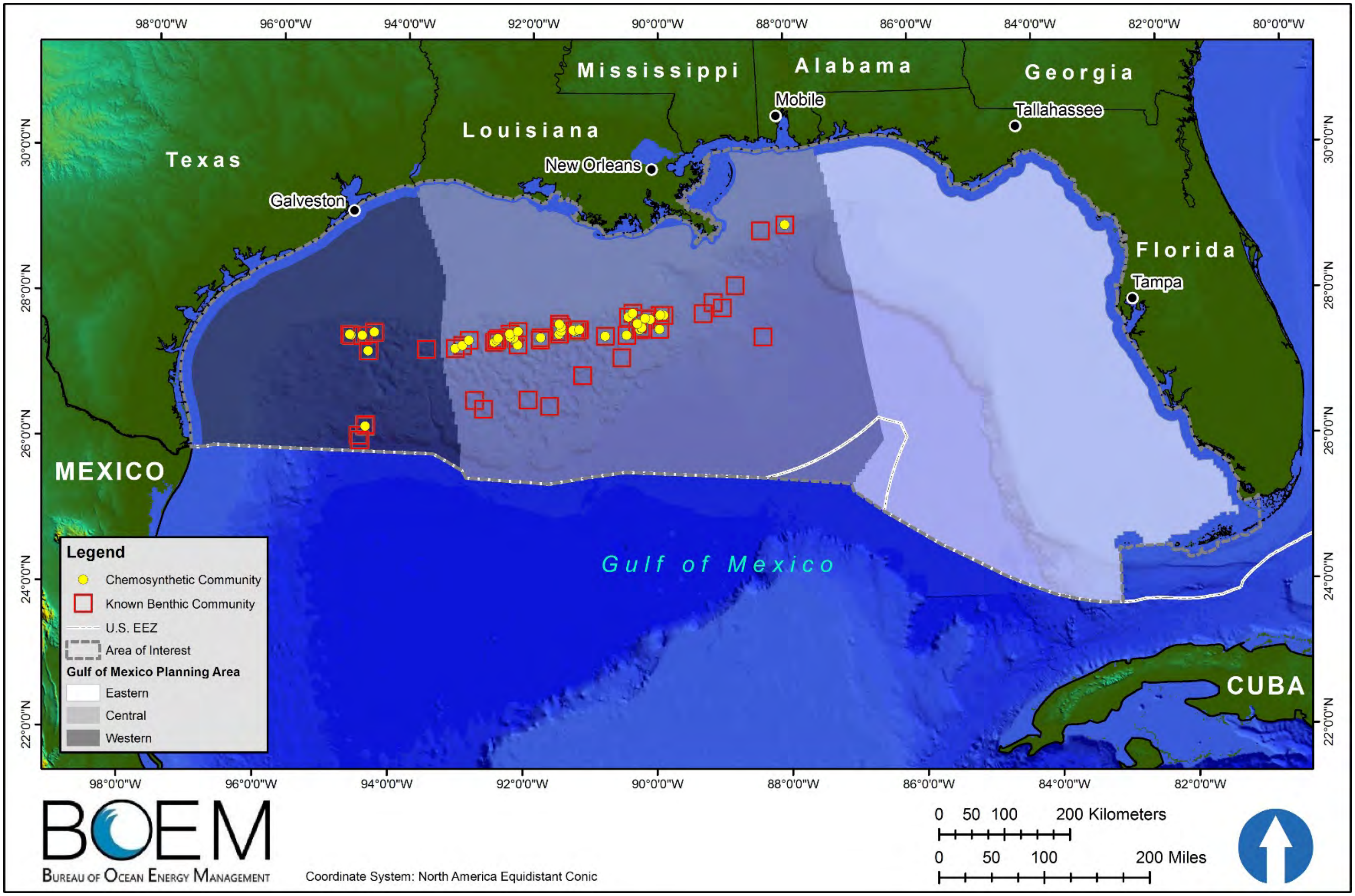

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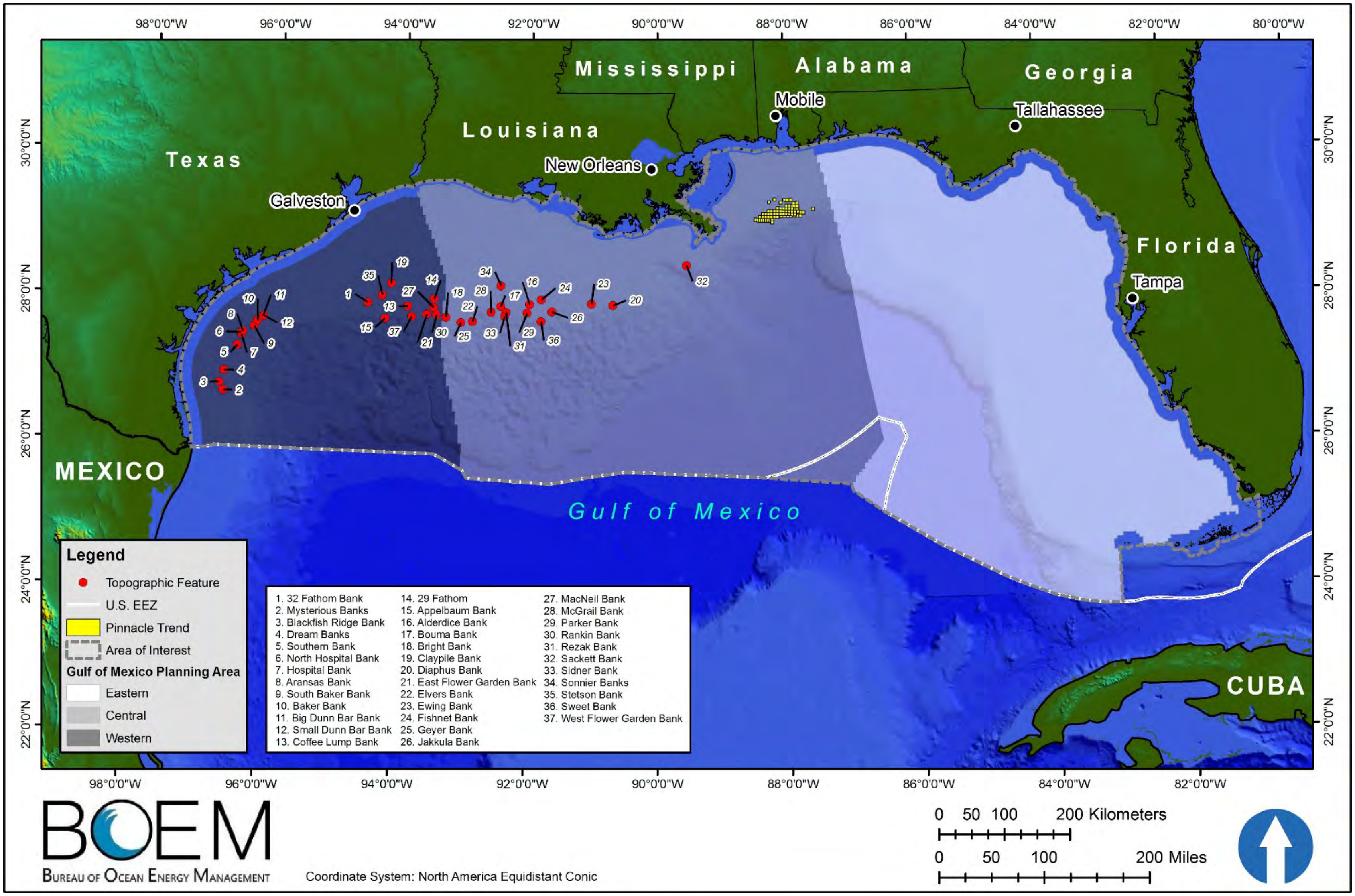

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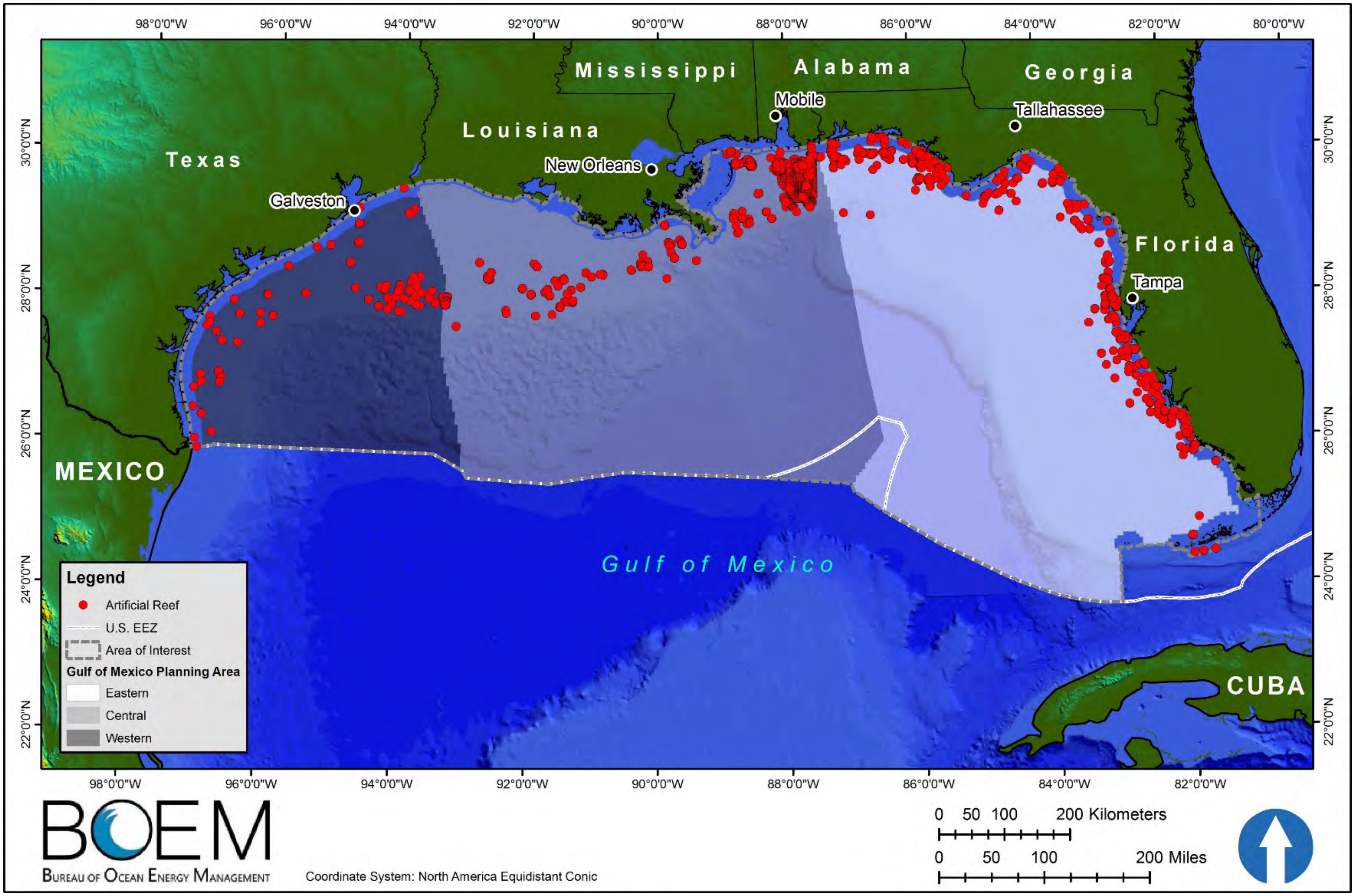

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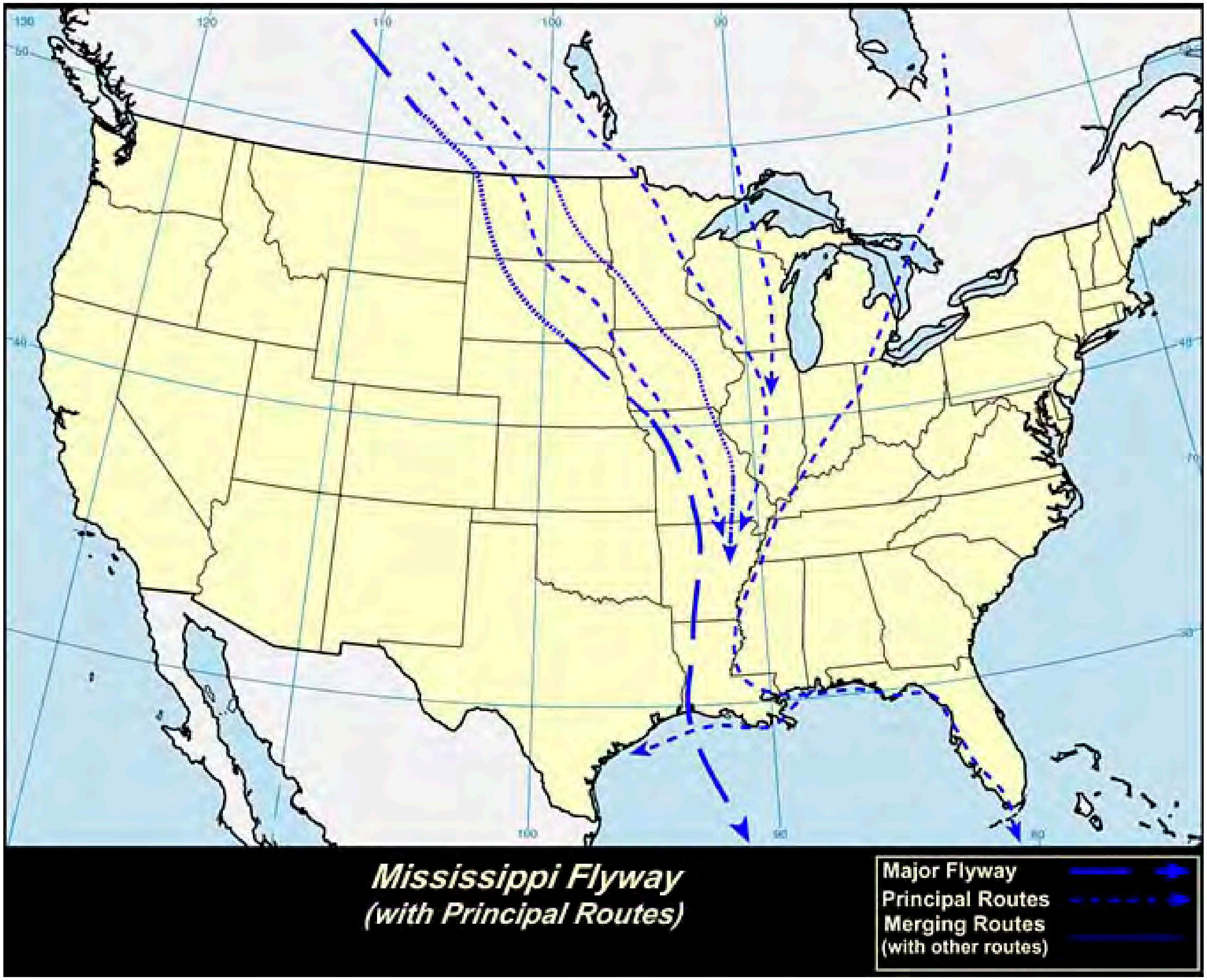

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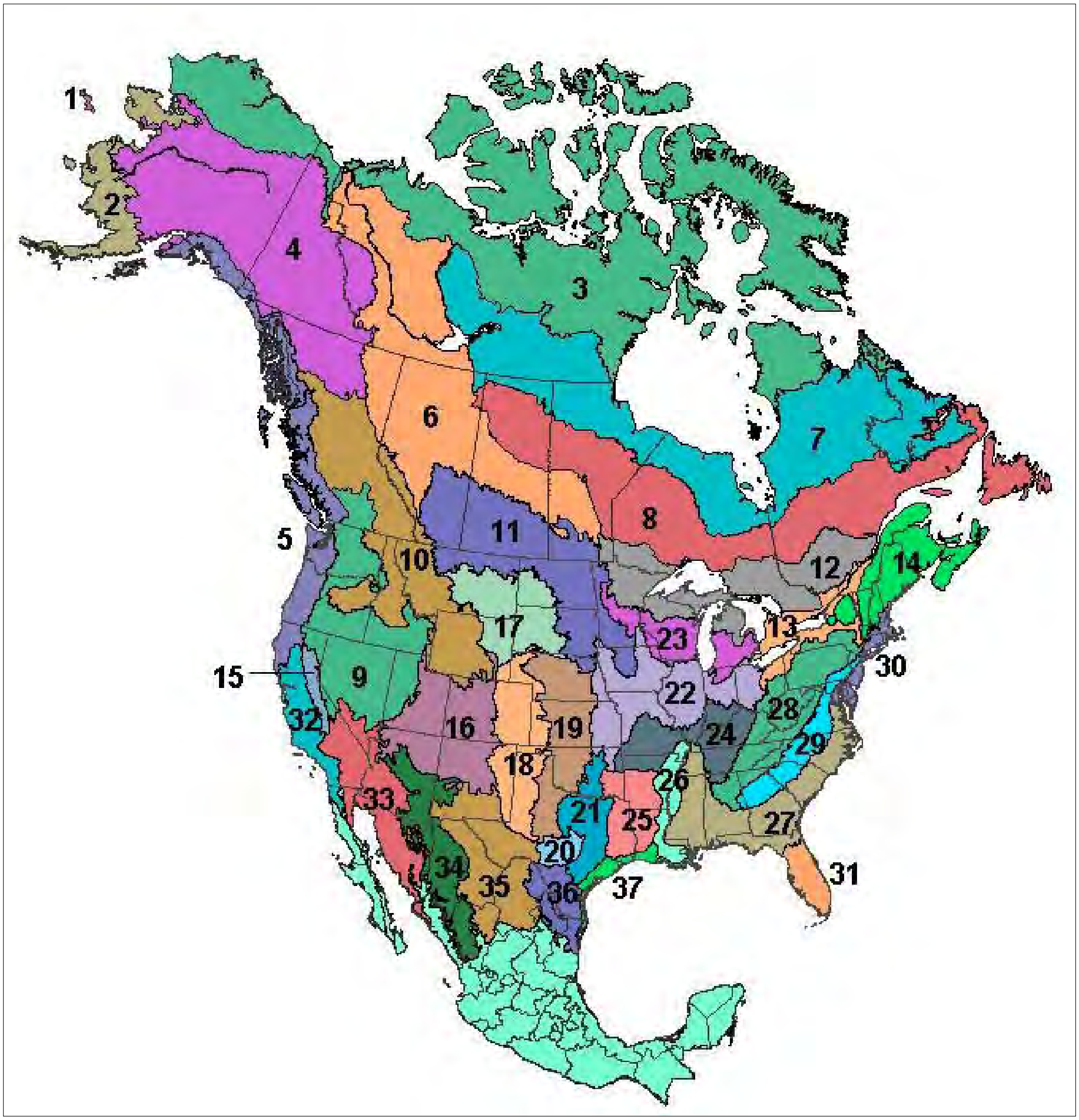

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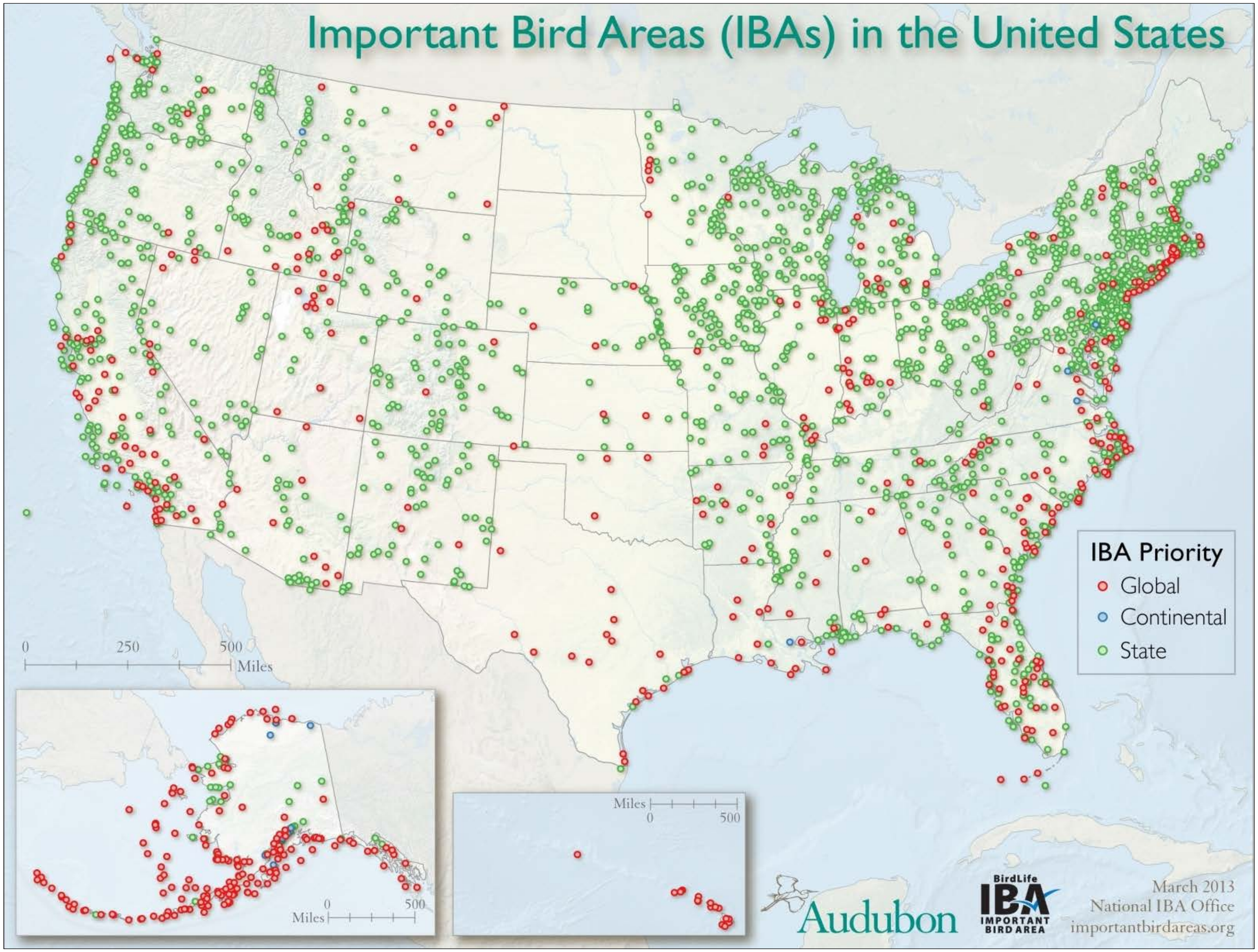

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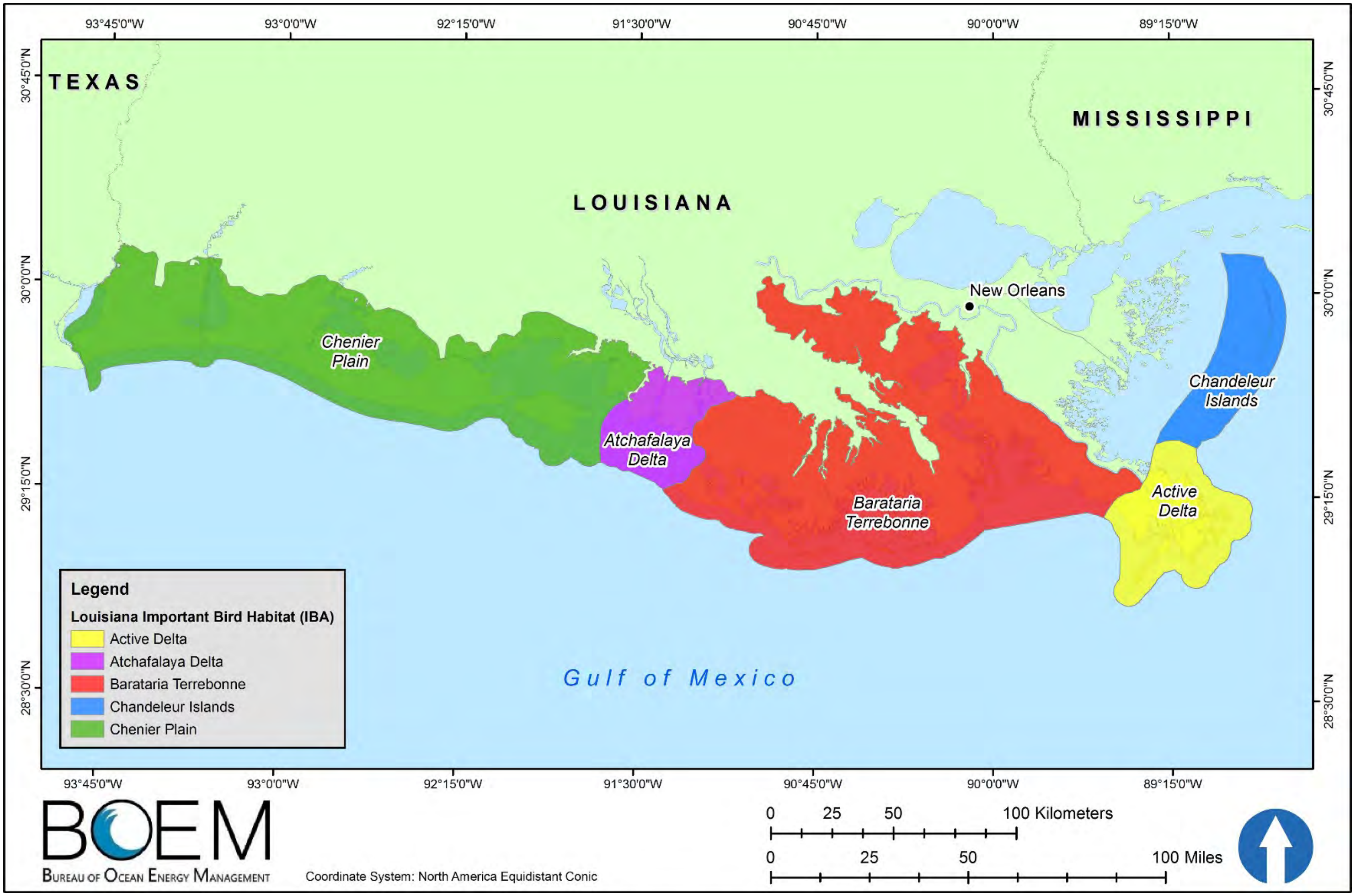

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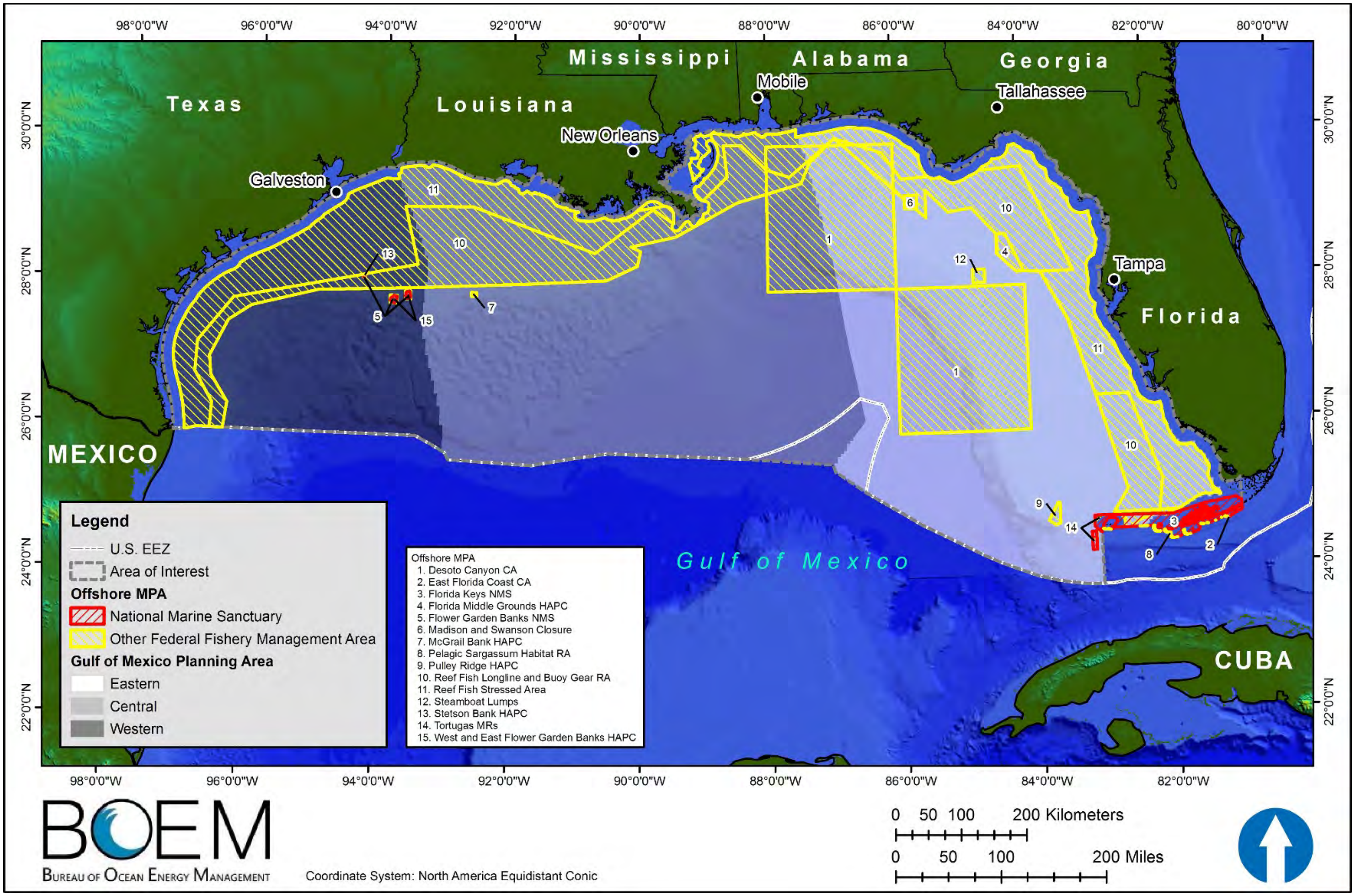

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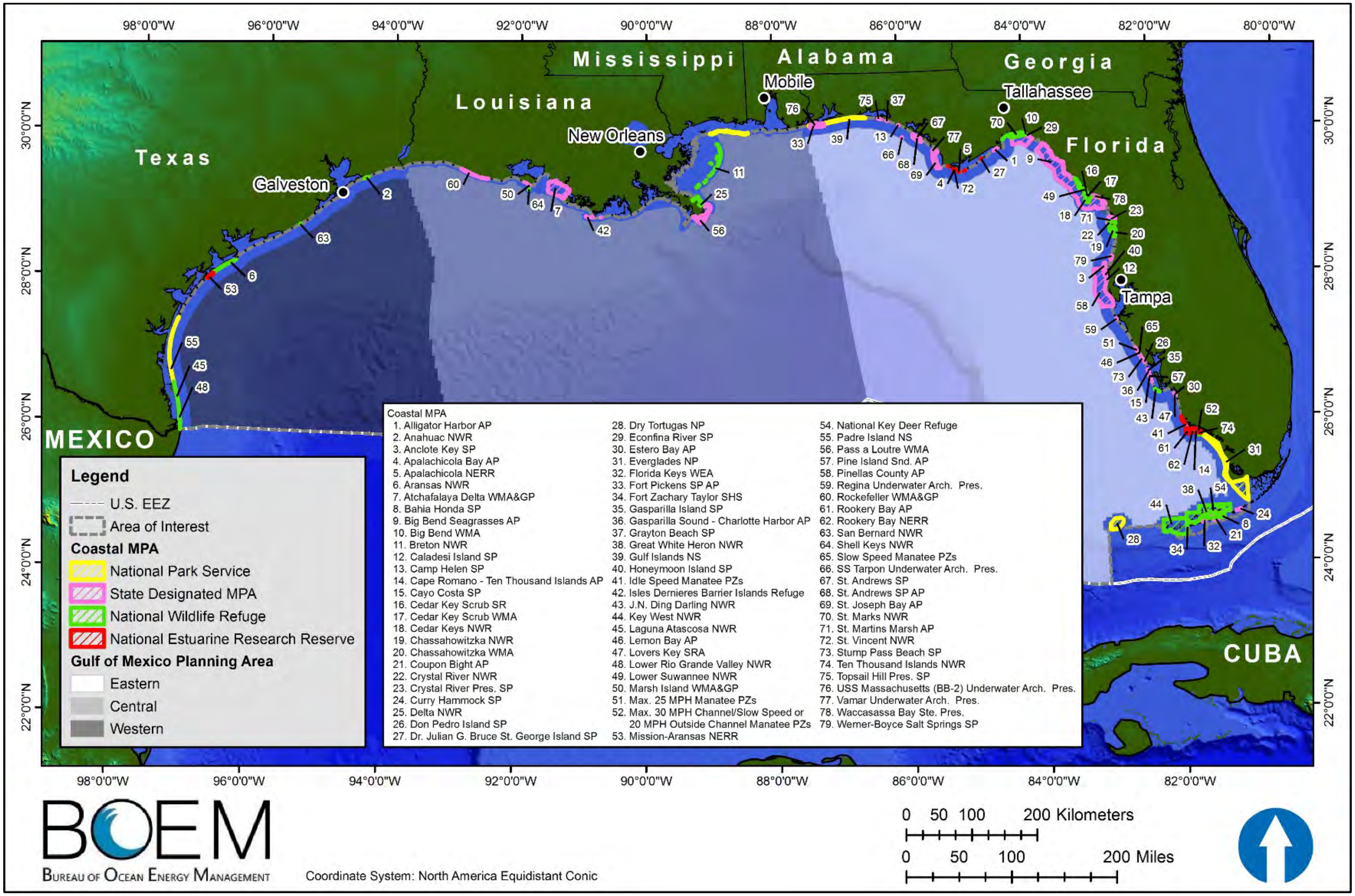

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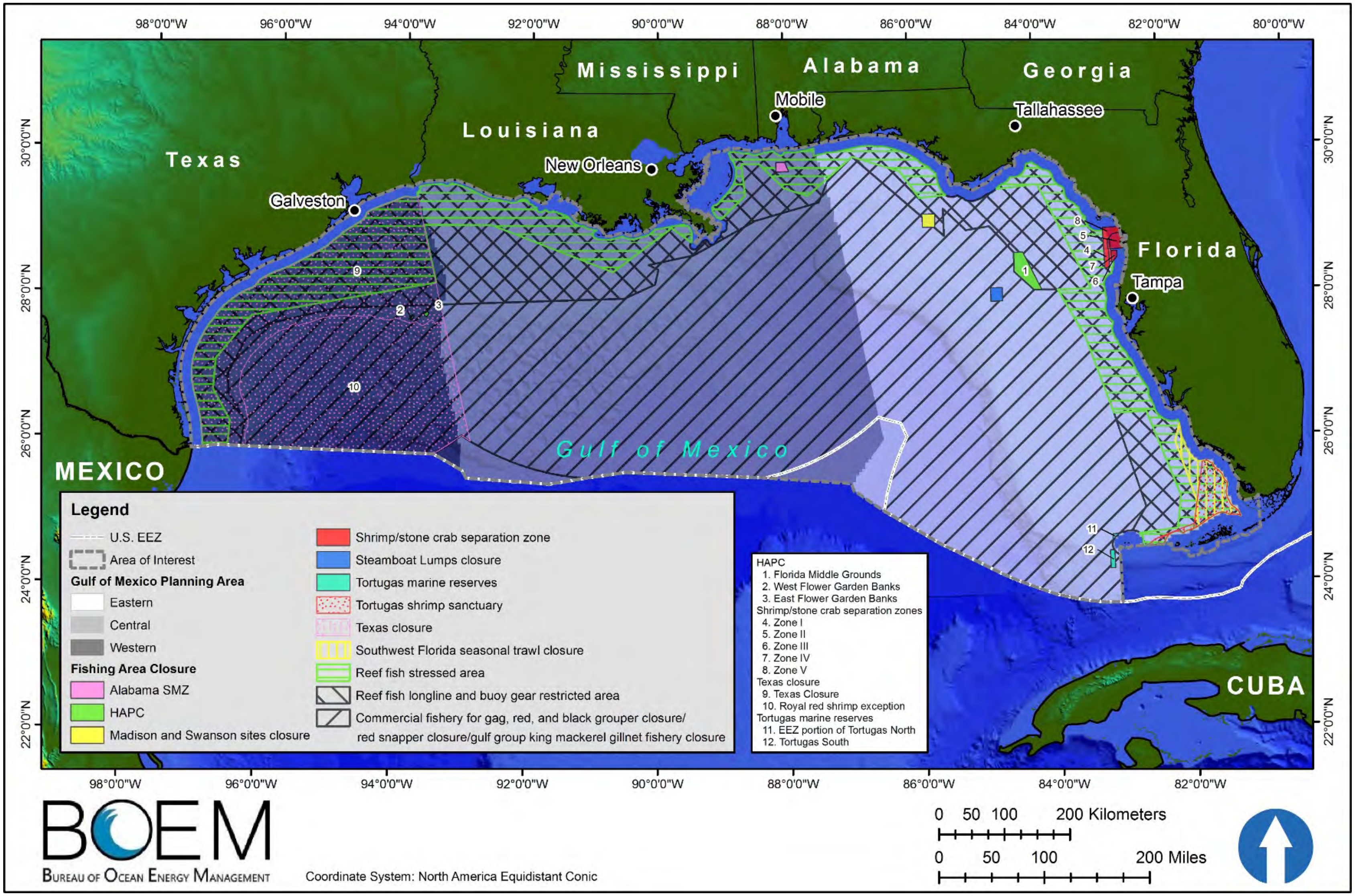

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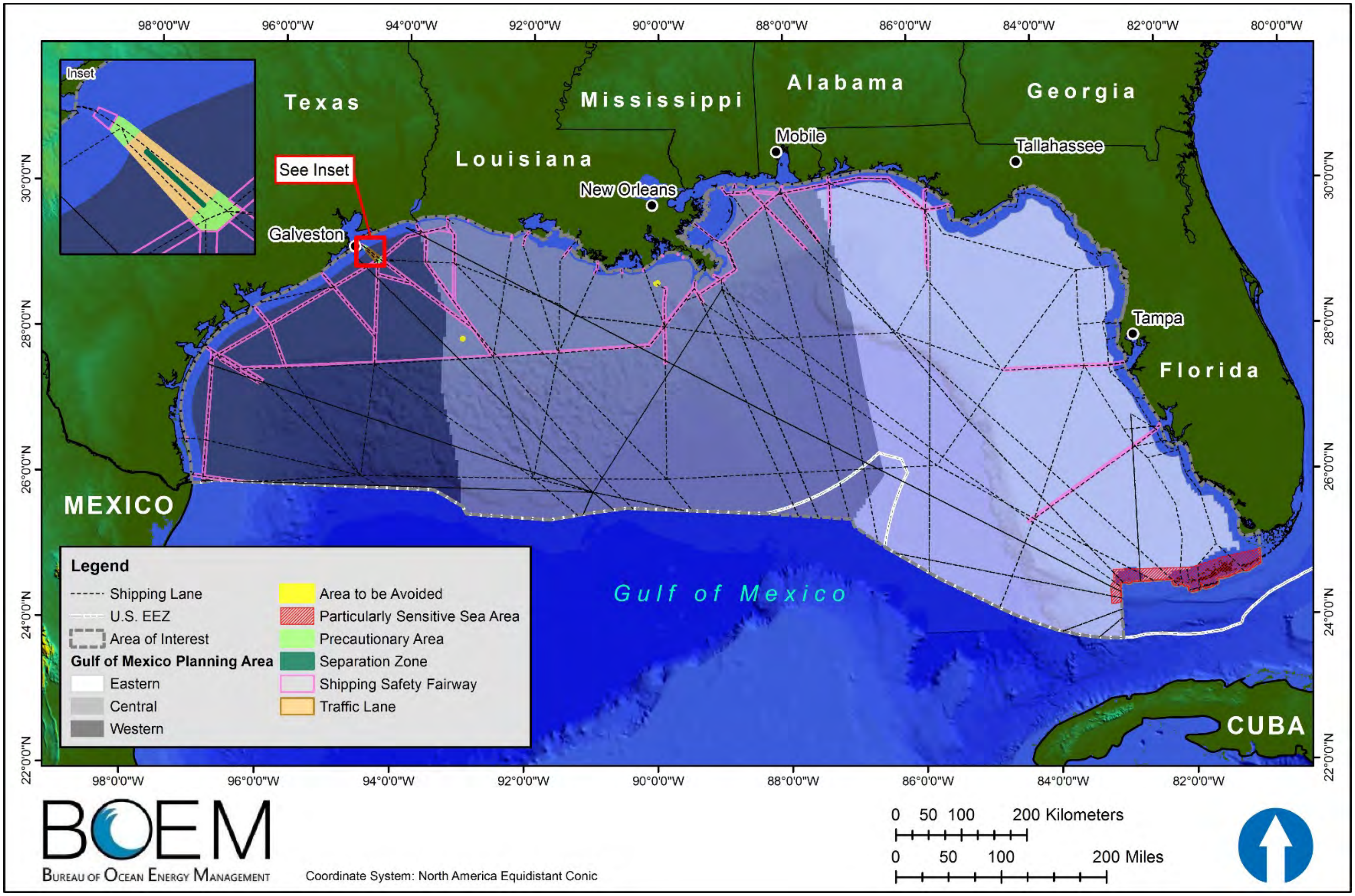

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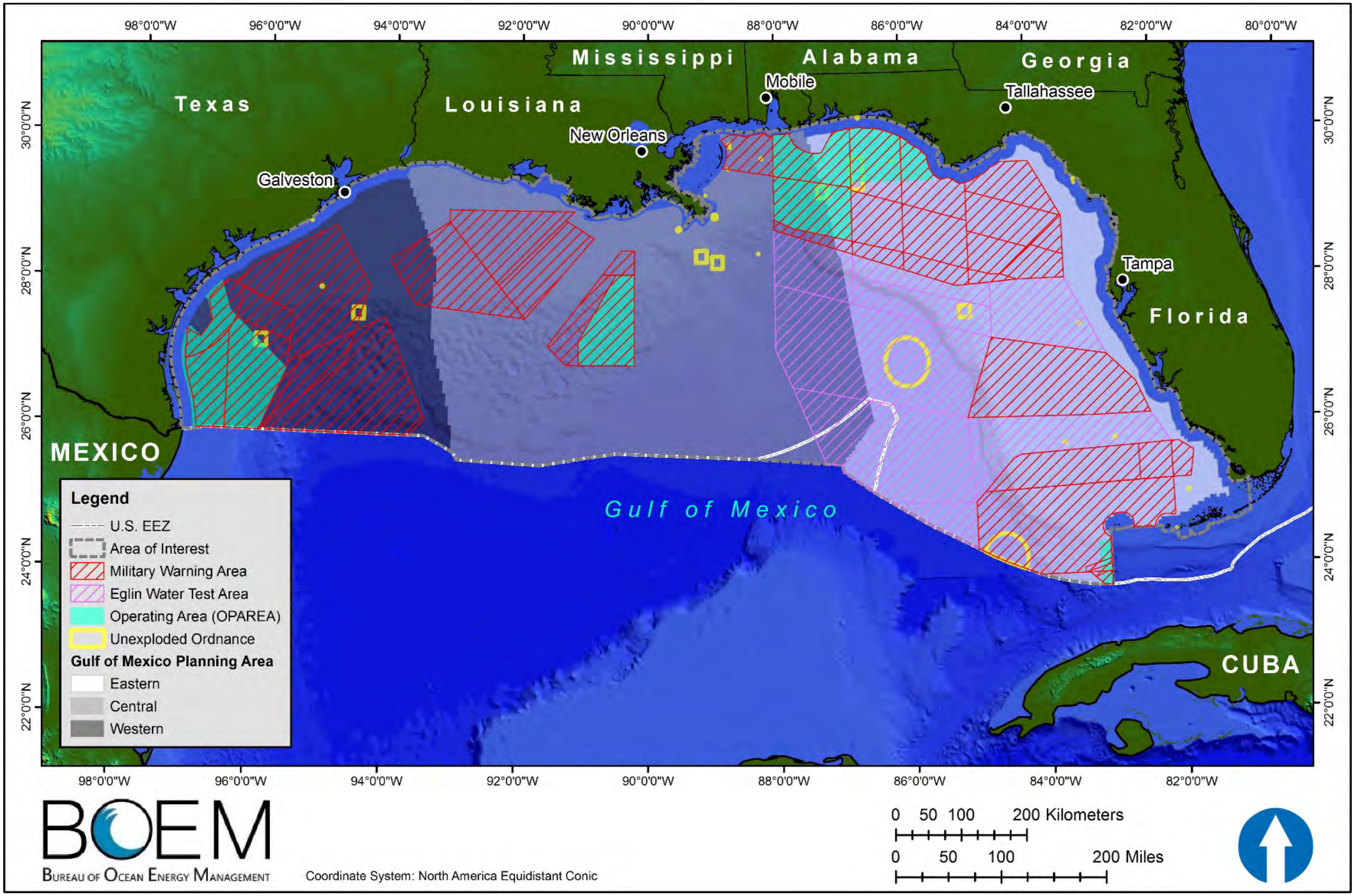

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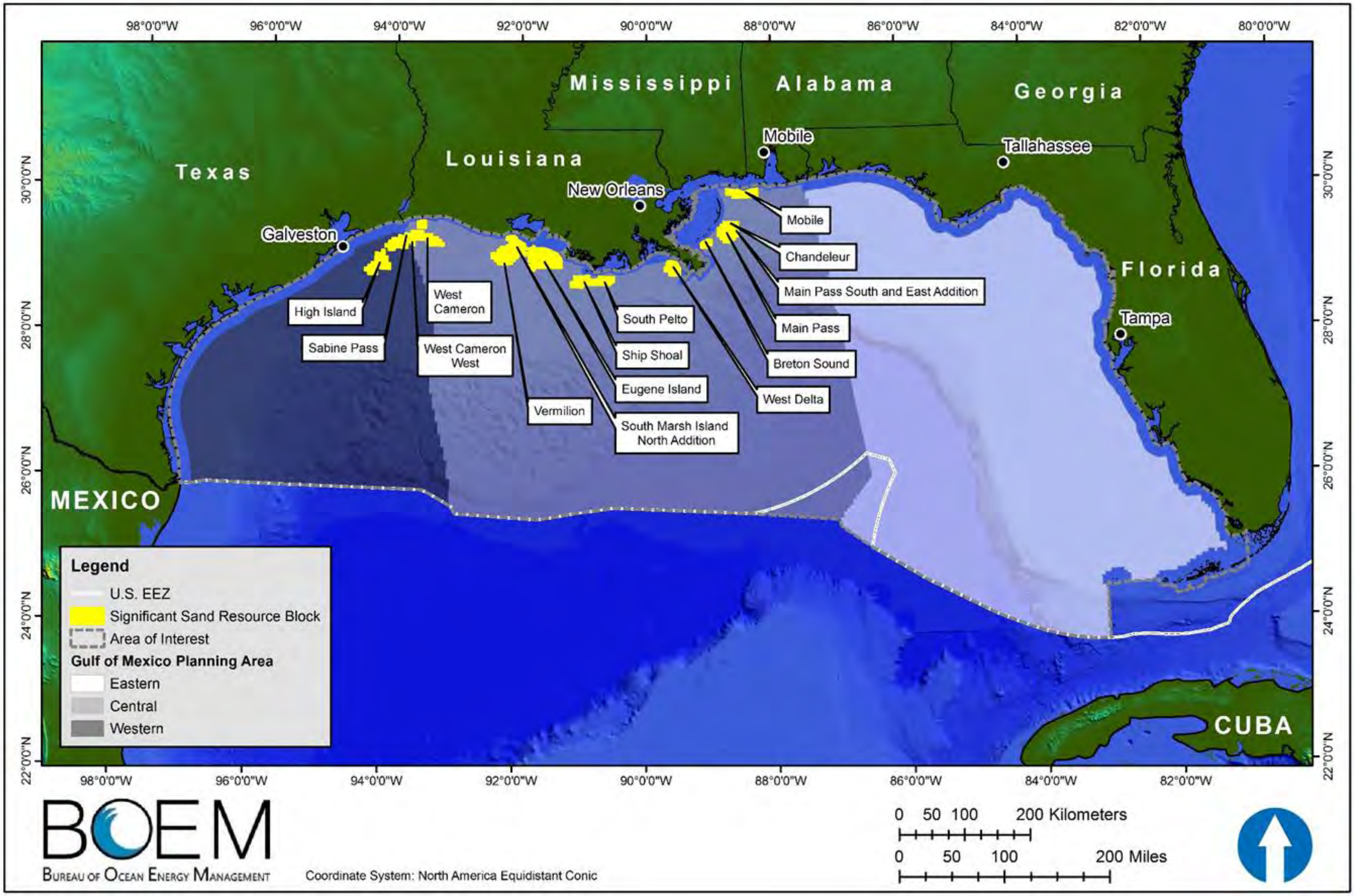

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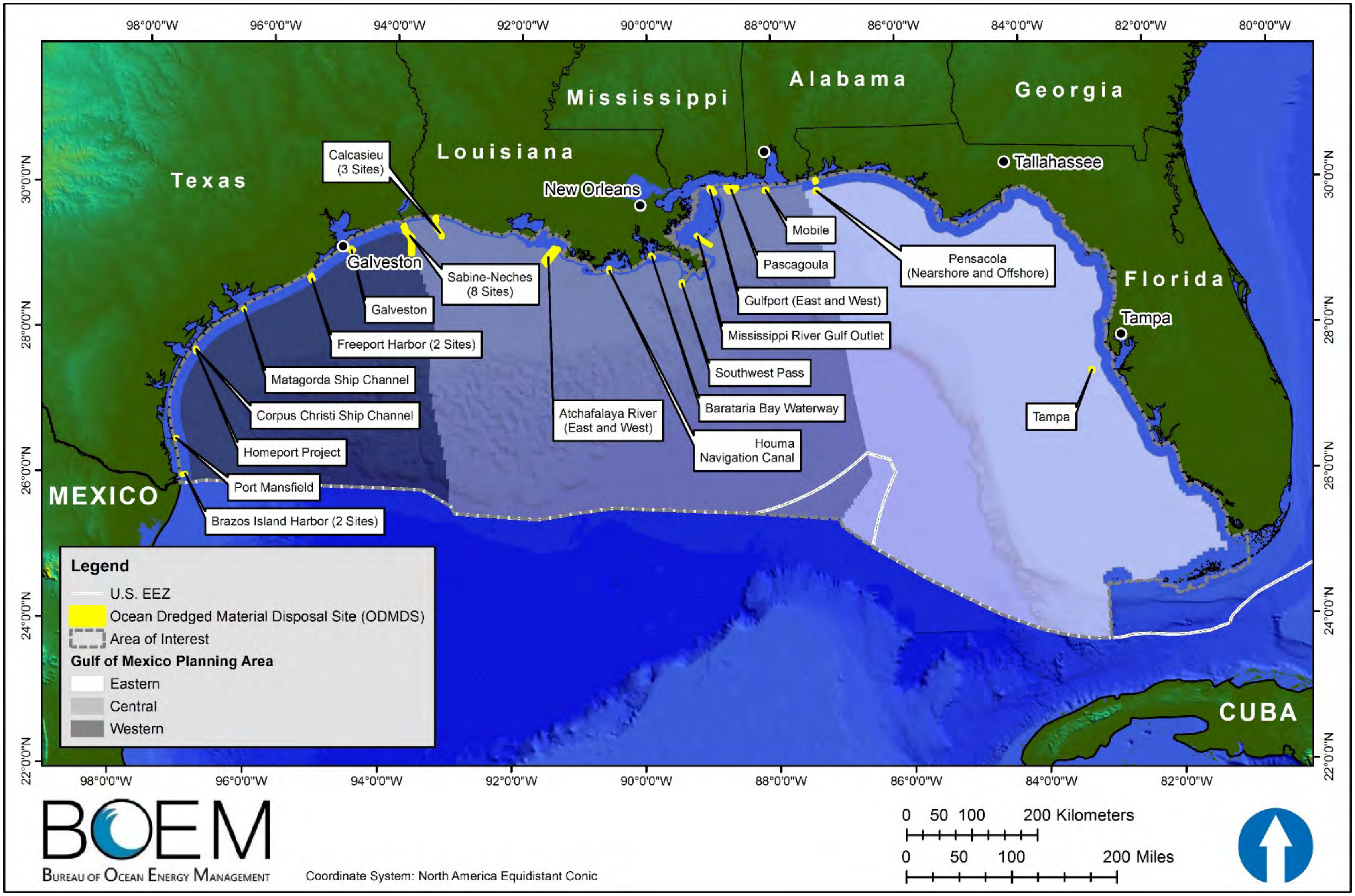

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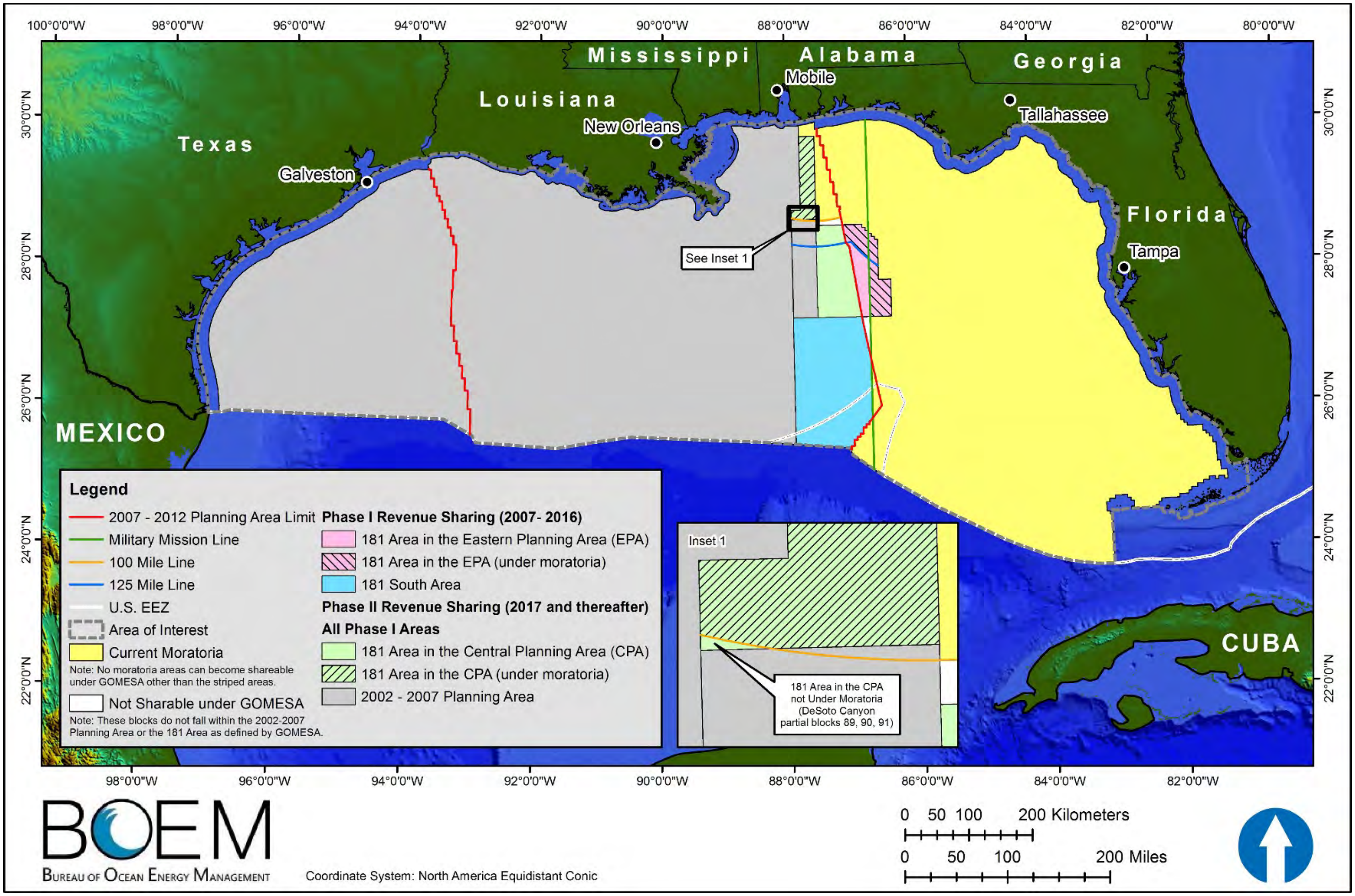

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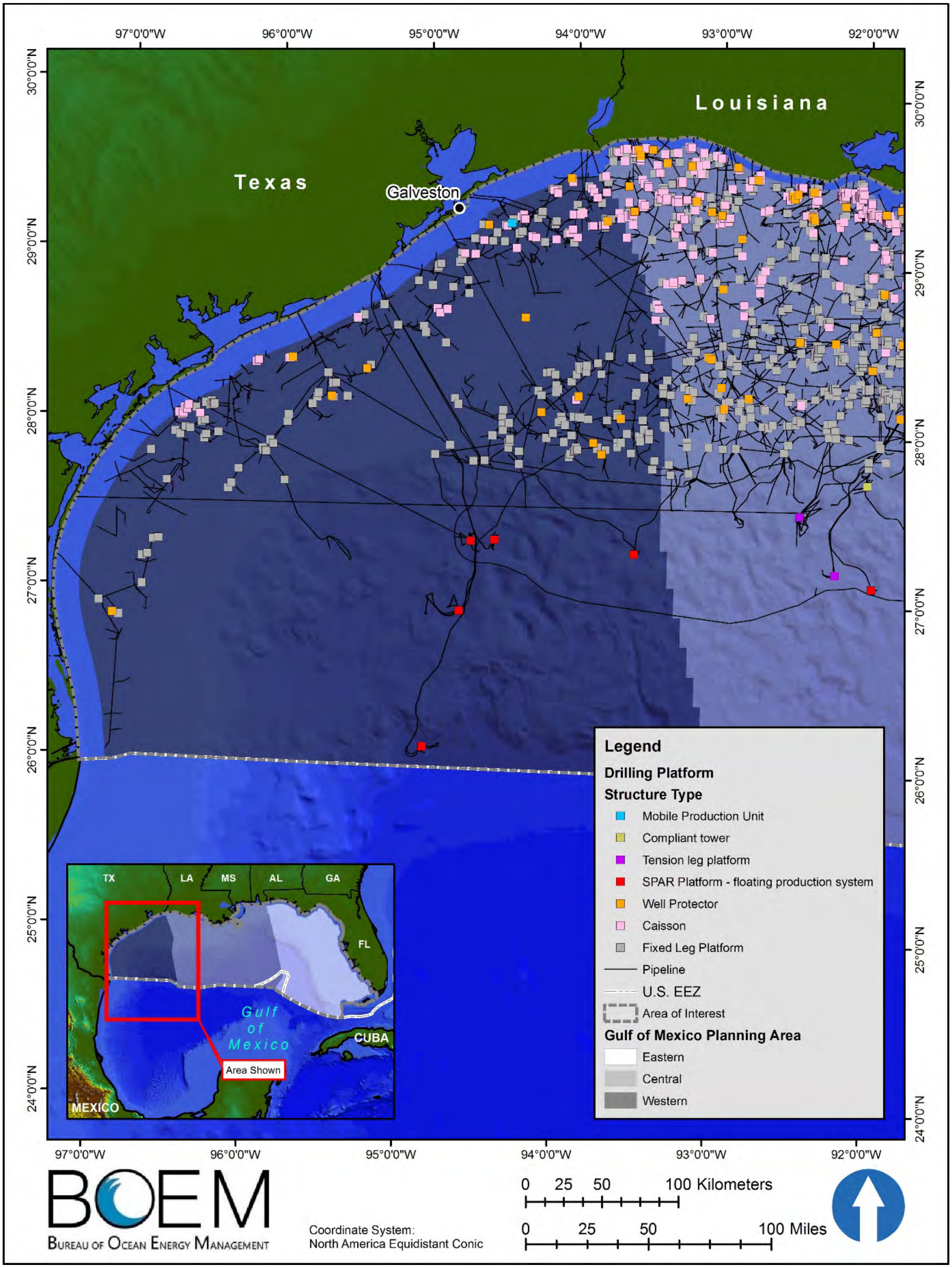

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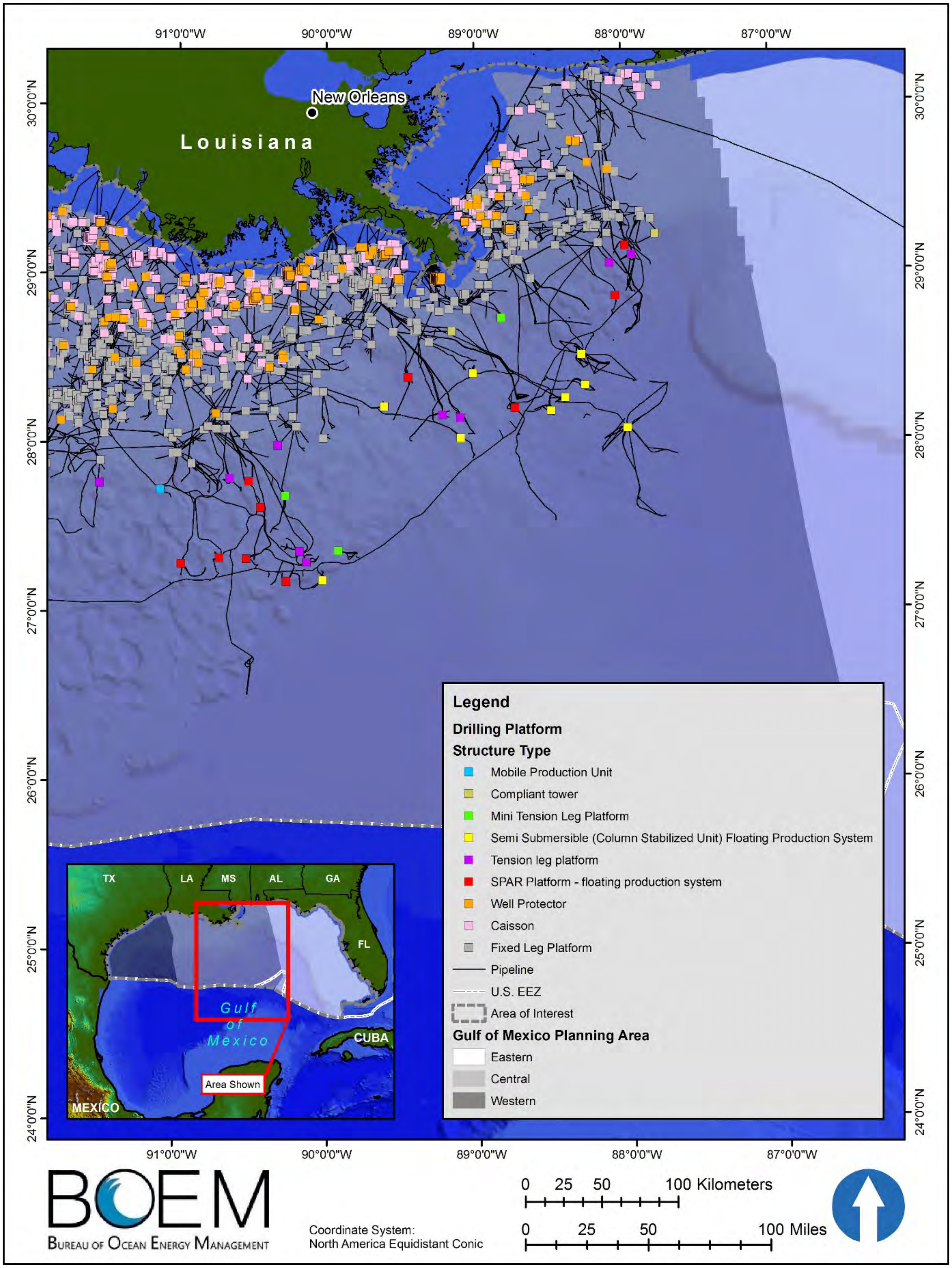

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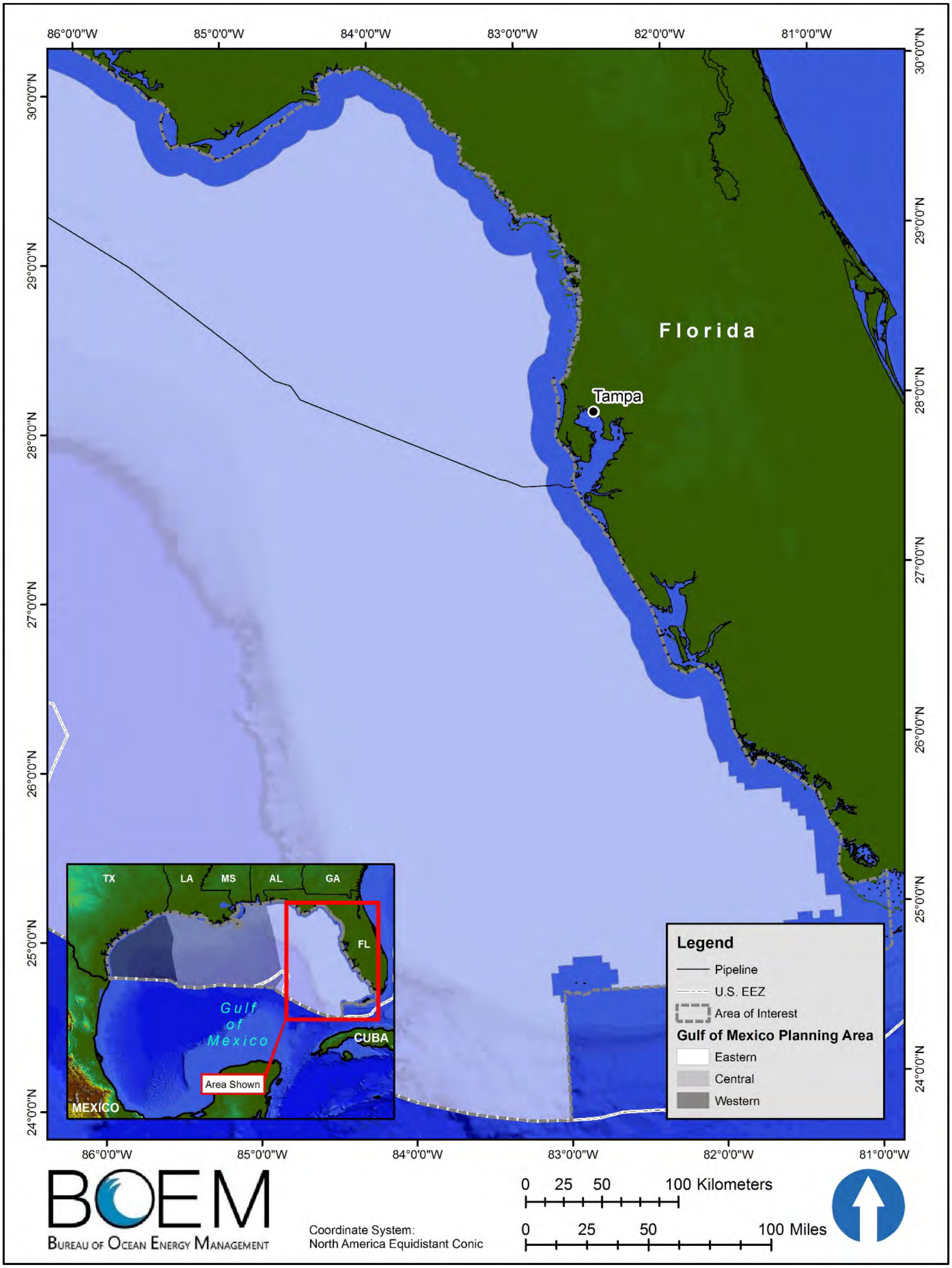

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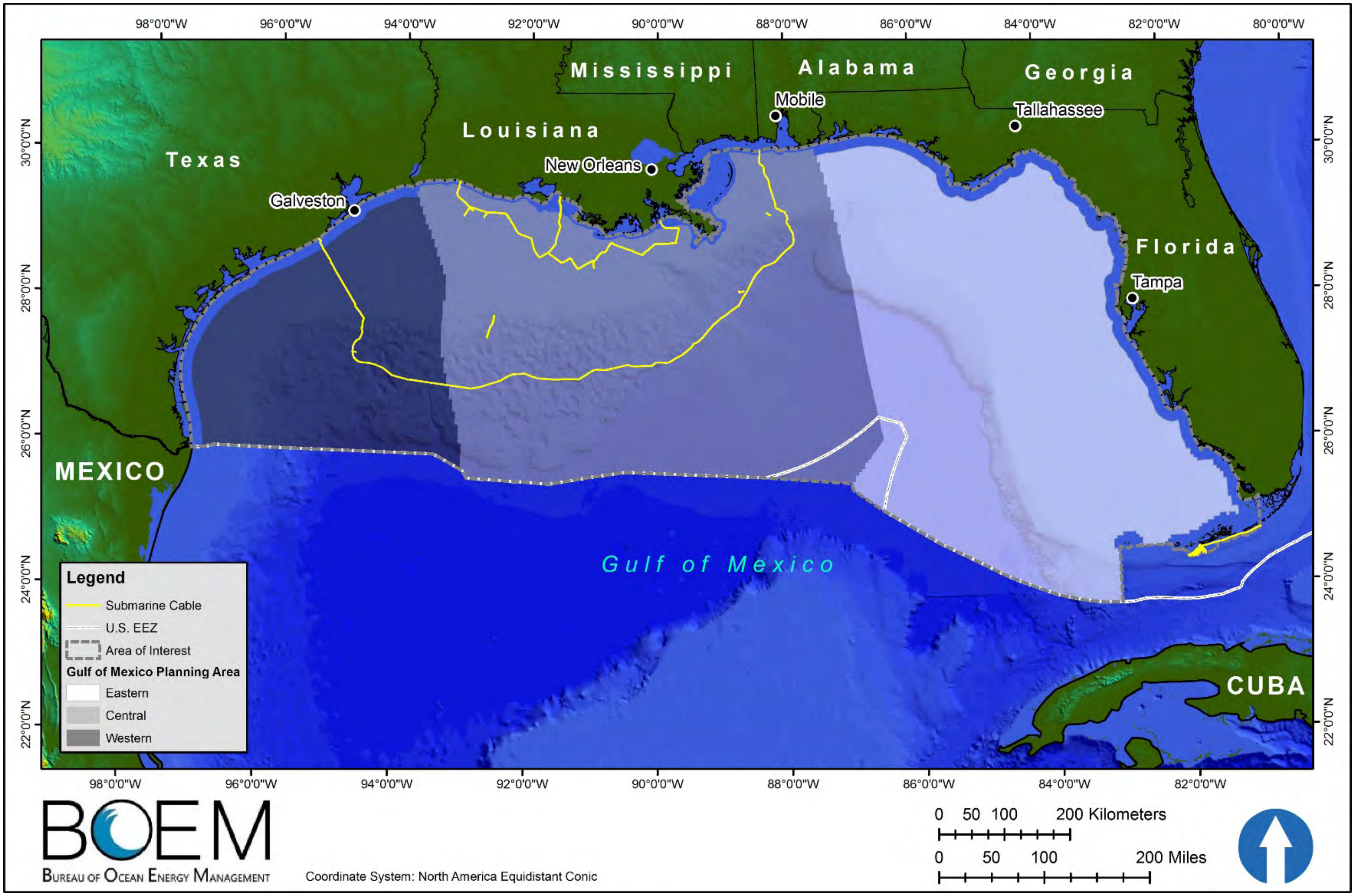

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Regulatory Citation	Mineral Resource	Description	Activity Phase
30 CFR part 550 (30 CFR part 250)	Oil, Gas, and Sulfur (Oil, Gas, and Sulfur Operations on the OCS)	550.102 What does this part do? (a) 30 CFR part 550 contains the regulations of the BOEM Offshore program that govern oil, gas, and sulfur exploration, development, and production operations on the OCS. When you conduct operations on the OCS, you must submit requests, applications, and notices, or provide supplemental information for BOEM approval.	Post-lease or on-lease exploration and/or development
		550.103 Where can I find more information about the requirements in this part? BOEM may issue NTLs that clarify, supplement, or provide more detail about certain requirements. NTLs may also outline what you must provide as required information in your various submissions to BOEM.	
		550.207 What ancillary activities may I conduct? Before or after you submit an Exploration Plan, Development and Production Plan, or Development Operations Coordination Document to BOEM, you may elect, the regulations in this part may require, or the Regional Supervisor may direct you to conduct ancillary activities. Ancillary activities include the following: (a) G&G explorations and development activities; (b) Geological and high-resolution geophysical, geotechnical, archaeological, biological, physical oceanographic, meteorological, socioeconomic, or other surveys; or (c) Studies that model potential oil and hazardous substance spills, drilling muds and cuttings discharges, projected air emissions, or potential hydrogen sulfide (H_2S) releases.	
30 CFR part 551 (30 CFR part 251)	Oil, Gas, and Sulfur (G&G Explorations of the OCS)	551.2 Purpose of this part (a) To allow you to conduct G&G activities on the OCS related to oil, gas, and sulfur on unleased lands or on lands under lease to a third party.	Pre-lease or off-lease exploration or scientific research
		551.3 Authority and applicability of this part (a) This part does not apply to G&G exploration conducted by or on behalf of the lessee on a lease on the OCS. Refer to 30 CFR part 550 if you plan to conduct G&G activities related to oil, gas, or sulfur under terms of a lease. (b) Federal agencies are exempt from the regulations in this part. (c) G&G exploration or G&G scientific research related to minerals other than oil, gas, and sulfur is covered by regulations at 30 CFR part 580.	

Table 1.1-1. Federal Regulations Applicable to Pre-hxLease and Post-Lease Activities by Mineral Resource of Interest (continued)

Regulatory Citation	Mineral Resource	Description	Activity Phase
30 CFR part 551 (30 CFR part 251) (continued)	Oil, Gas, and Sulfur (G&G Explorations of the OCS) (continued)	551.4 Types of G&G activities that require permits or notices (a) **Exploration –** You must have a BOEM-approved permit to conduct G&G exploration, including deep stratigraphic tests, for oil, gas, or sulfur resources. If you conduct both G&G exploration, you must have a separate permit for each. (b) **Scientific research –** You may only conduct G&G scientific research related to oil, gas, and sulfur on the OCS after you obtain a BOEM-approved permit or file a Notice.	
30 CFR part 580[a] (30 CFR part 280)	All Minerals Exclusive of Oil, Gas, and Sulfur (Prospecting for Minerals Other than Oil, Gas, and Sulfur on the OCS)	580.2 What is the purpose of this part? (a) Allow you to conduct prospecting activities or scientific research activities on the OCS in Federal waters related to hard minerals on unleased lands or on lands under lease to a third party. (b) Ensure that you carry out prospecting activities or scientific research activities in a safe and environmentally sound manner so as to prevent harm or damage to, or waste of, any natural resources (including any hard minerals in areas leased or not leased); any life (including fish and other aquatic life); property; or the marine, coastal, or human environment.	Pre-lease or off-lease prospecting
		580.4 What activities are not covered by this part? (a) G&G prospecting activities conducted by, or on behalf of, the lessee on a lease on the OCS; (b) Federal agencies; (c) Post-lease activities for mineral resources other than oil, gas, and sulfur, which are covered by regulations at 30 CFR parts 582[b] and 282[c]; and (d) G&G exploration or G&G scientific research activities related to oil, gas, and sulfur, including gas hydrates, which are covered by regulations at 30 CFR parts 551 and 251.	
		580.10 What must I do before I may conduct prospecting activities? You must have a BOEM-approved permit to conduct G&G prospecting activities, including deep stratigraphic tests, for hard minerals. If you conduct both G&G prospecting activities, you must have a separate permit for each.	
30 CFR part 585	Renewable Energy and Alternate Uses of Existing Facilities on the OCS	BOEM has developed guidelines for providing G&G, hazards, and archaeological information for renewable energy projects. The guidelines specify that BOEM recommends avoidance as a primary mitigation strategy.	Pre-lease and post-lease

BOEM = Bureau of Ocean Energy Management; CFR = Code of Federal Regulations; G&G = geological and geophysical; NTL = Notice to Lessees and Operators; OCS = Outer Continental Shelf.

[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.

[b]30 CFR part 582 – Operations of BOEM Issuance of Permits and Plans.

[c]30 CFR part 282 – Operations under a Mineral Lease under Provisions of Section 8(k) of the Outer Continental Shelf Lands Act.

Table 1.1-2. Program Area, Geological and Geophysical Activity, Permitting Authority, and Typical National Environmental Protection Agency Action

G&G Activity in Support of	On Lease	Off Lease and/or Third Party	Permitting Authority	How Approved		Typical NEPA Action
				OCS Plan[1]	Permit Application	
Oil and Gas						
Exploration (post-lease)	X	--	30 CFR part 550	EP	None	EA or EIS
Development (post-lease)	X	--	30 CFR part 550	DOCD or DPP	None	EA or EIS
Ancillary Activities (post-lease)	X	--	30 CFR part 550	Conditional, Plan Revision	Notification	Conditional, EA
Exploration (pre-lease)	--	X	30 CFR part 551	None	X	EA or EIS
Scientific Research	--	X	30 CFR part 551	None	X	EA
Renewable Energy						
Site Assessment	X	--	30 CFR part 585	SAP	None	EA or EIS
Renewable Energy Facility Development	X	--	30 CFR part 585	COP	None	EA or EIS
Other Activities	X	--	30 CFR part 585	GAP	None	EA or EIS
Marine Minerals						
Research and Prospecting	--	X	OCSLA Section 11 30 CFR part 580[2]	None	Authorization or Notification	EA or EIS
Leasing-Related Monitoring	X	--	OCSLA Section 8(k) 30 CFR parts 581-582[2]	None	None	None[3]

CFR = Code of Federal Regulations; COP = Construction and Operations Plan; DOCD = Development Operations Coordination Document; DPP = Development and Production Plan; EA = environmental assessment; EIS = environmental impact statement; EP = Exploration Plan; G&G = geological and geophysical; GAP = General Activities Plan; NEPA = National Environmental Policy Act; OCS = Outer Continental Shelf; OCSLA = Outer Continental Shelf Lands Act; SAP = Site Assessment Plan.

X indicates required; -- indicates not required.

[1] Plan types are defined in **Chapters 3.2.1.1, 3.2.2.1, and 3.2.3.1**.

[2] Applies to competitive leasing only, which BOEM has never done for marine minerals.

[3] Addressed in NEPA document for prospecting.

Table 1.2-1. Modeled and New Acoustic Guideline Criteria for Pulsed Sources

Functional Hearing Group	GOM Programmatic EIS Modeling		New Criteria[1]		Difference	
	Energy	Pressure	Energy	Pressure	Energy	Pressure
	SEL (dB re 1 μPa^2•s)	SPL_{peak} (dB re 1 μPa)	$L_{E, 24h}$ (dB re 1 μPa^2•s)	$L_{pk,flat}$ (dB re 1 μPa)	(dB)	(dB)
Low-frequency cetaceans	192	230	183	219	-9	-11
Mid-frequency cetaceans	187	230	185	230	-2	0
High-frequency cetaceans	161	200	155	202	-6	+2

dB = decibel; dB re 1 μPa = decibels referenced to 1 micropascal; dB re 1 μPa^2•s = decibels referenced to 1 micropascal per second; EIS = environmental impact statement; GOM = Gulf of Mexico; $L_{E,}$24h = sound exposure level, cumulative 24 hours; $L_{pk,\ flat}$ = peak sound pressure level (unweighted); SEL = sound exposure level; SPL_{peak} = peak sound pressure level.

[1] USDOC, NMFS, 2016b.

Note: The new criteria requires the summation of energy over 24 hours, which is different from the old criteria, which were based on the root mean square metric rather than cumulative sound exposure level.

Table 1.2-2. Modeled and New Acoustic Guideline Criteria for Non-Impulsive Sources

Functional Hearing Group	GOM Programmatic EIS Modeling		New Criteria[1]		Difference	
	Energy	Pressure	Energy	Pressure	Energy	Pressure
	SEL (dB re 1 μPa^2•s)	SPL_{peak} (dB re 1 μPa)	$L_{E,24h}$ (dB re 1 μPa^2•s)	Generally not needed or used	(dB)	(dB)
Low-frequency cetaceans	192	230	199	-	+7	N/A
Mid-frequency cetaceans	187	230	198	-	+11	N/A
High-frequency cetaceans	161	200	173	-	+12	N/A

dB = decibel; dB re 1 μPa = decibels referenced to 1 micropascal; dB re 1 μPa^2•s = decibels referenced to 1 micropascal per second; EIS = environmental impact statement; GOM = Gulf of Mexico; $L_{E,}$24h = sound exposure level, cumulative 24 hours; SEL = sound exposure level; SPL_{peak} = peak sound pressure level.

[1] USDOC, NMFS, 2016b.

N/A = not applicable.

Note: The new criteria requires the summation of energy over 24 hours, which is different from the old criteria, which were based on the root mean square metric rather than cumulative sound exposure level.

Table 2.2-1. Applicability of Mitigation Measures to Geological and Geophysical Surveys by Alternative (indicates which mitigation measure is applicable to an alternative)

Survey Type	Mitigation Measures														Survey Protocol		Seasonal Restrictions and Closures		
	Vessel Strike Avoidance	Marine Debris Guidance	Avoidance of Sensitive Benthic Communities	Avoidance of Historic and Prehistoric Sites	Shallow Hazards Guidance	NMS Regulations	Military Coordination	Ancillary Activity Guidance	Implement PSO Program	Implement Expanded PSO Program	Minimum Separation Distance	Reduced Level of Activity	Use of PAM Strongly Encouraged	Use of PAM Required	Seismic Airgun Survey Protocol	Non-Airgun HRG Survey Protocol	Coastal Waters Seasonal Restriction	Areas of Concern within the Eastern Planning Area[8]	CPA, EPA, Dry Tortugas, and Flower Garden Banks Closure Areas
Seismic Airgun Surveys	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	A-G	A,G	B- F[2] D[3]	B	E	A,G	B-F[4] C-F[5]	A-G	--	B[6] C-F[7]	B	F
Non-airgun HRG Surveys with frequencies >200 kHz	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	--	--	--	--	--	--	--	--	--	--	--	--
Non-airgun HRG Surveys with frequencies ≤200 kHz	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	--	C-F	--	--	--	--	--	--	C-F	--	--	F
Other G&G Surveys	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	--	--	--	--	--	--	--	--	--	--	--	--

CPA = Central Planning Area; EPA = Eastern Planning Area; ft = feet; HRG = high-resolution geophysical; kHz = kilohertz; m = meters; NMS = National Marine Sanctuary; PAM = passive acoustic monitoring; PSO = protected species observer.

[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] Expanded to include manatees and all water depths.

[3] Expanded from footnote 2 to include shutdown for all marine mammals, with the exception of bow-riding or actively approaching dolphins (i.e., common bottlenose, Fraser's, Clymene's, rough-toothed, striped, spinner, Atlantic spotted, pantropical, and Risso's) and all water depths.

[4] During periods of reduced visibility for surveys in waters deeper than 100 m (328 ft).

[5] PAM required for all airgun surveys at all times in the Mississippi Canyon and De Soto Canyon lease blocks.

[6] Applies to Federal coastal waters shoreward of the 20-m (66-ft) and a 5-km (3-mi) buffer extending seaward from the 20-m (66-ft) isobath between January 1 and April 30.

[7] Applies to all coastal waters shoreward of the 20-m (66-ft) isobath between February 1 and May 31.

[8] Does not apply to currently leased blocks, any portion of the area encompassed by Lease Sale 224, or neighboring blocks adjacent to permitted survey areas but within an otherwise off-limit area.

Table 2.2-2. Summary of Mitigation Measures Included in Alternatives A through G

Measure	Summarized Description	Alternative						
		A	B	C	D	E	F	G
Guidance for Vessel Strike Avoidance (NTL 2012-JOINT-G01)	All authorizations for shipboard surveys, regardless of vessel size, would include guidance for vessel strike avoidance while a vessel is in transit. The guidance would address protected species identification, vessel strike avoidance, and injured/dead protected species reporting in accordance with NMFS' Compliance Guide for the Right Whale Ship Strike Reduction Rule.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guidance for Marine Debris Awareness (NTL 2015-BSEE-G03)	All authorizations for shipboard surveys would include guidance for marine debris awareness, highlighting the environmental and socioeconomic impacts of marine trash and debris, as well as operator responsibilities for ensuring that trash and debris are not discharged into the marine environment.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guidance for Avoidance of Biologically Sensitive Underwater Features and Areas (NTL 2009-G39) and Deepwater (Sensitive) Benthic Communities (NTL 2009-G40)	All authorizations for seafloor-disturbing activities would be subject to restrictions to protect sensitive benthic communities (e.g., topographic features, hard/live bottom areas, deepwater coral communities, chemosynthetic communities). In areas where these communities are known or suspected, authorizations may include requirements for mapping and avoidance, as well as pre-deployment photographic surveys where bottom-founded equipment is to be deployed.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guidance for Archaeological Resources (NTLs 2005-G07, 2005 A03, 2008-G20, and 2011-JOINT-G01)	Authorizations for seafloor-disturbing activities would include requirements for operators to report suspected historic and prehistoric archaeological resources to BOEM and to take precautions to protect the resource. There are reporting and avoidance requirements for any previously undiscovered or suspected archaeological resource.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guidance for shallow hazards program (NTLs 2008-G05 and 2014 G03)	All seafloor-disturbing activities associated with exploration, development, production, and transportation operations must be preceded by a shallow hazards assessment.	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2.2-2. Summary of Mitigation Measures Included in Alternatives A through G (continued)

Measure	Summarized Description	Alternative						
		A	B	C	D	E	F	G
Regulations for Activities In or Near National Marine Sanctuaries (NMSs) (15 CFR part 922)	BOEM would not authorize seafloor-disturbing activities within an NMS no-activity zone. Seafloor-disturbing activities within the Flower Garden Banks NMS and outside of a no-activity zone are prohibited except for necessary activities conducted incidental to exploration for, development of, or production of oil and gas in those areas. Seafloor-disturbing activities proposed near the boundaries of an NMS would be assigned a setback distance by BOEM in consultation with the Sanctuary Manager.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guidance for Military Coordination (NTL 2014-G04)	To ensure personnel safety and reduce the likelihood of conflicts between military and OCS operations, all authorizations will include requirements in which the lessee or designated operator must enter into an agreement with the appropriate individual military command headquarters concerning the control of electromagnetic emissions and use of boats and aircraft in the applicable warning area or water test area before commencing such traffic.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Guidance for Ancillary Activities (NTL 2009-G34)	All authorizations for ancillary G&G exploration or development activities require notification 15 or 30 days prior to commencement of operations, depending on the type of survey, equipment, location, and water depth.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Minimum Separation Distances	When in the AOCs, simultaneous deep-penetration seismic airgun surveys shall maintain a separation distance of 40 km (25 mi) between active sources. When outside the AOCs, the separation distance will be 30 km (19 mi), excluding multiple ships operating in a coordinated survey (e.g., WAZ surveys) or due to safety or weather conditions.	No	Yes	No	No	No	No	No
Seismic Restriction in Eastern Planning Area	Deep-penetration seismic airgun surveys shall not be conducted within the portion of the AOCs within the EPA. This restriction does not apply to currently leased blocks, any portion of the area encompassed by Lease Sale 224, or neighboring blocks adjacent to permitted survey areas but within an otherwise off-limit area.	No	Yes	No	No	No	No	No

Table 2.2-2. Summary of Mitigation Measures Included in Alternatives A through G (continued)

Measure	Summarized Description	Alternatives						
		A	B	C	D	E	F	G
Seismic Airgun Survey Protocol: PSO and PAM Programs								
− Implementation of Seismic Survey Mitigation Measures and PSO Program (NTL 2012-JOINT-G02)	All authorizations for seismic airgun surveys in water depths >200 m (656 ft) in the WPA and CPA and in all water depths in the EPA would include ramp-up, protected species observers with specified training, visual and passive acoustic monitoring, exclusion zones, and reporting protocols for protected species.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
− Expanded PSO Program (manatees and all water depths)	The PSO Program would be expanded to include manatees as well as whales (whales are defined as all marine mammals in the Gulf of Mexico except dolphins and manatees; dolphins are defined as all marine mammal species in the family Delphinidae, which includes killer whales, pilot whales, and all of the dolphin species). Operators will immediately shut down all airguns and cease seismic operations any time a whale or manatee is detected entering or within the exclusion zone. Operators may recommence seismic operations and ramp-up of airguns only when the exclusion zone has been visually inspected for at least 30 minutes to ensure the absence of whales, sea turtles, and manatees. Further, the PSO Program would apply to all authorizations for deep-penetration seismic airgun surveys in the AOI regardless of water depth.	No	Yes	Yes	Yes	Yes	Yes	No

Table 2.2-2. Summary of Mitigation Measures Included in Alternatives A through G (continued)

Measure	Summarized Description	Alternative						
		A	B	C	D	E	F	G
− Expanded PSO Program (non-bow-riding Delphinids)	The PSO Program would be expanded to require shutdowns for all marine mammals in the exclusion zone (i.e., whales, manatees, and dolphins (refer to the definitions above) with the exception of bow-riding dolphins (i.e., common bottlenose, Fraser's, Clymene's, rough-toothed, striped, spinner, Atlantic spotted, pantropical, and Risso's).	No	No	No	Yes	No	No	No
− PAM Program	Monitoring for whales with PAM will allow ramp-up during times of reduced visibility when ramp-up would not be permitted otherwise. An assessment of the use of PAM, a description of the PAM system, the software used, and the Monitoring Plan should be reported to BSEE at the beginning of PAM use. The use of PAM is strongly encouraged.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
− Expanded PAM Requirement (low visibilty)	The use of PAM is required during periods of reduced visibility for deep-penetration seismic airgun surveys occurring in water depths >100 m (328 ft).	No	Yes	Yes	Yes	Yes	Yes	No
− Expanded PAM Requirement (canyons)	In addition to the above, PAM is required at all times for seismic airgun surveys in Mississippi Canyon and De Soto Canyon lease blocks.	No	No	Yes	Yes	Yes	Yes	No
Seasonal Restrictions for Federal Coastal Waters	The permittee shall not operate any airguns or airgun arrays in Federal coastal waters of the AOI from the 20-m (66-ft) isobath to the State-Federal boundary and a 5-km (3-mi) buffer extending seaward from the 20-m (66-ft) isobath between January 1 and April 30.	No	Yes	No	No	No	No	No
Seasonal Restrictions for All Coastal Waters	The permittee shall not operate any airguns or airgun arrays in coastal waters of the AOI from the 20-m (66-ft) isobath to shore between February 1 and May 31.	No	No	Yes	Yes	Yes	Yes	No

Table 2.2-2. Summary of Mitigation Measures Included in Alternatives A through G (continued)

Measures	Summarized Description	Alternative						
		A	B	C	D	E	F	G
HRG Survey Protocol	Authorizations for HRG non-airgun surveys in which one or more active acoustic sound sources will be operating at frequencies <200 kHz will require a 30-minute, pre survey clearance period of marine mammals and sea turtles before start-up or after a shutdown for all marine mammals except dolphins that are within the exclusion zone. One PSO and a 200-m (656-ft) exclusion zone are required in all water depths throughout the AOI. Authorizations for an HRG airgun survey require use of seismic airgun survey protocols described under Alternative A.	No	No	Yes	Yes	Yes	Yes	No
Reduction of G&G Activity Levels	Decrease the amount of deep-penetration, seismic multi-client surveys (in line miles) by 10 or 25 percent from estimated levels in a calendar year.	No	No	No	No	Yes	No	No
Area Closures	Closure of four areas: CPA Closure Area; EPA Closure Area; Dry Tortugas Closure Area; and Flower Gardens Closure Area. Areas are closed to all activities except HRG non-airgun surveys with equipment operating at frequencies >200 kHz.	No	No	No	No	No	Yes	No

AOC = Area of Concern; AOI = Area of Interest; BOEM = Bureau of Ocean Energy Management; BSEE = Bureau of Safety and Environmental Enforcement; CFR = Code of Federal Regulations; CPA = Central Planning Area; EPA = Eastern Planning Area; ft = foot; G&G = geological and geophysical; HRG = high-resolution geophysical; kHz = kilohertz; km = kilometer; m = meter; mi = mile; NMFS = National Marine Fisheries Service; NMS = National Marine Sanctuary; NTL = Notice to Lessees and Operators; OCS = Outer Continental Shelf; PAM = passive acoustic monitoring; PSO = protected species observer; WAZ = wide azimuth (survey).

Table 2.7-1. Alternative E1: 10-Percent Reduction of Deep-Penetration Seismic, Multi-Client Surveys (in line miles) from the Maximum Projected Activity Levels of Geological and Geophysical Activities for Oil and Gas Exploration in the Area of Interest

Year		Western Planning Area							Central Planning Area							Eastern Planning Area					
		HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	2D	3D[1]	WAZ[2]	4D
1	Shallow	(3) 400	(3) 93	0	0	(1) 2,620	0	(1) 9,507	(22) 2,000	(17) 496	0	0	(2) 13,605	0	(1) 9,900	(2) 100	(1) 31	0	0	0	0
	Deep	(4) 1,100	(19) 558	3	(0.33) 3,600	(1) 8,625	(1) 6,728	(3) 29,700	(32) 5,600	(35) 1,054	9	(0.67) 7,200	(5) 40,686	(6) 52,999	(6) 59,400	0	(2) 62	(1) 180	(1) 1,918	0	0
2	Shallow	(3) 350	(2) 62	0	0	0	0	0	(22) 2,000	(15) 434	0	0	(2) 18,400	(1) 4,897	0	(2) 100	0	0	0	0	0
	Deep	(5) 1,200	(14) 403	1	(0.5) 1,620	(1) 13,731	(3) 20,043	(3) 29,700	(32) 5,600	(33) 992	8	(0.50) 1,620	(5) 42,618	(5) 46,347	(6) 59,400	(1) 50	(1) 400	(1) 360	(1) 4,139	0	0
3	Shallow	(3) 350	(3) 93	0	0	0	0	(1) 9,507	(20) 1,950	(14) 403	0	0	(2) 16,538	0	(1) 9,900	(1) 50	(1) 31	0	0	0	0
	Deep	(6) 1,300	(16) 465	2	(1) 540	(1) 8,625	(2) 17,049	(3) 29,700	(35) 5,850	(30) 917	10	(1) 1,620	(4) 33,955	(5) 44,203	(6) 59,400	(2) 100	(2) 62	(1) 18,810	(1) 4,139	0	0
4	Shallow	(3) 325	(2) 62	0	0	(1) 2,620	0	0	(18) 1,900	(15) 434	0	0	(2) 21,433	(1) 6,781	0	0		0	0	0	0
	Deep	(6) 1,300	(14) 403	2	(1.00) 540	(1) 3,786	(3) 20,550	(3) 29,700	(35) 5,850	(33) 992	11	(1) 1,620	(2) 18,658	(2) 21,471	(6) 59,400	(2) 100	(1) 5	(1) 24,210	(1) 10,080	(1) 11,210	0
5	Shallow	(3) 300	(3) 93	0	0	0	0	0	(18) 1,900	(12) 372	0	0	(2) 13,715	0	(1) 9,900	0		0	0	0	0
	Deep	(6) 1,400	(16) 465	2	(1.00) 540	(1) 4,927	(1) 7,287	(3) 29,700	(40) 6,200	(27) 806	7	(1) 1,620	(3) 26,605	(5) 40,507	(6) 59,400	(1) 50	(1) 5	(1) 9,360	(1) 15,120	0	0
6	Shallow	(3) 300	(1) 31	0	0	0	0	0	(17) 1,700	(10) 310	0	0	(2) 17,661	(1) 3,453	0	0	0	0	0	0	0
	Deep	(6) 1,400	(8) 248	1	0	(1) 8,625	(1) 9,205	(3) 29,700	(42) 6,500	(24) 713	8	0	(2) 12,805	(3) 25,872	(6) 59,400	(2) 100	(1) 1	0	(1) 15,120	0	0
7	Shallow	(3) 600	(1) 31	0	0	(1) 2,620	0	(2) 19,013	(15) 1,500	(14) 403	0	0	(1) 12,578	(1) 0	(1) 9,900	0	0	0	0	0	0
	Deep	(7) 1,475	(5) 155	0	(0.33) 1,800	(1) 9,010	(1) 8,690	(3) 29,700	(45) 7,000	(30) 899	9	(0.67) 3,600	(2) 13,796	(4) 34,208	(6) 59,400	(3) 150	(1) 0	(1) 810	(1) 10,080	(1) 2,651	0
8	Shallow	(4) 800	(1) 31	0	0	0	0	0	(15) 1,500	(13) 403	0	0	(2) 20,252	(1) 4,514	0	0	0	0	0	0	0
	Deep	(7) 1,475	(5) 155	0	0	(1) 14,162	(1) 8,690	(3) 29,700	(50) 7,500	(29) 868	7	0	(2) 16,253	(3) 30,088	(6) 59,400	(4) 200	(1) 5	(1) 19,350	(1) 10,080	(1) 4,345	0
9	Shallow	(4) 800	(1) 31	0	0	0	0	(2) 19,013	(15) 1,500	(10) 310	0	0	(1) 12,286	0	(1) 9,900	0	0	0	0	0	0

Table 2.7-1. Alternative E1: 10-Percent Reduction of Deep-Penetration Seismic, Multi-Client Surveys (in line miles) from the Maximum Projected Activity Levels of Geological and Geophysical Activities for Oil and Gas Exploration in the Area of Interest (continued)

Year		Western Planning Area							Central Planning Area							Eastern Planning Area					
		HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	2D	3D[1]	WAZ[2]	4D
	Deep	(8) 1,500	(8) 248	1	(1) 540	(1) 13,368	(1) 8,690	(3) 29,700	(50) 7,500	(24) 713	8	(1) 1,620	(1) 7,819	(3) 31,056	(6) 59,400	(4) 200	(1) 0	(1) 24,660	(1) 10,080	(1) 4,476	0
10	Shallow	(6) 1,000	(1) 31	0	0	0 2,620	0	0	(12) 1,200	(10) 310	0	0	(2) 20,126	(1) 3,066	0	0	0	0	0	0	0
	Deep	(8) 1,500	(5) 155	1	0	(1) 8,516	0	(3) 29,700	(55) 8,000	(24) 713	10	0	(1) 10,002	(3) 26,210	(6) 59,400	(4) 200	(1) 5	(1) 9,000	(1) 10,080	0	0
Totals		(98) 18,875	(128) 3,813	13	(5.16) 9,180	(14) 103,853	(14) 106,934	(36) 354,040	(590) 82,750	(419) 12,542	87	(5.84) 18,900	(45) 389,789	(44) 375,674	(65) 643,500	(28) 1,400	(14) 607	(9) 106,740	(10) 90,836	(4) 22,682	0

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional; ft = foot; HRG = high-resolution geophysical; m= meter; SWD = seismic while drilling; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

Shallow = <200-m (656-ft) water depth; Deep = >200-m (656-ft) water depth.

Numbers in parentheses represent the number of surveys; numbers without parentheses represent the distance in miles.

1 3D surveys include ocean bottom cable surveys, nodal surveys, and vertical cable surveys.

2 WAZ estimates include coil shooting (exclusive to WesternGeco).

Table 2.7-2. Alternative E2: 25-Percent Reduction of Deep-Penetration Seismic, Multi-Client Surveys (in line miles) from the Maximum Projected Activity Levels of Geological and Geophysical Activities for Oil and Gas Exploration in the Area of Interest

Year	Water Depth	Western Planning Area							Central Planning Area							Eastern Planning Area					
		HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	2D	3D[1]	WAZ[2]	4D
1	Shallow	(3) 400	(3) 93	0	0	(1) 2,183	0	(1) 7,922	(22) 2,000	(17) 496	0	0	(2) 11,338	0	(1) 8,250	(2) 100	(1) 31	0	0	0	0
	Deep	(4) 1,100	(19) 558	3	(0.33) 3,000	(1) 7,187	(1) 5,607	(3) 24,750	(32) 5,600	(35) 1,054	9	(0.67) 6,000	(5) 33,905	(6) 44,166	(6) 49,500	0	(2) 62	(1) 150	(1) 1,598	0	0
2	Shallow	(3) 350	(2) 62	0	0	0	0	0	(22) 2,000	(15) 434	0	0	(2) 15,333	(1) 4,081	0	(2) 100	0	0	0	0	0
	Deep	(5) 1,200	(14) 403	1	(0.5) 1,350	(1) 11,443	(3) 16,703	(3) 24,750	(32) 5,600	(33) 992	8	(0.50) 1,350	(5) 35,515	(5) 38,623	(6) 49,500	(1) 50	(1) 400	(1) 300	(1) 3,449	0	0
3	Shallow	(3) 350	(3) 93	0	0	0	0	(1) 7,922	(20) 1,950	(14) 403	0	0	(2) 13,781	0-	(1) 8,250	(1) 50	(1) 31	0	0	0	0
	Deep	(6) 1,300	(16) 465	2	(1.00) 450	(1) 7,187	(2) 14,207	(3) 24,750	(35) 5,850	(30) 917	10	(1) 1,350	(4) 28,296	(5) 36,836	(6) 49,500	(2) 100	(2) 62	(1) 15,675	(1) 3,449	0	0
4	Shallow	(3) 325	(2) 62	0	0	(1) 2,183	0	0	(18) 1,900	(15) 434	0	0	(2) 17,861	(1) 5,651	0	0	0	0	0	0	0
	Deep	(6) 1,300	(14) 403	2	(1.00) 450	(1) 3,155	(3) 17,125	(3) 24,750	(35) 5,850	(33) 992	11	(1) 1,350	(2) 15,548	(2) 17,893	(6) 49,500	(2) 100	(1) 5	(1) 20,175	(1) 8,400	(1) 9,342	0
5	Shallow	(3) 300	(3) 93	0	0	0	0	0	(18) 1,900	(12) 372	0	0	(2) 11,429	0	(1) 8,250	0	0	0	0	0	0
	Deep	(6) 1,400	(16) 465	2	(1.00) 450	(1) 4,106	(1) 6,073	(3) 24,750	(40) 6,200	(27) 806	7	(1) 1,350	(3) 22,171	(5) 33,756	(6) 49,500	(1) 50	(1) 5	(1) 7,800	(1) 12,600		0
6	Shallow	(3) 300	(1) 31	0	0	0	0	0	(17) 1,700	(10) 310	0	0	(2) 14,717	(1) 2,878	0	0	0	0	0	0	0
	Deep	(6) 1,400	(8) 248	1	0	(1) 7,187	(1) 7,671	(3) 24,750	(42) 6,500	(24) 713	8	0	(2) 10,671	(3) 21,560	(6) 49,500	(2) 100	(1) 1	0	(1) 12,600	0	0
7	Shallow	(3) 600	(1) 31	0	0	(1) 2,183	0	(2) 15,845	(15) 1,500	(14) 403	0	0	(1) 10,481	(1) -	(1) 8,250	0	0	0	0	0	0
	Deep	(7) 1,475	(5) 155	0	(0.33) 1,500	(1) 7,508	(1) 7,242	(3) 24,750	(45) 7,000	(30) 899	9	(0.67) 3,000	(2) 11,497	(4) 28,507	(6) 49,500	(3) 150	(1) 0	(1) 675	(1) 8,400	(1) 2,209	0
8	Shallow	(4) 800	(1) 31	0	0	0	0	0	(15) 1,500	(13) 403	0	0	(2) 16,877	(1) 3,762	0	0	0	0	0	0	0
	Deep	(3) 400	(3) 93	0	0	(1) 2,183	0	(1) 7,922	(22) 2,000	(17) 496	0	0	(2) 11,338	0	(1) 8,250	(2) 100	(1) 31	0	0	0	0
9	Shallow	(4) 800	(1) 31	0	0	0	0	(2) 15,845	(15) 1,500	(10) 310	0	0	(1) 10,238	0	(1) 8,250	0	0	0	0	0	0

Table 2.7-2. Alternative E2: 25-Percent Reduction of Deep-Penetration Seismic, Multi-Client Surveys (in line miles) from the Maximum Projected Activity Levels of Geological and Geophysical Activities for Oil and Gas Exploration in the Area of Interest (continued)

Year	Water Depth	Western Planning Area							Central Planning Area							Eastern Planning Area					
		HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	SWD	2D	3D[1]	WAZ[2]	4D	HRG	VSP	2D	3D[1]	WAZ[2]	4D
	Deep	(8) 1,500	(8) 248	1	(1) 450	(1) 11,140	(1) 7,242	(3) 24,750	(50) 7,500	(24) 713	8	(1) 1,350	(1) 6,516	(3) 25,880	(6) 49,500	(4) 200	(1) 0	(1) 20,550	(1) 8,400	(1) 3,730	0
10	Shallow	(6) 1,000	(1) 31	0	0	(1) 2,183	0	0	(12) 1,200	(10) 310	0	0	(2) 16,772	(1) 2,555	0	0	0	0	0	0	0
	Deep	(8) 1,500	(5) 155	1	0	(1) 7,097	0	(3) 24,750	(55) 8,000	(24) 713	10	0	(1) 8,335	(3) 21,842	(6) 49,500	(4) 200	(1) 5	(1) 7,500	(1) 8,400	0	0
Totals		(98) 18,875	(128) 3,813	13	(5.16) 7,650	(14.00) 86,544	(14) 89,111	(36) 295,034	(590) 82,750	(419) 12,542	87	(5.84) 15,750	(14) 324,824	(44) 313,061	(65) 536,250	(28) 1,400	(14) 607	(9) 88,950	(10) 75,697	(4) 18,902	0

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional (3D time-lapse); ft = foot; HRG = high-resolution geophysical; m = meter; SP = seismic profiling; SWD = seismic while drilling; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

Shallow = <200-m (656-ft) water depth; Deep = >200-m (656-ft) water depth.

Numbers in parentheses represent the number of surveys; numbers without parentheses represent the distance surveyed in miles.

[1] 3D surveys include ocean bottom cable surveys, nodal surveys, and vertical cable surveys.

[2] WAZ estimates include coil shooting (exclusive to WesternGeco).

Table 2.9-1. Alternative G, the No New Activity Alternative: Projected Activity Levels of Geological and Geophysical Activities in the Area of Interest Over the 10-Year Period

<table>
<tr><th>Activity</th><th>Units</th><th>Oil & Gas</th><th>Renewable</th><th>Minerals</th><th>Totals</th></tr>
<tr><td colspan="6">Geophysical</td></tr>
<tr><td rowspan="2">Non-Airgun HRG Surveys</td><td># of Surveys</td><td colspan="4" rowspan="2">0</td></tr>
<tr><td>Line Miles</td></tr>
<tr><td rowspan="2">VSP Surveys</td><td># of Surveys</td><td>449</td><td rowspan="4">0</td><td rowspan="4">0</td><td>449</td></tr>
<tr><td>Line Miles</td><td>2,544</td><td>2,544</td></tr>
<tr><td rowspan="2">SWD Surveys</td><td># of Surveys</td><td>100</td><td>100</td></tr>
<tr><td>Line Miles</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">2D Surveys</td><td># of Surveys</td><td colspan="4" rowspan="2">0</td></tr>
<tr><td>Line Miles</td></tr>
<tr><td rowspan="2">3D Surveys</td><td># of Surveys</td><td colspan="4" rowspan="2">0</td></tr>
<tr><td>Line Miles</td></tr>
<tr><td rowspan="2">WAZ Surveys</td><td># of Surveys</td><td colspan="4" rowspan="2">0</td></tr>
<tr><td>Line Miles</td></tr>
<tr><td rowspan="2">4D Surveys</td><td># of Surveys</td><td colspan="4" rowspan="2">0</td></tr>
<tr><td>Line Miles</td></tr>
<tr><td rowspan="2">Total 3D, WAZ, 4D Survey</td><td># of Surveys</td><td colspan="4" rowspan="2">0</td></tr>
<tr><td>Line Miles</td></tr>
<tr><td rowspan="2">CSEM</td><td># of Surveys</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Line Miles</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="6">Geological</td></tr>
<tr><td colspan="6">Bottom Sampling</td></tr>
<tr><td>CPT</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Corings</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Grab Sample</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Vibracores</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Jet Probe</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Bottom Sampling Subtotal</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Bottom Impacts (10 m^2/sample)</td><td>m^2</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Shallow Drill Test Wells</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>COST Wells</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Bottom Impacts (20,000 m^2/well)</td><td>m^2</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="6">Other</td></tr>
<tr><td>Bottom-Founded Monitoring Buoy</td><td>Number</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Bottom Impacts
(Footprint 0.56 m^2/buoy +
Sweep 34,000 m^2/buoy)</td><td>m^2</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional; COST = Continental Offshore Stratigraphic Test; CPT = cone penetrometer test; CSEM = controlled source electromagnetic; HRG = high-resolution geophysical; m^2 = square meters; SWD = seismic while drilling; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

Table 2.13-1. Impact Levels by Resource and Applicable Impact-Producing Factors Across Alternatives A through G, as Discussed in **Chapter 2.13**

Resource and Impact-Producing Factor		Alternative[1]						
		A	B	C	D	E	F	G*
Marine Mammals								
Active Acoustic Sound Sources	Deep-Penetration Airguns	Mod	Mod[2,3,4,5]	Mod[2,4,5]	Mod[2,5,7]	Mod[2,4,5]	Min[2,3,4,5]	No Impact
	Shallow-Penetration Airguns	Min	Min[2,3,4,5]	Min[2,4,5]	Min[2,5,7]	Min[2,4,5]	Min[2,3,4,5]	No Impact
	HRG Equipment	Min	Min	Min[6]	Min[6]	Min[6]	Min[6]	No Impact
Vessel and Equipment Noise		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Vessel Traffic		Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	No Impact
Aircraft Traffic and Noise		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Trash and Debris		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Entanglement		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Accidental Fuel Spills		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Cumulative (incremental increase)		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min
Sea Turtles								
Active Acoustic Sound Sources	Airguns	Min	Min	Min	Min	Min	Min	No Impact
	HRG Equipment	Nom-Min	Nom-Min	Nom-Min[6]	Nom-Min[6]	Nom-Min[6]	Nom-Min[6]	No Impact
Vessel and Equipment Noise		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Vessel Traffic		Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	No Impact
Aircraft Traffic and Noise		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Trash and Debris		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Entanglement		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Accidental Fuel Spills		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Cumulative (incremental increase)		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min
Fisheries Resources and Essential Fish Habitat								
Active Acoustic Sound Sources	Airguns	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
	HRG Equipment	Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Vessel and Equipment Noise		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Trash and Debris		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Seafloor Disturbance		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Drilling Discharges		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Entanglement		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Accidental Fuel Spills		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Cumulative (incremental increase)		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min

Table 2.13-1. Impact Levels by Resource and Applicable Impact-Producing Factor Across Alternatives A through G, as Discussed in **Chapter 2.13** (continued)

Resource and Impact-Producing Factor		Alternative[1]						
		A	B	C	D	E	F	G
Benthic Communities								
Active Acoustic Sound Sources	Airguns	Nom	Nom	Nom	Nom	Nom	Nom	No Impact
	HRG Equipment	Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Trash and Debris		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Seafloor Disturbance		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Drilling Discharges		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Accidental Fuel Spills		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Cumulative (incremental increase)		Nom	Nom	Nom	Nom	Nom	Nom	No-Nom
Marine and Coastal Birds								
Active Acoustic Sound Sources	Airguns	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
	HRG Equipment	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Vessel and Equipment Noise		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Vessel Traffic		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Aircraft Traffic and Noise		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Trash and Debris		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Accidental Fuel Spills		Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	No Impact
Cumulative (incremental increase)		Nom	Nom	Nom	Nom	Nom	Nom	Nom
Marine Protected Areas								
Active Acoustic Sound Sources	Airguns	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	No Impact
	HRG Equipment	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Trash and Debris		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Seafloor Disturbance		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Drilling Discharges		No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No Impact
Accidental Fuel Spills		Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	Nom-Mod	No Impact
Cumulative (incremental increase)		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No-Nom
Sargassum Communities								
Vessel Traffic		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Vessel Discharges		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Trash and Debris		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Accidental Fuel Spills		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Cumulative (incremental increase)		Nom	Nom	Nom	Nom	Nom	Nom	No-Nom

Table 2.13-1. Impact Levels by Resource and Applicable Impact-Producing Factor Across Alternatives A through G, as Discussed in **Chapter 2.13** (continued)

Resource and Impact-Producing Factor		Alternative[1]						
		A	B	C	D	E	F	G
Commercial Fisheries								
Active Acoustic Sound Sources	Airguns	Min	Min	Min	Min	Min	Min	No Impact
	HRG Equipment	Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Vessel Traffic		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Stand-Off Distance		Min	Min	Min	Min	Nom-Min	Min	No Impact
Seafloor Disturbance		Min	Min	Min	Min	Min	Min	No Impact
Entanglement		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	No Impact
Accidental Fuel Spills		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Cumulative (incremental increase)		Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom-Min	Nom
Recreational Fisheries								
Active Acoustic Sound Sources	Airguns	Nom	Nom	Nom	Nom	Nom	Nom	No Impact
	HRG Equipment	Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Vessel Traffic		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Stand-Off Distance		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Accidental Fuel Spills		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Cumulative (incremental increase)		Nom	Nom	Nom	Nom	Nom	Nom	Nom
Archaeological Resources								
Seafloor Disturbance		Nom-Maj	Nom-Maj	Nom-Maj	Nom-Maj	Nom-Maj	Nom-Maj	No Impact
Drilling Discharges		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Entanglement		Nom-Maj	Nom-Maj	Nom-Maj	Nom-Maj	Nom-Maj	Nom-Maj	No Impact
Accidental Fuel Spills		Nom	Nom	Nom	Nom	Nom	Nom	No Impact
Cumulative (incremental increase)		Nom	Nom	Nom	Nom	Nom	Nom	No-Nom
Multiple-Use Areas								
Vessel Traffic		No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom
Aircraft Traffic and Noise		No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom
Stand-Off Distance		No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom
Seafloor Disturbance		No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom	No-Nom
Accidental Fuel Spills		Nom	Nom	Nom	Nom	Nom	Nom	Nom
Cumulative (incremental increase)		Nom	Nom	Nom	Nom	Nom	Nom	Nom

Table 2.13-1. Impact Levels by Resource and Applicable Impact-Producing Factor Across Alternatives A Through G, as Discussed in **Chapter 2.13** (continued)

Resource and Impact-Producing Factor	Alternative[1]						
	A	B	C	D	E	F	G
Human Resources, Land Use, and Economics							
Land Use and Infrastructure	Ben-Min	Ben-Min	Ben-Min	Ben-Min	Ben-Min	Ben-Min	Min-Mod
Environmental Justice	Ben-Nom	Ben-Nom	Ben-Nom	Ben-Nom	Ben-Nom	Ben-Nom	Min
Demographics	Ben-Nom	Ben-Min	Ben-Min	Ben-Min	Minor	Minor	Min-Mod
Economics	Ben-Min	Ben-Mod	Ben-Min	Ben-Mod	Min-Mod	Min-Mod	Mod-Maj

Note: Impacts are categorized as Beneficial, Major, Moderate, Minor, or Nominal (refer to **Chapter 4.1.2** for definitions).

Ben = Beneficial Impact; G&G = geological and geophysical; HRG = high-resolution geophysical; Maj = Major Impact; Min = Minor Impact; Mod = Moderate Impact; No = No Impact; Nom = Nominal Impact.

[1] Alternative A = Pre-Settlement (June 2013) Alternative; Alternative B = Settlement Agreement Alternative; Alternative C = Alternative A Plus Additional Mitigation Measures; Alternative D = Alternative C Plus Marine Mammal Shutdowns; Alternative E = Alternative C at Reduced Activity Levels; Alternative F = Alternative C Plus Area Closures; Alternative G = No New Activity Alternative.

[2] Provides protection to coastal marine mammal species (i.e., common bottlenose dolphins, manatees, Atlantic spotted dolphins) when they are reproducing (calving) and increases the fitness values of the reproducing species.

[3] Provides protection for whale species (Bryde's, beaked, sperm, dwarf and pygmy sperm whales) and manatees providing localized reduction in sound exposure and associated impacts for those species.

[4] Provides protection to bay, sound and estuary (BSE) stocks of common bottlenose dolphins, individual coastal stocks of common bottlenose dolphins and Atlantic spotted dolphins, and manatees; individual beaked whales and sperm whales, as well as potentially calving sperm whales; the small population of geographically and genetically distinct Bryde's whales in the GOM.

[5] Provides protection to vocalizing marine mammals.

[6] Provides protection to all marine mammals and sea turtles, with additional protection (shutdown) for sperm, Bryde's, beaked, dwarf and pygmy sperm whales, and manatees.

[7] Provides protection for all marine mammals except bow-riding or actively approaching dolphins (i.e., common bottlenose, Fraser's, Clymene's, rough-toothed, striped, spinner, Atlantic spotted, pantropical, and Risso's).

* Impact determinations provided for Alternative G assume no new permitted activity and, therefore, no routine or accidental events. The G&G activity from previously permitted activities are included in the cumulative analysis.

Table 2.13-2. Impact Levels for Marine Mammals from Airguns and Those Species Groups Protects Across Alternatives A through G, as Discussed in **Chapter 4.2**

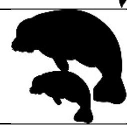
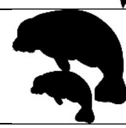
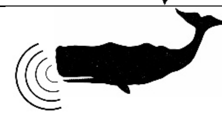
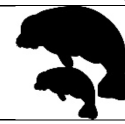
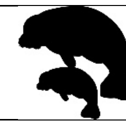
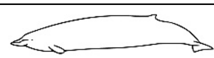
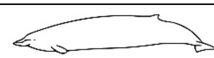
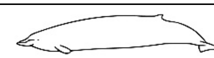
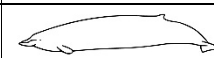
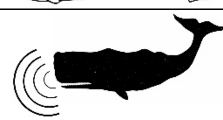
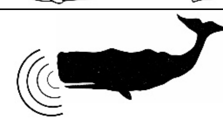
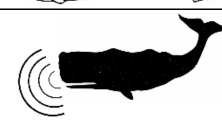
Resource and Impact-Producing Factor		Alternative						
		A	B	C	D	E	F	G*
Marine Mammals								
Active Acoustic Sound Sources	Airguns	Mod	Mod	Mod	Mod	Mod	Min	Min
Additional protection afforded to marine mammal species groups from mitigation measures								
								
								
								
								
								
								

Table 2.13-2. Impact Levels for Marine Mammals from Airguns and Those Species Groups Protects Across Alternatives A through G, as Discussed in **Chapter 4.2** (continued)

Coastal marine mammal species (i.e., common bottlenose dolphins, manatees, Atlantic spotted dolphins) when they are reproducing (calving) or bay, sound, and estuary stocks of common bottlenose dolphins, individual coastal stocks of common bottlenose dolphins and Atlantic spotted dolphins as applicable.

Manatees and their offspring.

Vocalizing marine mammals.

Sperm, dwarf, and pygmy sperm whales.

All marine mammals.

Bryde's whale and/or the genetically distinct Bryde's whales in the GOM as applicable.

Calving sperm whales.

Except bow-riding dolphins (common bottlenose, Fraser's, Clymene's, rough-toothed, striped, spinner, Atlantic spotted, pantropical, and Risso's).

Beaked whales.

Note: Impacts are categorized as Moderate, Minor, or Nominal (refer to **Chapter 4.1.2** for definitions).

* Impact determinations provided for Alternative G are prior to any decline in geological and geophysical activities, and these ratings will decline over time as activities are phased out.

Table 3.1-1. Types of Geological and Geophysical Activities Included in this Programmatic Environmental Impact Statement

Survey Type	Applicable Program Areas			Purpose(s)
	O&G	REN	MMP	
Deep-Penetration Seismic Surveys				Most, if not all deep-penetration seismic surveys require the use of airguns. Seismic surveys evaluate subsurface geological formations to assess potential hydrocarbon reservoirs and optimally site exploration and development wells. The 2D surveys provide a cross-sectional image of the Earth's structure while 3D provide a volumetric image of underlying geological structures. Repeated 3D surveys result in time lapse, or 4D, surveys that assess the depletion of a reservoir. The VSP surveys provide information about geologic structure, lithology, and fluids.
2D Seismic Surveys	X	--	--	
3D Seismic Surveys	X	--	--	
Ocean-Bottom 2D Seismic Surveys (Cable or Nodes)	X	--	--	
Ocean-Bottom 3D Seismic Surveys (Cable or Nodes)	X	--	--	
Wide-Azimuth and Related Multi-Vessel Surveys	X	--	--	
Borehole Seismic Surveys (2D and 3D VSP Surveys)	X	--	--	
Vertical Cable Surveys	X	--	--	
4D Time-Lapse Surveys	X	--	--	
Airgun High-Resolution Geophysical Surveys				A single airgun used to assess shallow hazards, benthic habitats, renewable energy structure emplacement.
High-Resolution Seismic Surveys	X	X	-	
Non-Airgun Acoustic High-Resolution Geophysical Surveys				Assess shallow hazards, potential sand and gravel resources for coastal restoration, archaeological resources, and benthic habitats. Devices used in subbottom profiling surveys include • sparkers; • boomers; • pingers; and • CHIRP subbottom profilers.
Subbottom Profiling Surveys	X	X	X	
Side-Scan Sonars	X	X	X	
Single-Beam and Multibeam Echosounders	X	X	X	
Non-Acoustic Marine Geophysical Surveys				Electromagnetic signals are used to develop a conductivity/ resistivity profile of the seafloor, helping to identify economic hydrocarbon accumulations and aid with archaeological surveys.
Marine Gravity Surveys	X	--	--	
Marine Magnetic Surveys	X	--	--	
Marine Magnetotelluric Surveys	X	--	--	
Marine Controlled Source Electromagnetic Surveys	X	--	--	
Airborne Remote Surveys				Gravity and magnetic surveys are used to assess structure and sedimentary properties of subsurface horizons. Airborne magnetic surveys evaluate deep crustal structure, salt-related structure, and intra-sedimentary anomalies.
Airborne Gravity Surveys	X	--	--	
Airborne Magnetic Surveys	X	--	--	

Table 3.1-1. Types of Geological and Geophysical Activities Included in this Programmatic Environmental Impact Statement (continued)

Survey Type	Applicable Program Areas			Purpose(s)
	O&G	REN	MMP	
Geological and Geotechnical Surveys				Collect surface and near surface sediment samples to assess seafloor properties for siting structures such as platforms, pipelines, or cables. Different types of geologic cores include • gravity corers; • multicorers; • piston corers; • rotary corers; • ROV push cores; and • vibracorers. Geologic coring is also used to assess sediment characteristics for use in coastal restoration projects. Shallow test drilling is conducted to place test equipment into a borehole to evaluate gas hydrates or other properties. The COST wells evaluate stratigraphy and hydrocarbon potential without drilling directly into oil and gas bearing strata.
Grab and Box Sampling	X	X	X	
Geologic Coring	X	X	X	
Shallow Test Drilling	X	X	--	
COST Wells	X	X	--	
Cone Penetrometer Tests	X	X	--	
Other Surveys and Equipment				The devices in this category assist in the execution of surveys, either by providing location or facilitating underwater service tasks. Additionally, water guns are no longer used as a seismic source except in extremely rare instances.
Acoustic Pingers	X	X	--	
Transponders, Transceivers, Responders	X	X	--	
ROVs and AUVs	X	X	--	

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional; AUV = autonomous underwater vehicle; CHIRP = compressed high-intensity radar pulse; COST = continental offshore stratigraphic test; HRG = high-resolution geophysical; MMP = Marine Minerals Program; O&G = Oil and Gas Program; REN = Renewable Energy Program; ROV = remotely operated vehicle; VSP = vertical seismic profile.

Table 3.2-1. Projected Range of Activity Levels of Acoustic Geophysical Activities for Oil and Gas Exploration in the Area of Interest Over the 10-Year Time Period (numbers of surveys) and Survey Line Distance (miles)

Year	Water Depth	Western Planning Area						
		HRG	VSP	SWD	2D	3D[a]	WAZ[b]	4D
Year 1	Shallow	(1-3) 125-400	(1-3) 31-93	(0)	(0)	(0-1) 0-2,911	(0)	(0-1) 0-10,563
	Deep	(2-4) 550-1,100	(12-19) 372-558	(0-3)	(0-1) 0-4,000	(0-1) 0-9,583	(0-1) 0-7,476	(1-3) 11,000-33,000
Year 2	Shallow	(1-3) 110-350	(0-2) 0-62	(0)	(0)	(0)	(0)	(0)
	Deep	(3-5) 720-1,200	(7-14) 202-403	(0-1)	(0-1) 0-1,800	(0-1) 0-15,257	(1-3) 7,420-22,270	(1-3) 11,000-33,000
Year 3	Shallow	(0-3) 0-350	(1-3) 31-93	(0)	(0)	(0)	(0)	(0-1) 0-10,563
	Deep	(3-6) 650-1,300	(10-16) 290-465	(0-2)	(0-1) 0-600	(0-1) 0-9,583	(0-2) 0-18,943	(1-3) 11,000-33,000
Year 4	Shallow	(1-3) 110-325	(0-2) 0-62	(0)	(0)	(0-1) 0-2,911	(0)	(0)
	Deep	(2-6) 957-1,300	(10-14) 287-403	(0-2)	(0-1) 0-600	(0-1) 0-4,207	(1-3) 7,610-22,833	(1-3) 11,000-33,000
Year 5	Shallow	(1-3) 100-300	(1-3) 31-93	0	(0)	(0)	(0)	(0)
	Deep	(4-6) 933-1,400	(11-16) 320-465	(0-2)	(0-1) 0-600	(0-1) 0-5,474	(0-1) 0-8,097	(1-3) 11,000-33,000
Year 6	Shallow	(1-3) 100-300	(0-1) 0-31	0	(0)	(0)	(0)	(0)
	Deep	(4-6) 933-1,400	(6-8) 186-248	(0-1)	(0)	(0-1) 0-9,583	(0-1) 0-10,228	(1-3) 11,000-33,000
Year 7	Shallow	(1-3) 200-600	(0-1) 0-31	0	(0)	(0-1) 0-2,911	(0)	(0-2) 0-21,126
	Deep	(5-7) 1,200-1,475	(3-5) 93-155	0	(0-1) 0-2,000	(0-1) 0-10,011	(0-1) 0-9,656	(1-3) 11,000-33,000
Year 8	Shallow	(2-4) 400-800	(0-1) 0-31	0	(0)	(0)	(0)	(0)
	Deep	(5-7) 1,200-1,475	(3-5) 93-155	0	(0)	(0-1) 0-15,735	(0-1) 0-9,656	(1-3) 11,000-33,000
Year 9	Shallow	(2-4) 400-800	(0-1) 0-31	0	(0)	(0)	(0)	(0-2) 0-21,126
	Deep	(6-8) 1,300-1,500	(6-8) 186-248	(0-1)	(0-1) 0-600	(0-1) 0-14,853	(0-1) 0-9,656	(1-3) 11,000-33,000
Year 10	Shallow	(5-6) 900-1,000	(0-1) 0-31	0	(0)	(0-1) 0-2,911	(0)	(0)
	Deep	(6-8) 1,300-1,500	(4-5) 124-155	(0-1)	(0)	(0-1) 0-9,462	(0)	(1-3) 11,000-33,000
Totals		(55-98) 12,188-18,875	(75-128) 2,246-3,843	(0-13)	(0-7) 0-10,200	(0-14) 0-115,392	(2-14) 15,030-118,815	(10-36) 110,000-393,378

Table 3.2-1. Projected Range of Activity Levels of Acoustic Geophysical Activities for Oil and Gas Exploration in the Area of Interest Over the 10-Year Time Period (numbers of surveys) and Survey Line Distance (miles) (continued)

Year	Water Depth	Central Planning Area						
		HRG	VSP	SWD	2D	3D[a]	WAZ[b]	4D
Year 1	Shallow	(15-22) 1,360-2,000	(11-17) 341-496	0	(0)	(0-2) 0-15,117	(0)	(0-1) 0-11,000
	Deep	(21-32) 3,670-5,600	(22-35) 696-1,054	(6-9)	(0-1) 0-8,000	(3-5) 29,836-45,207	(4-6) 38,866-58,888	(4-6) 43,560-66,000
Year 2	Shallow	(15-22) 1,360-2,000	(9-15) 286-434	0	(0)	(0-2) 0-20,444	(0-1) 0-5,441	(0)
	Deep	(21-32) 3,670-5,600	(21-33) 655-992	(5-8)	(0-1) 0-1800	(3-5) 31,253-47,353	(3-5) 33,988-51,497	(4-6) 43,560-66,000
Year 3	Shallow	(13-20) 1,267-1,950	(9-14) 266-403	0	(0)	(0-2) 0-18375	(0)	(0-1) 0-11,000
	Deep	(23-35) 3,840-5,850	(19-30) 605-917	(6-10)	(0-1) 0-1,800	(2-4) 24,900-37,728	(3-5) 32,415-49,114	(4-6) 43,560-66,000
Year 4	Shallow	(14-18) 1,480-1,900	(11-15) 325-434	0	(0)	(0-2) 0-23814	(0-1) 0-7,534	(0)
	Deep	(31-35) 5,260-5,850	(24-33) 744-992	(7-11)	(0-1) 0-1,800	(0-2) 0-20,731	(1-2) 17,892-23,857	(5-6) 49,600-66,000
Year 5	Shallow	(14-18) 1,480-1,900	(10-12) 335-372	0	(0)	(0-2) 0-15,239	(0)	(0-1) 0-11,000
	Deep	(36-40) 5,580-6,200	(23-27) 725-806	(5-7)	(0-1) 0-1,800	(1-3) 26,605-29,561	(4-5) 40,507-45,008	(5-6) 65,340-66,000
Year 6	Shallow	(15-17) 1,530-1,700	(9-10) 279-310	0	(0)	(0-2) 0-19,623	(0-1) 0-3,837	(0)
	Deep	(38-42) 5,850-6,500	(21-24) 642-713	(6-8)	(0)	(0-2) 0-14,228	(2-3) 25,872-28,747	(5-6) 65,340-66,000
Year 7	Shallow	(13-15) 1,350-1,500	(11-14) 363-403	0	(0)	(0-1) 0-13,975	(0)	(0-1) 0-11,000
	Deep	(40-45) 6,300-7,000	(26-30) 809-899	(7-9)	(0-1) 0-4,000	(0-2) 0-15,329	(3-4) 34,208-38,009	(5-6) 65,340-66,000
Year 8	Shallow	(13-15) 1,350-1,500	(11-13) 363-403	0	(0)	(0-2) 0-22,502	(0-1) 0-5016	(0)
	Deep	(45-50) 6,750-7,500	(25-29) 781-868	(5-7)	(0)	(0-2) 0-18,059	(2-3) 30,088-33,431	(5-6) 65,340-66,000
Year 9	Shallow	(13-15) 1,350-1,500	(9-10) 279-310	0	(0)	(0-1) 0-13,651	(0)	(0-1) 0-11,000
	Deep	(45-50) 6,750-7,500	(21-24) 642-713	(6-8)	(0-1) 0-1800	(0-1) 0-8,688	(2-3) 31,056-34,507	(5-6) 65,340-66,000
Year 10	Shallow	(10-12) 1,080-1,200	(9-10) 279-310	0	(0)	(0-2) 0-22,362	(0-1) 0-3407	(0)
	Deep	(50-55) 7,200-8,000	(21-24) 642-713	(8-10)	(0)	(0-1) 0-11,113	(2-3) 26,210-29,122	(5-6) 65,340-66,000
Totals		(485-590) 68,477-82,750	(322-419) 10,057-12,542	(61-87)	(0-7) 0-21,000	(9-45) 112,594-433,099	(26-44) 311,102-417,415	(47-65) 572,320-715,000

Table 3.2-1. Projected Range of Activity Levels of Acoustic Geophysical Activities for Oil and Gas Exploration in the Area of Interest Over the 10-Year Time Period (numbers of surveys) and Survey Line Distance (miles) (continued)

Year	Water Depth	Eastern Planning Area						
		HRG	VSP	SWD	2D	3D[a]	WAZ[b]	4D
Year 1	Shallow	(0-2) 0-100	(0-1) 0-31	(0)	(0)	(0)	(0)	(0)
	Deep	(0)	(0-2) 0-62	(0)	(0-1) 0-200	(0-1) 0-2,131	(0)	(0)
Year 2	Shallow	0-(2) 0-100	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(0-1) 0-50	(0-1) 0-400	(0)	(0-1) 0-400	(0-1) 0-4,599	(0)	(0)
Year 3	Shallow	(0-1) 0-50	(0-1) 0-31	(0)	(0)	(0)	(0)	(0)
	Deep	(0-2) 0-100	(0-2) 0-62	(0)	(0-1) 0-20,900	(0-1) 0-4,599	(0)	(0)
Year 4	Shallow	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(1-2) 50-100	(0-1) 0-5	(0)	(0-1) 0-26,900	(0-1) 0-11,200	(0-1) 0-12,456	(0)
Year 5	Shallow	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(0-1) 0-50	(0-1) 0-5	(0)	(0-1) 0-10,400	(0-1) 0-16,800	(0)	(0)
Year 6	Shallow	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(1-2) 90-100	(0-1) 0-0.5	(0)	(0)	(0-1) 0-16,800	(0)	(0)
Year 7	Shallow	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(2-3) 135-150	(0-1) 0-0.5	(0)	(0-1) 0-900	(0-1) 0-11,200	(0-1) 0-2,945	(0)
Year 8	Shallow	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(2-4) 180-200	(0-1) 0-5	(0)	(0-1) 0-21,500	(0-1) 0-11,200	(0-1) 0-4,828	(0)
Year 9	Shallow	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(2-4) 180-200	(0-1) 0-0.5	(0)	(0-1) 0-27,400	0-(1) 0-11,200	(0-1) 0-4,973	(0)
Year 10	Shallow	(0)	(0)	(0)	(0)	(0)	(0)	(0)
	Deep	(2-4) 180-200	(0-1) 0-5	(0)	(0-1) 0-10,000	(0-1) 0-11,200	(0)	(0)
Totals		(10-28) 815-1,400	(0-14) 0-607.5	(0)	(0-9) 118,600	(0-10) 0-100,929	(0-4) 0-25,202	(0)

2D = two-dimensional; 3D = three-dimensional; 4D = three-dimensional time-lapse; ft = foot; HRG = high-resolution geophysical; m = meter; SWD = seismic while drilling; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

Shallow = <200-m (656-ft) water depth; Deep = >200-m (656-ft) water depth.

Numbers in parentheses represent the number of surveys; numbers without parentheses represent the distance in miles.

[a] 3D surveys include ocean bottom cable and nodal surveys, vertical cable surveys.

[b] WAZ estimates include coil shooting (exclusive to WesternGeco).

Table 3.2-2. Projected Activity Levels of Non-Acoustic and Geological Activities for Oil and Gas Exploration in the Area of Interest Over the 10-Year Time Period (numbers of surveys) and Survey Line Distance (miles) or Cores

Year	Western Planning Area			Central Planning Area			Eastern Planning Area		
	Geologic Coring	CSEM	Drilling Test[1]	Geologic Coring	CSEM	Drilling Test[1]	Geologic Coring	CSEM	Drilling Test[1]
Year 1	0	0	0	(2) 20 cores	(1) 760 miles	0	(1) 15 cores	0	0
Year 2	0	(1) 660 miles	0	(3) 80 cores	(2) 1,520 miles	0	(2) 30 cores	0	0
Year 3	(1) 10 cores	0	0	(4) 90 cores	0	0	(2) 30 cores	0	0
Year 4	0	0	0	(2) 20 cores	(1) 760 miles	0	(2) 80 cores	0	0
Year 5	(1) 40 cores	(1) 660 miles	0	(2) 60 cores	0	0	0	(1) 460 miles	0
Year 6	0	(1) 660 miles	0	(2) 20 cores	(1) 760 miles	0	(2) 30 cores	0	0
Year 7	0	0	(1) 1 well	0	0	0	0	0	0
Year 8	0	0	0	(5) 95 cores	0	0	(2) 30 cores	0	0
Year 9	(2) 20 cores	(1) 660 miles	0	0	(1) 760 miles	(1) 1 well	0	(1) 460 miles	0
Year 10	0	0	0	(5) 95 cores	0	0	(2) 30 cores	0	0
Totals	(4) 70 cores	(4) 2,640 miles	(1) 1 well	(25) 480 cores	(6) 4,560 miles	(1) 1 well	(13) 245 cores	(2) 920 miles	0

CSEM = controlled-source electromagnetic.

Typically, one OCS block is 9 square miles (23.3 square kilometers, 2,331 hectares, or 5,760 acres).

[1] Penetration <150 meters (500 feet).

Table 3.2-3. Projected Activity Levels of Geological and Geophysical Activities for Renewable Energy Site Characterization and Assessment in the Area of Interest Over the 10-Year Time Period

Renewable Energy Area	OCS Blocks Equivalent	HRG Surveys[1] (hours Line Miles)	2D or 3D Deep-Penetration Seismic	Geotechnical Surveys[2]			Bottom-founded Monitoring Buoys (min.-max.)
				CPT (min.-max.)	Geologic Coring (min.-max.)	Grab Samples (min.-max.)	
Wind Energy	6	(920) 3,472	0	84-270	87-270	87-270	1-2
Alternate Use	0	0	0	0	0	0	0
Total	6	(920) 3,472	0	84-270	84-270	84-270	1-2

2D = two-dimensional; 3D = three-dimensional; CPT = cone penetrometer test; HRG = high-resolution geophysical; max = maximum; min = minimum; OCS = Outer Continental Shelf.

[1] HRG survey effort per block was assumed to be 500 nautical miles (925 kilometers), requiring 150 hours to complete. Added 20 nautical miles (23 miles; 37 kilometers) and 20 hours for surveying one transmission cable route (USDOI, BOEM, 2012).

[2] Geotechnical survey effort was estimated to be 14-45 sampling locations per block based on the potential range of wind turbine densities per block (assuming one sampling location per turbine location).

Table 3.2-4. Projected Activity Levels of Geological Surveys for Outer Continental Shelf Marine Minerals Projects in the Area of Interest Over the 10-Year Time Period

Year	Project	State	Cycle Volume (yd^3)	Depth (m)	Distance Offshore (km)	Vibracores	Jet Probes	Grab Samples
Western Planning Area								
Year 2 to Year 5	East Texas Coast	TX	5,000,000	7-10	24	45	0	40
Central Planning Area								
Year 1	North Breton Island	LA	4,000,000	3-6	5.5-7.5	36	0	0
Year 2 to Year 5	Terrebonne Basin Barrier Shoreline Restoration	LA	6,000,000	4-7	15	90	0	0
	Cameron Parish Shoreline Restoration (east of Calcasieu Pass)	LA	5,000,000	7-10	27	45	0	0
	Alabama Coast	AL	6,000,000	9-15	5.5-10	54	0	50
Eastern Planning Area								
Year 2 to Year 5	Manatee, Sarasota, and or Charlotte County (Sarasota, Manasota, and Captiva Ridge Fields)	FL	1,500,000	10-20	16-24	23	10	0
	Lee County (Captiva Ridge Field, Sanibel Island Ridge Field)	FL	1,500,000	10-20	16-24	23	10	0
Year 6 to Year 8	Pinellas County (Sand Key Ridge Field)	FL	2,000,000	10-20	16-24	30	10	0
	Manatee, Sarasota, Charlotte (Sarasota, Manasota, and Captiva Ridge Fields)	FL	1,500,000	10-20	16-24	23	10	0
	Lee (Captiva Ridge Field, Sanibel Island Ridge Field)	FL	1,500,000	10-20	16-24	23	10	0
		Total	34,000,000			392	50	90

AL = Alabama; FL = Florida; km = kilometers; LA = Louisiana; m = meters; TX = Texas; yd^3 = cubic yards.

Table 3.2-5. Projected Activity Levels of Geophysical Surveys for Marine Minerals Projects in the Area of Interest Over the 10-Year Time Period

Timeframe	Project	State	Cycle Volume (yd^3)	Depth (m)	Distance Offshore (km)	Prospecting HRG[1]		Pre-Dredge HRG[1]		Post-Dredge HRG[2]	
						Line Miles	Duration (hours)	Line Miles	Duration (hours)	Line Miles	Duration (hours)
Western Planning Area											
Year 4 to Year 6	East Texas Coast	TX	5,000,000	7-10	24	63.4	12.2	83.9	16.2	83.9	16.2
Central Planning Area											
Year 1 to Year 3	Caminada Headland (Increment 2)	LA	6,100,000	6-7	15	0.0	0.00	0.0	0.0	133.8	25.85
	Caillou Headlands (Whiskey Island) Restoration	LA	5,300,000	6-7	15	0.0	0.0	0.0	0.0	121.4	23.4
	North Breton Island	LA	5,000,000	3-6	5.5-7.5	63.4	12.2	126.8	24.5	126.8	24.5
	Mississippi Coastal Improvements Program – Gulf Islands Restoration	MS	11,000,000	9-15	8-10	0.0	0.0	0.0	0.0	87.2	16.8
Year 4 to Year 6	Terrebonne Basin Barrier Shoreline Restoration	LA	6,000,000	4-7	15	76.1	14.7	0.0	0.0	0.0	0.0
	Cameron Parish Shoreline Restoration (East of Calcasieu Pass)	LA	4,000,000	7-0	27	50.7	9.8	83.9	16.2	83.9	16.2
	Alabama Coast	AL	5,000,000	9-15	5.5-10	63.4	12.2	0.0	0.0	0.0	0.0
Year 7 to Year 10	Terrebonne Basin Barrier Shoreline Restoration (continued)	LA	6,000,000	4-7	15	0.0	0.0	259.3	50.1	259.3	50.1
	Alabama Coast (continued)	AL	5,000,000	9-15	5.5-10	0.0	0.0	71.3	13.8	71.3	13.8
Eastern Planning Area											
Year 1 to	Long Boat Key	FL	500,000	10-15	20	0.0	0.0	5.7	1.1	5.7	1.1

Table 3.2-5. Projected Activity Levels of Geophysical Surveys for Marine Minerals Projects in the Area of Interest Over the 10-Year Time Period (continued)

Timeframe	Project	State	Cycle Volume (yd^3)	Depth (m)	Distance Offshore (km)	Prospecting HRG[1]		Pre-Dredge HRG[1]		Post-Dredge HRG[2]	
						Line Miles	Duration (hours)	Line Miles	Duration (hours)	Line Miles	Duration (hours)
Year 3	Collier County (Toms Hill)	FL	600,000	15-18	25	0.0	0.0	5.2	1.0	5.2	1.0
Year 4 to Year 6	Manatee, Sarasota, and or Charlotte County (Sarasota, Manasota, and Captiva Ridge Fields)	FL	1,500,000	10-20	16-24	19.0	3.7	14.3	2.8	14.3	2.8
	Lee County (Captiva Ridge Field, Sanibel Island Ridge Field)	FL	1,500,000	10-20	16-24	19.0	3.7	14.3	2.8	14.3	2.8
Year 7 to Year 10	Pinellas County (Sand Key Ridge Field)	FL	2,000,000	10-20	16-24	25.4	4.9	19.0	3.7	19.0	3.7
	Manatee, Sarasota, Charlotte (Sarasota, Manasota, and Captiva Ridge Fields)	FL	1,500,000	10-20	16-24	19.0	3.7	14.3	2.8	14.3	2.8
	Lee County (Captiva Ridge Field, Sanibel Island Ridge Field)	FL	1,500,000	10-20	16-24	19.0	3.7	14.3	2.8	14.3	2.8
	Collier County (Toms Hill)	FL	600,000	15-18	25	0.0	0.0	5.2	1.0	5.2	1.0
Total			68,100,000	N/A	N/A	418.4	80.8	717.5	138.8	1,059.9	204.9

AL = Alabama; FL = Florida; HRG = high-resolution geophysical; km = kilometers; LA = Louisiana; m = meters; N/A = not available; OCS = Outer Continental Shelf; TX = Texas; yd^3 = cubic yards.

[1] Prospecting and pre-dredge HRG involves the use of subbottom profiler, side-scan sonar, bathymetry (echosounders), and magnetometer.

[2] On-lease typically involves only a bathymetry (echosounders).

Table 3.2-6. Characteristics of the Proposed Geological and Geophysical Activities Scenario in the Area of Interest Over the 10-Year Time Period

Activity Type	Purpose	Number of Surveys or Level of Effort	Primary Platform and Size	Scale of Activity	Penetration Depth	Approximate Duration/ Event	Shore Base[1]	Service Vessel	High-Energy Sound Source(s)	Bottom Area Disturbed
Oil and Gas Exploration										
HRG (Airgun or Non-Airgun) Seismic Survey	Shallow hazards assessment and archaeological determinations	550-716	1 ship, ~30 m	103,025 line mi	10s to 100s of m	3 days - 1 week	1	0	• 1-2 airguns • Boomer, sparker, or CHIRP subbottom profiler • Side-scan sonar • Multi-beam depth sounder	0
Vertical Seismic Profiling/ Checkshot	Calibrate seismic with known geology	397-561	1 ship, ~30 m	16,962 line mi	100s to 1,000s of m	3-4 days	1	0	Single airgun	0
Seismic While Drilling	Monitor drilling for transition zones, etc.	61-100	Well platform	≥1/16 OCS block	100s to 1,000s of m	Intermittent; up to 6 months	0-1	0	Airgun	Wellbore
2D Seismic Survey	Identify geologic structure	0-23	1 ship, ~100 m	149,800 line mi	kms to 10s of kms	2-12 months	0-1	0-1	Airgun array	0
3D Seismic Survey	Identify geologic structure	9-69	1-2 ships, ~100 m	649,420 line mi	kms to 10s of kms	4-12 months	0-1	0-1	Dual airgun array	0
WAZ and Related Multi-Vessel	Better define complex geologic structure	28-62	4-6 ships, ~100 m	561,432 line mi	kms to 10s of kms	1 year	0-2	1-2	4 arrays	0

Table 3.2-6. Characteristics of the Proposed Geological and Geophysical Activities Scenario in the Area of Interest Over the 10-Year Time Period (continued)

Activity Type	Purpose	Number of Surveys or Level of Effort	Primary Platform and Size	Scale of Activity	Penetration Depth	Approximate Duration/ Event	Shore Base[1]	Service Vessel	High-Energy Sound Source(s)	Bottom Area Disturbed
4D Seismic Survey	Monitor change in oil and gas reservoirs	57-101	1-2 ships, ~100 m	1,108,378 line mi	kms to 10s of kms	4-12 months	0-1	0-1	Dual airgun array	0
CSEM	Optimize reservoir identification	≤12	1 ship, ~20 100 m	8,120 mi	3-5 km	1-6 months	0-1	0-1	0	Anchors with bottom receivers, <1 OCS block
Gravity and Magnetic	Passive measurement, gravity and magnetic fields	0-3	Acquisition with seismic typical	100s to 1,000s of line km	kms to 10s of kms	4-12 months	0-1	0-1	0	0
Aeromagnetic	Passive measurement, magnetic fields	0-1	1 aircraft	100s to 1,000s of line kms	kms to 10s of kms	1-3 months	0-1	0	0	0
CPT	Measure sediment engineering properties	≤1 event (100 tests)	1 barge/ship, ~60 m	≥1/16 OCS block or along cable route to shore	<10 m	<3 days	1	0	0	~10 m^2/ sample
Corings	Extract sediment core	≤42 events (795 cores)	1 barge/ship, ~20 m	<1/16 OCS block	<300 m	<3 days	0-1	0	0	~10 m^2/ sample
Grab Sampling	Collect sediment and benthic fauna	0-1	1 barge/ship, ~60 m	<1/16 OCS block	<1 m	<3 days	1	0	0	~10 m^2/ sample
Shallow Drill Test Wells	Test drilling outside of lease program	≤2 wells	Platform or drillship, ~100 m	<1/16 OCS block	<150 m	5-30 days	0-1	0-2	0	≤2 ha well

Table 3.2-6. Characteristics of the Proposed Geological and Geophysical Activities Scenario in the Area of Interest Over the 10-Year Time Period (continued)

Activity Type	Purpose	Number of Surveys or Level of Effort	Primary Platform and Size	Scale of Activity	Penetration Depth	Approximate Duration/ Event	Shore Base[1]	Service Vessel	High-Energy Sound Source(s)	Bottom Area Disturbed
COST Well	Test drilling outside of lease program	≤1 well	Platform or drillship, ~100 m	<1/16 OCS block	≥150 m	5-30 days	0-1	0-2	0	≤2 ha/well
Renewable Energy										
HRG Survey	Shallow hazards assessment and archaeological determinations	≤1 survey	1 ship, ~20-30 m	Each survey ≥1/16 OCS[2] block plus cable route to shore; total 5,587 km (6 OCS blocks)	Surficial to 10s to 100s of meters	3 days - 1 weeks	1	0	• Boomer, sparker, or CHIRP subbottom profiler • Side-scan sonar • Multi-beam depth sounder	0
CPT	Measure sediment engineering properties	≤1 event (270 tests)	1 barge/ship, ~60 m	≥1/16 OCS block or along cable route to shore	<10 m	9 days	1	0	• 0	~10 m^2/ sample
Corings	Extract sediment core	≤1 event (270 cores)	1 barge/ship, ~60 m	≥1/16 OCS block or along cable route to shore	<300 m	9 days	1	0	0	~10 m^2/ sample
Grab Sampling	Collect sediment and benthic fauna	≤1 event (270 samples)	1 barge/ship, ~60 m	≥1/16 OCS block or along cable route to shore	<1 m	9 days	1	0	0	~10 m^2/ sample
Bottom-Founded Monitoring Buoy	Measure ocean and meteorological conditions	≤1 event (2 buoys)	1 barge/ship, ~20 m	≥1/16 OCS block	Surficial	<3 days	1-2	0	0	~1 m^2/ buoy

Table 3.2-6. Characteristics of the Proposed Geological and Geophysical Activities Scenario in the Area of Interest Over the 10-Year Time Period (continued)

Activity Type	Purpose	Number of Surveys or Level of Effort	Primary Platform and Size	Scale of Activity	Penetration Depth	Approximate Duration/ Event	Shore Base[1]	Service Vessel	High-Energy Sound Source(s)	Bottom Area Disturbed
Marine Minerals										
HRG Survey	Shallow hazards assessment and archaeological determinations	≤18 events, ~47 days	1 ship, ~30 m	~3,533 line km	10s to 100s of m	3 days - 2 weeks	1	0	• Boomer, sparker, or CHIRP subbottom profiler • Side-scan sonar • Multi-beam echosounder	0
Grab Sampling	Collect sediment and benthic fauna	≤2 events (90 grabs)	1 barge/ship, ~20 m	≥1/16 OCS block	<1 m	<3 days	1	0	0	~10 m^2/ sample
Vibracoring	Extract sediment core	≤10 events (392 cores)	1 barge/ship, ~20 m	≥1/16 OCS block	10-15 m	3-5 days	1	0	0	~10 m^2/ sample
Jet Probe	Extract sediment core	≤5 events (50 probes)	1 barge/ship, ~20 m	≥1/16 OCS block	10-15 m	3-5 days	1	0	0	~10 m^2/ sample

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional (three-dimensional time-lapse); CHIRP = compressed high-intensity radiated pulse; COST = continental offshore stratigraphic test; CPT = cone penetrometer test; CSEM = controlled source electromagnetic; ha = hectares; HRG = high-resolution geophysical; km = kilometer; m = meters; m^2 = square meters; mi = mile; OCS = Outer Continental Shelf; WAZ = wide azimuth (survey).

[1] Shore base is the point of deployment to return berth.

[2] 1/16 of an OCS block (256 ac) is the smallest area considered for renewable energy leasing.

Table 3.2-7. Summary of All Projected Maximum Activity Levels of Geological and Geophysical Activities in the Area of Interest Over the 10-Year Time Period for the Oil and Gas, Renewable Energy, and Marine Minerals Program Areas (sum of survey activities from **Tables 3.2-2 through 3.2-6**)

Activity	Units	Oil & Gas	Renewable	Minerals	Totals
Geophysical					
HRG Surveys (Airgun and Non-Airgun)	# of Surveys	716	1	18	735
	Line Miles	103,025	3,472	2,196	108,693
VSP Surveys	# of Surveys	561	0	0	561
	Line Miles	16,992	0	0	16,962
SWD Surveys	# of Surveys	100	0	0	100
	Line Miles	0	0	0	0
2D Surveys	# of Surveys	23	0	0	11
	Line Miles	149,800	0	0	149,800
3D Surveys	# of Surveys	69	0	0	60
	Line Miles	649,420	0	0	649,420
WAZ Surveys	# of Surveys	62	0	0	58
	Line Miles	561,432	0	0	561,432
4D Surveys	# of Surveys	101	0	0	101
	Line Miles	1,108,378	0	0	1,108,378
Total 3D, WAZ, 4D Survey	# of Surveys	232	0	0	219
	Line Miles	2,319,230	0	0	2,319,230
CSEM	# of Surveys	12	0	0	12
	Line Miles	8,120	0	0	8,120
Geological					
Bottom Sampling					
CPT	Number	100	270	0	370
Corings	Number	795	270	0	1,065
Grab Sample	Number	1	270	90	361
Vibracores	Number	0	0	392	392
Jet Probe	Number	0	0	50	50
Bottom Sampling Subtotal	Number	896	810	532	2,238
Bottom Impacts (10 m^2/sample)	m^2	8,960	8,100	5,320	22,380
Shallow Drill Test Wells	Number	2	0	0	2
COST Wells	Number	1	0	0	1
Bottom Impacts (20,000 m^2/well)	m^2	60,000	0	0	60,000
Other					
Bottom-Founded Monitoring Buoy	Number	0	2	0	2
Bottom Impacts (Footprint 0.56 m^2/buoy + Sweep 34,000 m^2/buoy)	m^2	0	68,001	0	68,001
Total Bottom Impacts	m^2				150,381

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional; COST = Continental Offshore Stratigraphic Test; CPT = cone penetrometer test; CSEM = controlled source electromagnetic; HRG = high-resolution geophysical; m^2 = square meters; SWD = seismic while drilling; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

Table 3.3-1. Impact-Producing Factor Descriptions

Impact-Producing Factor	Survey Type(s)	Brief Description
Active Acoustic Sound Sources • Airguns	Deep-penetration seismic surveys and HRG surveys	Underwater noise from compressed air release
• Electromechanical Sources	HRG surveys	Underwater noise from subbottom profilers (boomer, sparker, or CHIRP), side-scan sonar, and multi-beam echosounders
Vessel and Equipment Noise	All vessel surveys; drilling of COST wells and shallow test wells	Underwater noise from vessel engines and equipment, and from drilling activities
Vessel Traffic	All vessel surveys	Vessel movements including survey lines and round trips to onshore base
Aircraft Traffic and Noise	Aeromagnetic surveys	Aircraft traffic, and noise from engines and propellers
Stand-Off Distances	Deep-penetration seismic airgun surveys with towed streamers	Temporary exclusion zone around streamer arrays to avoid entanglement
Vessel Discharges	All vessel surveys	Bilge, ballast, sanitary, and domestic waste discharges
Trash and Debris	All vessel surveys	Accidental release of trash or debris into the ocean
Seafloor Disturbance • Bottom Sampling	Geotechnical sampling and testing	Collection of vibracore, geologic core, and grab samples; CPT testing
• Cables, Nodes, and Anchors	Certain deep-penetration seismic airgun surveys and CSEM and MT surveys	Temporary placement of cables, nodes, sensors, or anchors on or in the seafloor
• COST Wells and Shallow Test Drilling	Drilling of COST wells and shallow test wells	Seafloor disturbance due to placement of well template, jetting of well, and anchoring of drilling rig
• Monitoring Buoys	Site characterization for renewable energy areas	Temporary anchoring of monitoring buoys
Drilling Discharges	Drilling of COST wells and shallow test wells	Release of drilling fluids and cuttings at the seafloor and from drilling rigs
Entanglement	Certain deep-penetration seismic airgun surveys using OBCs and OBNs	Temporary placement of cables, nodes, sensors, or anchors on or in the seafloor
Accidental Fuel Spills	All vessel surveys	Potential for release of diesel or fuel oil from a vessel accident

CHIRP = compressed high-intensity radiated pulse; COST = Continental Offshore Stratigraphic Test; CPT = cone penetrometer test; CSEM = controlled source electromagnetic; HRG = high-resolution geophysical; MT = magnetotelluric; OBC = ocean bottom cable; OBN = ocean bottom node.

Table 3.3-2. Characteristics of Active Acoustic Sound Sources Included in the Proposed Action

Source	Usage	Typical Operating Frequencies[a]	Broadband Source Level$_{\text{zero-to-peak}}$ (dB re 1 μPa at 1 m)[b]
Large Airgun Array (8,000 in^3)	Deep-penetration seismic surveys, oil and gas exploration (2D, 3D, WAZ, VSP, 4D, etc.)	10-2,000 Hz (most energy at <500 Hz)	248.1
Small Airgun Array (90 in^3)	HRG surveys	10-2,000 Hz (most energy at <600 Hz)	227.7
Pinger	HRG surveys	2,000 Hz	--
Sparker	HRG surveys	50-4,000 Hz	212
Boomer	HRG surveys	300-3,000 Hz	203.3
CHIRP Subbottom Profiler	HRG surveys	0.5-24 kHz	203
Side-Scan Sonar	HRG surveys	16-1,500 kHz	213
Single-Beam Echosounder	HRG surveys	12-240 kHz	195-205
Multi-Beam Echosounder	HRG surveys	50-400 kHz	206

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional; CHIRP = compressed high-intensity radiated pulse; dB re 1 μPa at 1 m = decibels referenced to 1 micropascal at 1 meter; HRG = high-resolution geophysical; Hz = hertz; in^3 = cubic inches; kHz = kilohertz; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

[a] Operating frequencies obtained from **Appendix F**.

[b] Source level obtained from **Appendix D**.

-- Not applicable; a pinger is not broadband.

Table 3.3-3. Vessel and Helicopter Traffic Associated with the Proposed Action

Survey Type	Projected Vessel-Months[1]	Estimated Transits to Shore Base for Survey Vessels	Estimated Transits to Shore Base for Service Vessels	Estimated Helicopter Transits Needed to Support Surveys
Vessel Based (2D, 3D, 4D, WAZ)	3,446	328	19,368	7,329
Platform Based (VSP, SWD)	66	165	19	168
Vessel Based (Non-Airgun HRG)	72	288	0	0
Other	17	24	107	0
Oil and Gas G&G Activities Subtotal		805	19,494	7,497
HRG	0.18	5	0	0
Sampling	0.1	27	0	0
Bottom-Founded Buoy	0.1	2	0	0
Renewable Energy G&G Activities Subtotal		34	0	0
HRG	18	90	0	0
Sampling	2	4	0	0
Vibracore/Jet	15	60	0	0
Marine Minerals G&G Activities Subtotal		154	0	0
Combined Total Transits		993	19,689	7,497

2D = two-dimensional; 3D = three-dimensional; 4D = four-dimensional; G&G = geological and geophysical; HRG = high-resolution geophysical; SWD = seismic while drilling; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

[1] Vessel months are used as a measure of vessel utilization, or vessel activity, necessary to complete the data acquisition. Vessel months were calculated by multiplying the projected number of survey events times the mean number of vessels used in that survey type times the mean duration of that survey type.

Table 3.4-1. Cumulative Scenario Activities that Include Coincident Impact-Producing Factors with the Proposed Action Geological and Geophysical Activities

Cumulative Scenario Component and Associated Activities	Impact-Producing Factor										
	Active Acoustic Sound Sources	Vessel and Equipment Noise	Vessel Traffic	Aircraft Traffic and Noise	Stand-Off Distance	Vessel Discharges	Trash and Debris	Seafloor Disturbance	Drilling Discharges	Entanglement	Accidental Fuel Spill
Federal OCS Programs											
Oil and Gas Exploration and Development	-	+	+	+	+	+	+	+	+	-	+
Decommissioning	-	+	+	-	+	+	+	+	-	-	+
Renewable Energy Development	-	+	+	-	+	+	+	+	-	-	+
Marine Minerals Use	-	+	+	-	+	+	+	+	-	-	+
Oil and Gas Activities in State Water											
Oil and Gas Exploration and Development	+	+	+	+	+	+	+	+	+	+	+
Decommissioning	-	+	+	-	+	+	+	+	-	-	+
Other Major Factors Influencing the AOI											
Deepwater Ports	-	+	+	-	+	+	+	-	-	-	+
Commercial and Recreational Fishing	+	+	+	-	+	+	+	+	-	+	+
Shipping and Marine Transportation	-	+	+	-	-	+	+	-	-	-	+
Dredged Material Disposal	-	+	+	-	+	+	+	+	-	-	+
Existing, Planned, and New Cable Infrastructure	+	+	+	-	+	+	+	+	-	-	+
Military Activities	+	+	+	+	+	+	+	+	-	-	+
Scientific Research	+	+	+	+	-	+	+	+	-	+	+
Maintenance Dredging and Federal Channels	-	+	+	+	+	+	+	+	-	-	+
Coastal Restoration Programs	-	+	+	-	+	+	+	+	-	-	+
Mississippi River Hydromodification and Subsidence	-	+	+	-	-	+	+	-	-	-	+
Extreme Climatic Events	-	-	-	-	-	-	-	+	-	-	+
Climate Change and Sea-Level Rise	-	-	-	-	-	-	-	-	-	-	-
Natural Oil Seeps	-	-	-	-	-	-	-	-	-	-	+

AOI = Area of Interest; OCS = Outer Continental Shelf; "+" = the activity includes coincident impact-producing factors; and "-" = the activity does not include coincident impact-producing factors.

Table 3.4-2. Summary of Oil and Gas Exploration and Development Activities in the U.S. Gulf of Mexico Projected 10-Year Projections (bold) (based on 40-year projections [not bold] [Modified from: USDOI, BOEM, 2015d, 2016b])

Activity	**10-Year Projections**				40-Year Projections (2012-2051) Used as Basis			
	WPA	**CPA**	**EPA**	**Total OCS**	WPA	CPA	EPA	Total OCS
Wells Drilled								
Exploration and Delineation Wells	**295-423**	**1,430-2,028**	**3-7**	**1,728-2,457**	1,180-1,690	5,720-8,110	10-27	6,910-9,827
Development and Production Wells	**363-530**	**1,770-2,505**	**0-10**	**2,133-3,045**	1,450-2,120	7,080-10,020	0-40	8,530-12,180
Producing Oil Wells	**124-184**	**700-961**	**0-6**	**824-1,151**	495-737	2,801-3,843	0-25	3,296-4,605
Producing Gas Wells	**196-288**	**887-1,289**	**0-3**	**1,084-1,580**	785-1,153	3,549-5,157	0-10	4,334-6,320
Production Structures								
Installed	**64-96**	**295-410**	**0-1**	**359-507**	255-384	1,180-1,640	0-2	1,435-2,026
Decommissioned Using Explosives	**40-60**	**177-252**	**0**	**217-312**	160-240	707-1,006	1	868-1,247
Total Decommissioned	**58-88**	**262-371**	**0-1**	**320-459**	233-350	1,046-1,485	0-2	1,279-1,837
Method of Transportation								
Percent Piped	**N/A**	**N/A**	**N/A**	**N/A**	84->99	93->99	N/A	92->99
Percent Barged	**N/A**	**N/A**	**N/A**	**N/A**	<1	>1	N/A	<1
Percent Tankered	**N/A**	**N/A**	**N/A**	**N/A**	0-15	0-6	N/A	0-7
Length of Installed Pipelines (km)	**1,306-3,085**	**6,301-14,294**	**0-58**	**7,607-17,437**	5,224-12,339	25,204-57,177	0-233	30,428-69,749
Vessel and Helicopter Traffic								
Service Vessel Trips (round-trips × 10^3)	**120-180**	**707-907**	**0-9**	**828-1,096**	481-720	2,829-3,627	0-35	3,310-4,382
Helicopter Operations (× 10^3)	**1,305-2,613**	**5,945-11,125**	**0-16**	**7,178-13,901**	5,220-10,450	23,780-44,500	0-655	28,710-55,605

CPA = Central Planning Area; EPA = Eastern Planning Area; km = kilometers; N/A = not available; OCS = Outer Continental Shelf; WPA = Western Planning Area.

Table 3.4-3. Structure Removal Permit Applications on the Area of Interest, 2004 to 2015 (Modified from: USDOI, BSEE, 2017)

Final Disposition	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*	Total	%
Scrapping/Shore	144	118	164	124	176	237	223	352	282	186	198	115	2,319	83.3
Reuse	2	2	1	19	16	4	3	1	16	13	18	2	97	3.5
Rigs-to-Reefs	8	21	20	34	35	40	53	40	28	36	36	18	369	13.2
Total	154	141	185	177	227	281	279	393	326	235	232	135	2,785	100

*Data through January 27, 2016.
% = percent.

Table 3.4-4. Structures Removed from the Area of Interest, 2004 to 2015 (Modified from: USDOI, BSEE, 2017)

Structure Type	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015*	Total	%
Caissons	101	41	52	60	59	80	57	113	98	99	84	38	882	38.2
Platforms	64	65	46	82	74	129	142	152	147	105	88	70	1,164	50.4
Mobile Offshore Production Units	0	0	0	1	1	0	0	0	0	0	0	0	2	0.07
Mini-Tension Leg Platforms	0	0	1	0	0	0	0	0	0	0	0	0	1	0.03
Well Protectors	29	17	16	17	19	25	19	28	38	18	29	5	260	11.3
Total	194	123	115	160	153	234	218	298	283	216	201	113	2,309	100

*Data through January 27, 2016.
% = percent.

Table 3.4-5. Summary of Annual Oil and Gas Production from State Waters of Several Gulf Coast States (From: Louisiana Department of Natural Resources, 2017; Railroad Commission of Texas, 2017; Geological Survey of Alabama, State Oil and Gas Board, 2017)

State	Year	Crude Oil (bbl)	Natural Gas (MMcf)
Louisiana	2009	3,858,277	70,811,813
	2010	4,671,151	62,296,972
	2011	5,064,106	63,099,986
	2012	5,036,472	71,866,441
	2013	5,584,262	58,666,623
	2014	5,551,263	42,805,939
	2015	5,246,644	32,625,158
	2016	4,952,376	24,619,857
Texas*	2009	229,984	85.9
	2010	209,923	63.4
	2011	416,639	834.3
	2012	272,226	443.3
	2013	375,106	14.8
	2014	384,040	445,5
	2015	271,665	207.3
	2016	148,233	48.7
Alabama**	2009	31,860	109,811
	2010	34,585	102,052
	2011	23,832	84,730
	2012	12,116	87,875

bbl = barrels; MMcf = million cubic feet.

*Texas offshore data reported as crude oil and casinghead gas between 2009 and 2016; 2013 data reported as gas well gas and condensate.

**2014-2016 data were not publically available at the time this table was prepared.

Table 3.4-6. Summary of Deepwater Ports in the Area of Interest (Modified from: USDOT, MARAD, 2015a)

Port Name	Operator	Comments	Status
Louisiana Offshore Oil Port	Marathon Domestic LLC	On June 1, 2000, a deepwater port license was issued to the Louisiana Offshore Oil Port (LOOP), the only deepwater port petroleum terminal in existence. LOOP is located 25.7 km (16 mi) southeast of Port Fourchon, Louisiana. LOOP was built by a group of major oil and pipeline companies and has been operational since 1981. It serves as an unloading and distribution port for supertankers coming into the GOM. The petroleum is piped north to Lafourche Parish, where it is stored and piped to U.S. markets.	Operational
Port Dolphin	Port Dolphin Energy LLC	On March 29, 2007, an application was filed with MARAD to construct a deepwater port located approximately 28 mi (45 km) offshore of Tampa, Florida. The applicant is a wholly owned subsidiary of Höegh LNG. The port will consist of two Submerged Turret Loading buoys. On October 26, 2009, MARAD issued a ROD approving, with conditions, the license application, and on April 19, 2010, the official license was issued. Port Dolphin is currently working with the relevant Federal and State agencies to obtain the required authorizations and permits for construction and operation of the facility. MARAD anticipated that construction of the Port Dolphin facility would commence in late 2014. As of January 2015, Port Dolphin has acquired certification to build its 67.6-km (42-mi) long pipeline from Port Manatee to the port terminal site. The Federal Energy Regulatory Commission has issued a certificate of public necessity and convenience to build and operate the pipeline.	Not operational (industry sources indicate that the project has been abandoned)
Main Pass Energy Hub	Freeport McMoRan	A notice of revised application was submitted on June 22, 2006; the Main Pass Energy Hub represents a conversion of a sulfur/brine mining facility into an LNG terminal for regasification. The project was approved on November 20, 2007. The Main Pass Energy Hub is located 25.7 km (16 mi) offshore Louisiana in Main Pass Block 299. Due to significant financial challenges, Freeport McMoRan has been unable to comply with the conditions of the ROD. On January 2, 2012, MARAD moved to rescind approval of the ROD for the project.	Not operational
Gulf Gateway Energy Bridge, LLC (Gulf Gateway)	Excelerate Energy Limited Partnership	Gulf Gateway, located off the coast of Louisiana, consists of a Submerged Turret Loading system (i.e., submerged turret buoy; chains, lines, and anchors; flexible riser; and subsea manifold). A ROD was issued on December 31, 2003, and the license was issued on May 26, 2004. On February 22, 2012, Excelerate Energy notified MARAD and USCG of its intention to decommission the Gulf Gateway deepwater port due to irreparable hurricane damage to pipelines interconnecting with the deepwater port, as well as a changing natural gas market, which impacted the operator's ability to receive consistent shipments. The MARAD approved the decommissioning and terminated the license for the Gulf Gateway deepwater port on June 28, 2013.	Not operational

Table 3.4-6 Summary of Deepwater Ports in the Area of Interest (Modified from: USDOT, MARAD, 2015a) (continued)

Port Name	Operator	Comments	Status
Bienville Offshore Energy Terminal	TORP Technology LP	Application filed on January 12, 2006, for an LNG facility to be located in the GOM, 101 km (63 mi) south of Mobile Point, Alabama. The facility consists of a HiLoad Unit, which is a floating structure connecting directly to the LNG carrier hull. On October 9, 2008, the applicant elected to withdraw its application in order to consider technical modifications to its proposed project. On October 29, 2010, MARAD approved, with conditions, the modified TORP Terminal deepwater port license application. The approval conditions required that TORP Terminal meet all financial responsibilities requirements of the Deepwater Port Act of 1974, as amended. Since issuance of the ROD, TORP Terminal has been unable to meet the financial responsibility conditions required for license issuance. As a result, the TORP Terminal applicant withdrew its deepwater port license application from the final licensing process and terminated all project activities. In response, MARAD acknowledged the withdrawal and rescinded the official ROD on June 18, 2012.	Not operational
Port Pelican	Port Pelican, LLC	On November 25, 2002, an application was submitted for a deepwater port license to construct an LNG gravity-based structure facility off the coast of Louisiana. The Port Pelican Deepwater Port License was issued on January 20, 2004, the first deepwater port license to be issued for the construction and operation of an LNG facility. On July 11, 2005, Port Pelican LLC provided a letter to MARAD and USCG of its plans to place the project on an indefinite hold. On October 4, 2005, a Notice of Cancellation was published. On October 28, 2009, MARAD received notification from Port Pelican LLC of the relinquishment of its license. In response, MARAD published a notice on December 9, 2009, announcing the relinquishment of the license and cancellation of all actions related to the project. To date, the project remains closed with MARAD.	Project closed
Gulf Landing	U.S. Gas & Oil, LLC	On November 3, 2003, an application was filed for the construction and operation of an offshore gravity-based structure to be located 61 km (38 mi) offshore Louisiana. On February 16, 2005, the ROD was issued, and on April 29, 2005, the official license was issued for Gulf Landing. However, in March 2007, Gulf Landing LLC announced its intention to terminate all project and construction activities for the proposed facility. On April 30, 2009, Gulf Landing LLC surrendered its deepwater port license. The MARAD accepted the license surrender and issued a license surrender notice on July 1, 2009 *(Federal Register,* 2009b*).*	Project closed

GOM = Gulf of Mexico; km = kilometers; LNG = liquefied natural gas; MARAD = Maritime Administration; mi = miles; ROD = Record of Decision; USCG = U.S. Coast Guard.

Table 3.4-7. Summary of Commercial Vessel Port Visits for Vessels >1,000 Gross Tons to Area of Interest Ports in 2012 (Modified from: USDOT, MARAD, 2015b)

Port	State	Tankers	Containers	LNG/PNG	Roll On-Roll Off	Bulk	General Cargo	Total Calls
Houston	TX	5,555	1,008	575	223	887	1,040	9,288
South Louisiana	LA	957	1	39	1	1,203	94	2,295
Sabine-Neches Waterway	TX	1,642	0	80	57	301	152	2,232
New Orleans	LA	409	438	21	17	883	334	2,102
Mobile	AL	162	252	0	89	430	318	1,251
Texas City	TX	1,045	1	0	0	27	4	1,077
Corpus Christi	TX	750	0	34	4	139	85	1,012
Galveston Lightering Area	TX	979	0	0	0	0	0	979
Tampa	FL	331	55	86	26	271	136	905
Greater Baton Rouge	LA	586	0	28	0	161	64	839
Lake Charles	LA	578	0	20	0	112	102	812
Galveston	TX	341	1	8	168	123	165	806
Freeport	TX	444	106	49	3	13	62	677
Pascagoula	MS	447	0	31	20	80	59	637
Louisiana Offshore Oil Port	LA	304	0	0	0	0	0	304
Point Comfort	TX	142	0	40	0	106	4	292
Ingleside	TX	84	0	82	0	108	9	283
Southwest Pass Lightering Area	LA	281	0	0	0	0	0	281
Gulfport	MS	0	195	0	0	11	2	208
Port Manatee	FL	15	1	1	0	61	115	193
Brownsville	TX	72	0	0	1	88	28	189
South Sabine Point Lightering Area	TX	160	0	0	0	0	0	160
Pensacola	FL	2	0	0	0	4	24	30
Panama City	FL	1	0	0	0	5	1	7
Total		15,287	2,058	1,094	609	5,013	2,798	26,859

FL = Florida; LA = Louisiana; LNG = liquefied natural gas; MARAD = Maritime Administration; MS = Mississippi; PNG = pressurized natural gas; TX = Texas.

Table 3.4-8. Vessel Trips in the Area of Interest in 2012 Recorded by Vessels Equipped with Automatic Identifications Systems (From: Marine Cadastre, 2015)

Category	Vessel Length (m)						
	No Data	5-19	20-29	30-59	60-170*	171-300	Total
No Vessel Type Reported/Not Available	47,717	1,899	2,066	2,456	1,574	1,351	57,063
Reserved for Future Use	727	116	343	1,630	883	129	3,828
Reserved, for Regional Use	--	--	--	8	--	6	14
Wing in Ground	331	37	149	601	1,961	116	3,195
Other Types of Ship	2,416	2,300	3,411	7,237	4,408	967	20,739
Fishing	718	555	927	749	129	--	3,078
Towing	5,125	10,464	21,988	9,395	1,609	2,562	51,143
Towing and Length of the Tow Exceeds 200 m or Breadth Exceeds 25 m	454	625	1,782	2,935	436	23	6,255
Engaged in Dredging or Underwater Operations	612	93	26	944	1,365	6	3,046
Engaged in Diving Operations	101	56	--	548	513	--	1,218
Engaged in Military Operations	677	545	83	1,319	480	182	3,286
Sailing	114	81	51	479	7	2	734
Pleasure Craft	374	1,066	953	3,088	376	--	5,857
High-Speed Craft	56	79	36	564	85	5	825
Pilot Vessel	1,065	2,547	389	435	16	39	4,491
Search and Rescue Vessels	138	398	56	40	18	--	650
Tugs	2,884	7,153	15,355	13,130	894	735	40,151
Port Tenders	90	64	4	2	16	--	176
Vessels with Anti-Pollution Facilities or Equipment	133	2	--	82	156	1	374
Law Enforcement Vessels	60	55	61	20	5	--	201
Spare – for Assignments to Local Vessels	16	3	41	141	--	--	201
Ships According to RR Resolution No. 18 (Mob 83)**	--	--	52	141	14	--	207
Passenger Ships	1,642	1,019	854	7,589	1,079	2,303	14,486
Cargo Ships	1,616	787	277	6,026	17,100	33,528	59,334
Tankers	278	1,019	10	110	5,987	20,708	28,112
Total	67,344	30,963	48,914	59,669	39,111	62,663	308,664

m = meters; -- = no data.

*Range of survey vessels is 60-90 m.

**Resolution No. 18 (Mob-83) relates to the Procedure for Identifying and Announcing the Position of Ships and Aircraft of States Not Parties to an Armed Conflict.

Table 3.4-9. Cruise Ship Departures from Gulf of Mexico Ports by Year (From: USDOT, MARAD, 2015b)

Port	State	2008	2009	2010	2011
Galveston	TX	146	134	152	149
Mobile	AL	84	76	75	60
New Orleans	LA	79	101	89	136
Tampa	FL	177	181	192	199
Total		407	492	508	544

AL = Alabama; FL = Florida; LA = Louisiana; TX = Texas.

Table 4.1-1. Types of Geological and Geophysical Activities by Survey Type and Associated Impact-Producing Factors Associated with Each Survey Type as Described in **Appendix F**

Survey Type	Reference Section in **Appendix F**	Airgun and Other Active Acoustic Sources	Vessel and Equipment Noise	Vessel Traffic	Aircraft Traffic and Noise	Stand-Off Distances	Vessel Discharges	Trash and Debris	Seafloor Disturbance	Drilling Discharges	Entanglement	Accidents
Deep-Penetration Seismic Surveys												
2D Seismic Surveys	1.1.1	+	+	+	+	+	+	+	-	-	-	+
3D Seismic Surveys	1.1.2	+	+	+	+	+	+	+	-	-	-	+
Ocean Bottom 2D and 3D Seismic Surveys (Cables and Nodes)	1.1.3	+	+	+	+	+	+	+	+	-	+	+
Wide Azimuth and Related Multi-Vessel Surveys	1.1.4	+	+	+	+	+	+	+	-	-	-	+
Borehole Seismic Surveys (2D and 3D VSP Surveys)	1.1.5	+	+	+	+	+	+	+	-	-	-	+
Vertical Cable Surveys	1.1.6	+	+	+	+	+	+	+	+	-	-	+
4D Time-Lapse Surveys	1.1.7	+	+	+	+	+	+	+	-	-	-	+
Airgun High-Resolution Geophysical Surveys												
High-Resolution Seismic Surveys	1.2	+	+	+	-	+	+	+	-	-	-	+
Non-Airgun Acoustic High-Resolution Geophysical Surveys												
Subbottom Profiling Surveys	1.3.1	+	+	+	-	-	+	+	-	-	-	+
Side-Scan Sonars	1.3.2	+	+	+	-	-	+	+	-	-	-	+
Single and Multibeam Echosounders	1.3.3	+	+	+	-	-	+	+	-	-	-	+
Non-Acoustic Marine Geophysical Surveys												
Marine Geophysical (Gravity, Magnetic, MT, CSEM)	1.4.1-1.4.4	-	-	+	-	-	+	+	+	-	-	+
Airborne Remote Surveys												
Airborne Gravity Surveys	1.5.1	-	-	-	+	-	-	-	-	-	-	-
Airborne Magnetic Surveys	1.5.2	-	-	-	+	-	-	-	-	-	-	-
Geological and Geotechnical Surveys												
Grab and Box Sampling	2.1	-	+	+	-	-	+	+	+	-	-	+

Table 4.1-1. Types of Geological and Geophysical Activities by Survey Type and Associated Impact-Producing Factors Associated with Each Survey Type as Described in **Appendix F** (continued)

Survey Type	Reference Section in **Appendix F**	Airgun and Other Active Acoustic Sources	Vessel and Equipment Noise	Vessel Traffic	Aircraft Traffic and Noise	Stand-Off Distances	Vessel Discharges	Trash and Debris	Seafloor Disturbance	Drilling Discharges	Entanglement	Accidents
Geologic Coring	2.2	-	+	+	-	+	+	+	+	+	-	+
COST and Shallow Test Wells	2.3	-	+	+	-	+	+	+	+	+	-	+
Cone Penetrometer Tests	2.4	-	-	+	-	-	+	+	+	-	-	+
Other Surveys and Equipment												
Pingers, Transponders, ROVs, AUVs, Buoys, Anchors, Sensors	4.1-4.4	+	-	+	-	-	-	+	+	-	-	+

AUV = autonomous underwater vehicle; COST = continental offshore stratigraphic test; CSEM = controlled source electromagnetic; FAZ = full azimuth; MAZ = multi-azimuth; MT = magnetotelluric; RAZ = rich azimuth; ROV = remotely operated vehicle; VSP = vertical seismic profile; WAZ = wide azimuth (survey).

Key: + indicates a potential impact; - indicates no impact expected.

Table 4.1-2. Preliminary Screening of Potential Impacts (Leopold Matrix)

Resource	Active Acoustic Sound Sources	Vessel and Equipment Noise	Vessel Traffic	Aircraft Traffic and Noise	Stand-Off Distances	Vessel Discharges	Trash and Debris	Seafloor Disturbance	Drilling Discharges	Entanglement	Accidental Fuel Spill
Marine Mammals	+	+	+	+	-	-	+	-	-	+	+
Sea Turtles	+	+	+	+	-	-	+	-	-	+	+
Fisheries Resources and Essential Fish Habitat	+	+	-	-	-	-	+	+	+	+	+
Benthic Communities	+	-	-	-	-	-	+	+	+	-	+
Marine and Coastal Birds	+	+	+	+	-	-	+	-	-	-	+
Marine Protected Areas	+	-	-	-	-	-	+	+	+	-	+
Sargassum Communities	-	-	+	-	-	+	+	-	-	-	+
Commercial Fisheries	+	-	+	-	+	-	-	+	-	+	+
Recreational Fisheries	+	-	+	-	+	-	-	-	-	-	+
Archaeological Resources	-	-	-	-	-	-	-	+	+	+	+
Other Marine Uses	-	-	+	+	+	-	-	+	-		+
Human Resources, Land Use, and Economics[1]	-	-	-	-	-	-	-	-	-	-	-
Recreational Resources and Tourism	-	-	-	-	-	-	-	-	-	-	-
Air Quality	-	-	+	+	-	-	-	-	-	-	-
Water Quality	-	-	-	-	-	+	+	-	+	-	+
Geography and Geology	-	-	-	-	-	-	-	+	-	-	-
Physical Oceanography	-	-	-	-	-	-	-	-	-	-	-
Coastal Barrier Island Beaches, Seagrass, and Wetlands	-	-	-	-	-	-	-	-	-	-	-

G&G = geophysical and geological.
Shading = resources were eliminated from detailed analysis due to limited anticipated impacts associated with G&G activities.
Key: + indicates a potential impact; - indicates no impact expected.
[1] The impact-producing factors do not apply to this resource; however, resource subcomponents have potential impacts from some alternatives.

Table 4.1-3. Length and Area of Oiling of State and Federal Lands along the Northern Gulf Coast Caused by the *Deepwater Horizon* Oil Spill (From: Deepwater Horizon Natural Resource Damage Assessment Trustees, 2015, 2016) (The Federal lands include only USDOI sites.)

State	State Lands		Federal Lands (USDOI only)	
	Kilometers (miles)	Hectares (acres)	Kilometers (miles)	Hectares (acres)
Texas	43 (27)	341 (842)	13 (8)	80 (197)
Louisiana	250 (156)	1,363 (3,368)	43 (27)	256 (632)
Mississippi	102 (64)	448 (1,124)	93 (57)	546 (1,334)
Alabama	116 (72)	526 (1,299)	20 (12)	99 (244)
Florida	155 (96)	737 (1,820)	114 (71)	692 (1,710)

USDOI = United States Department of the Interior.

Table 4.2-1. Marine Mammals Potentially Occurring in the Area of Interest (Sources: Davis and Fargion, 1996; Jefferson et al., 2008; Roberts et al., 2016; Southall et al. 2007; Waring et al., 2013, 2014, 2015, 2016; Würsig et al., 2000)

Species	MMPA Stock[1]	Distribution[2]	Abundance (SAR /CetMap)[3]		Occurrence in AOI[4]	Habitat in AOI[5]	Auditory Range[2]	Functional Hearing Group[6]	Status[7] (ESA/ MMPA Stock)	
ORDER CETACEA										
Suborder Mysticeti (Baleen Whales)										
Bryde's Whale *(Balaenoptera edeni)*	Gulf of Mexico	Worldwide in tropical and subtropical waters of the world in coastal and pelagic waters, and often in shelf break waters or near topographic features.	33	44	Uncommon	Shelf Edge and Upper Slope within De Soto Canyon or Florida Escarpment	<60 to 900 Hz	L	C	S
Suborder Odontoceti (Toothed Whales, Dolphins, and Porpoises)										
Family Delphinidae										
Pygmy Killer Whale *(Feresa attenuata)*	Gulf of Mexico	Worldwide in tropical to subtropical oceanic waters.	152	2,126	Uncommon	Oceanic	45 to 117 kHz	M	--	--
Short-Finned Pilot Whale (*Globicephala macrorhynchus*)	Gulf of Mexico	Worldwide in tropical to subtropical waters, generally on the continental shelf break and in deep oceanic waters.	2,415	1,981	Common	Oceanic	280 Hz to 100 kHz	M	--	--
Risso's Dolphin (*Grampus griseus*)	Gulf of Mexico	Worldwide in tropical to warm temperate waters.	2,442	3,137	Common	Oceanic	400 Hz to 65 kHz	M	--	--
Fraser's Dolphin (*Lagenodelphis hosei*)	Gulf of Mexico	Worldwide in warm temperate, subtropical, and tropical pelagic waters.	--	1,665	Uncommon	Oceanic	6.6 kHz to <40 kHz	M	--	--

Table 4.2-1. Marine Mammals Potentially Occurring in the Area of Interest (continued)

Species	MMPA Stock[1]	Distribution[2]	Abundance (SAR/CetMap)[3]		Occurrence in AOI[4]	Habitat in AOI[5]	Auditory Range[2]	Functional Hearing Group[6]	Status[7] (ESA/ MMPA Stock)	
Killer Whale (*Orcinus orca*)	Gulf of Mexico	Mostly in polar waters but can be found in temperate waters. Can be found in lower densities in tropical, subtropical, and offshore waters.	28	185	Uncommon	Oceanic	80 Hz to 85 kHz	M	--	--
Melon-Headed Whale (*Peponocephala electra*)	Gulf of Mexico	Worldwide in tropical and subtropical waters.	2,235	6,733	Common	Oceanic	8 to 40 kHz	M	--	--
False Killer Whale (*Pseudorca crassidens*)	Gulf of Mexico	Worldwide in warm temperate and tropical oceans in relatively deep offshore waters.	--	3,204	Uncommon	Shelf-Oceanic	4 to 130 kHz	M	--	--
Pantropical Spotted Dolphin (*Stenella a. attenuata*)	Gulf of Mexico	Offshore tropical waters.	50,880	84,014	Common	Oceanic	3.1 to 140 kHz	M	--	--
Clymene Dolphin (*Stenella clymene*)	Gulf of Mexico	Deep tropical, subtropical, and warm temperate waters.	129	11,000	Common	Oceanic	0.1 to 160 kHz	M	--	--
Striped Dolphin (*Stenella coeruleoalba*)	Gulf of Mexico	Tropical to cool temperate waters.	1,849	4,914	Common	Oceanic	0.1 to 160 kHz	M	--	--
Atlantic Spotted Dolphin (*Stenella frontalis*)	Gulf of Mexico	Tropical to warm temperate waters.	--	47,488	Common	Shelf-Shelf Edge	0.1 to 160 kHz	M	--	--
Spinner Dolphin (*Stenella l. longirostris*)	Gulf of Mexico	Tropical to temperate oceanic waters.	11,441	13,485	Common	Oceanic	0.1 to 160 kHz	M	--	--
Rough-Toothed Dolphin (*Steno bredanensis*)	Gulf of Mexico	Deep tropical and subtropical waters.	624	4,853	Common	Shelf Edge-Oceanic	0.1 to 200 kHz	M	--	--
Common Bottlenose Dolphin (*Tursiops t. truncatus*)	Northern Gulf of Mexico, Oceanic	Worldwide in temperate and tropical waters.	5,806	138,602	Common	Oceanic	0.05 to 150 kHz	M	--	--

Table 4.2-1. Marine Mammals Potentially Occurring in the Area of Interest (continued)

Species	MMPA Stock[1]	Distribution[2]	Abundance (SAR/CetMap)[3]		Occurrence in AOI[4]	Habitat in AOI[5]	Auditory Range[2]	Functional Hearing Group[6]	Status[7] (ESA/ MMPA Stock)	
	Northern Gulf of Mexico, Continental Shelf	Worldwide in temperate and tropical waters.	51,192	138,602	Common	Shelf and Shelf Edge	0.05 to 150 kHz	M	--	--
	Gulf of Mexico, Eastern Coastal	Worldwide in temperate and tropical waters.	12,388	138,602	Common	Coastal and Inner Shelf	0.05 to 150 kHz	M	--	--
	Gulf of Mexico, Northern Coastal	Worldwide in temperate and tropical waters.	7,185	138,602	Common	Coastal and Inner Shelf	0.05 to 150 kHz	M	--	S
	Gulf of Mexico, Western Coastal	Worldwide in temperate and tropical waters.	20,161	138,602	Common	Coastal and Inner Shelf	0.05 to 150 kHz	M	--	S
	Northern Gulf of Mexico; Bay, Sound, and Estuary Stock Block (32 stocks)	Worldwide in temperate and tropical waters.	Refer to **Table 4.2-2**	138,602	Common (localized)	Coastal	0.05 to 150 kHz	M	--	S

Table 4.2-1. Marine Mammals Potentially Occurring in the Area of Interest (continued)

Species	MMPA Stock[1]	Distribution[2]	Abundance (SAR/CetMap)[3]		Occurrence in AOI[4]	Habitat in AOI[5]	Auditory Range[2]	Functional Hearing Group[6]	Status[7] (ESA/ MMPA Stock)	
Family Physeteridae										
Sperm Whale (*Physeter microcephalus*)	Gulf of Mexico	Worldwide in polar to tropical waters	763	2,128	Common	Oceanic	2.5 to 60 kHz	M	E	S
Family Kogiidae										
Pygmy Sperm Whale (*Kogia breviceps*)	Gulf of Mexico	Worldwide in temperate to tropical oceanic waters.	186[8]	2,234[8]	Uncommon	Oceanic	60 to 200 kHz	H	--	--
Dwarf Sperm Whale (*Kogia sima)*	Gulf of Mexico	Worldwide in temperate to tropical oceanic waters.			Uncommon	Oceanic	60 to 200 kHz	H	--	--
Family Ziphiidae										
Blainville's Beaked Whale (*Mesoplodon densirostris*)	Gulf of Mexico	Worldwide in offshore temperate and tropical waters.	149[8]	2,910[8]	Rare	Oceanic	<1 to 48 kHz	M	--	--
Gervais' Beaked Whale (*Mesoplodon europaeus*)	Gulf of Mexico	Worldwide in deep offshore temperate and tropical waters.			Uncommon	Oceanic	30 to 48 kHz	M	--	--
Cuvier's Beaked Whale (*Ziphius cavirostris*)	Gulf of Mexico	Deep offshore in subtropical and temperate waters.	74	2,910	Rare	Oceanic	300 Hz to 135 kHz	M	--	--
ORDER SIRENIA										
West Indian Manatee (Florida subspecies) (*Trichechus manatus latirostris*)	Florida	Warm waters throughout the southeastern United States.	3,333[9]	--	Common	Shelf-Coastal	0.6 to 12 kHz	*[10]	E	S

AOI = Area of Interest; CetMap = Cetacean Density and Distribution Mapping Working Group; ESA = Endangered Species Act; Hz = hertz; kHz = kilohertz; MMPA = Marine Mammal Protection Act; SAR = stock assessment report

-- = no data.

[1] From Waring et al., 2016.

[2] From **Appendix E, Sections 2.1-2.3**.

[3] SAR – Best population estimate (within associated stock). "NBest" from Table 1 of the Waring et al. (2016) SAR. CetMap abundance derived from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al., 2016).

Table 4.2-1. Marine Mammals Potentially Occurring in the Area of Interest (continued)

[4] Occurrence in the Gulf of Mexico from Würsig et al. (2000). Categories include the following:
Common – abundant wherever it occurs in the region;
Uncommon – may or may not be widely distributed but does not occur in large numbers; and
Rare – present in such small numbers throughout the region that it is seldom seen;

[5] From Waring et al., 2013, 2015, 2016.

[6] Functional marine mammal hearing groups and specific auditory ranges (modified from Southall et al., 2007).
L = Low-Frequency Cetacean (7 Hz to 25 kHz).
M = Mid-Frequency Cetacean (150 Hz to 160 kHz).
H = High-Frequency Cetacean (200 Hz to 180 kHz).

[7] ESA Stock, C = candidate and E = endangered; MMPA Stock, S = strategic stock

[8] Some congeners, such as dwarf and pygmy sperm whales, and Blainville's and Gervais' beaked whales are difficult to differentiate at sea, and sightings of either species are usually categorized as Kogia spp, and Mesoplodon spp., respectively. Therefore, the minimum population estimate for dwarf and pygmy sperm whales, and Blainville's and Gervais' beaked whales are combined (Waring et al., 2013).

[9] State of Florida, Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute, 2015.

[10] Manatee hearing is not addressed by Southall et al. (2007). Based on review of marine mammal hearing capabilities, manatee hearing is generally similar to that of the Southall et al. (2007) range for phocid pinnipeds in water (except at the lowest frequencies) (75 Hz-75 kHz).

Table 4.2-2. Stocks of Common Bottlenose Dolphins within the Area of Interest (From: Waring et al., 2016)

Stock	Bay, Sound, and Estuary Stock Block (refer to **Figure 4.2-4**)	ESA/MMPA/ Stock Status[1]	Occurrence[2]	Best Population Estimate
Northern Gulf of Mexico Oceanic	N/A	-	Common	5,806
Northern Gulf of Mexico Continental Shelf	N/A	-	Common	17,777
Gulf of Mexico Eastern Coastal	N/A	-	Common	7,702
Gulf of Mexico Northern Coastal	N/A	-/S	Common	2,473
Gulf of Mexico Western Coastal	N/A	-/S	Common	3,499
Bay, Sound, and Estuary Stocks				
Laguna Madre	B51	-/S	Common (local)	80
Nueces Bay, Corpus Christi Bay	B52	-/S	Common (local)	58
Copano Bay, Aransas Bay, San Antonio Bay, Redfish Bay, Espiritu Santo Bay	B50	-/S	Common (local)	55
Matagorda Bay, Tres Palacios Bay, Lavaca Bay	B54	-/S	Common (local)	61
West Bay	B55	-/S	Common (local)	32
Galveston Bay, East Bay, Trinity Bay	B56	-/S	Common (local)	152
Sabine Lake	B57	-/S	Common (local)	0
Calcasieu Lake	B58	-/S	Common (local)	0
Vermilion Bay, West Cote Blanche Bay, Atchafalaya Bay	B59	-/S	Common (local)	0
Terrebonne Bay, Timbalier Bay	B60	-/S	Common (local)	100
Barataria Bay	B61	-/S	Common (local)	138
Mississippi River Delta	B30	-/S	Common (local)	332
Mississippi Sound, Lake Borgne, Bay Boudreau	B02-05, 29, 31	-/S	Common (local)	901
Mobile Bay, Bon Secour Bay	B06	-/S	Common (local)	122
Perdido Bay	B07	-/S	Common (local)	0
Pensacola Bay, East Bay	B08	-/S	Common (local)	33
Choctawhatchee Bay	B09	-/S	Common (local)	179
St. Andrew Bay	B10	-/S	Common (local)	124
St. Joseph Bay	B11	-/S	Common (local)	152
St. Vincent Sound, Apalachicola Bay, St. George Sound	B12-13	-/S	Common (local)	439
Apalachee Bay	B14-15	-/S	Common (local)	491
Waccasassa Bay, Withlacoochee Bay, Crystal Bay	B16	-/S	Common (local)	100
St. Joseph Sound, Clearwater Harbor	B17	-/S	Common (local)	37
Tampa Bay	B32-34	-/S	Common (local)	559
Sarasota Bay, Little Sarasota Bay	B20, 35	-/S	Common (local)	160
Pine Island Sound, Charlotte Harbor, Gasparilla Sound, Lemon Bay	B21-23	-/S	Common (local)	826
Caloosahatchee River	B36	-/S	Common (local)	0
Estero Bay	B24	-/S	Common (local)	104
Chokoloskee Bay, Ten Thousand Islands, Gullivan Bay	B25	-/S	Common (local)	208
Whitewater Bay	B27	-/S	Common (local)	242
Florida Keys (Bahia Honda to Key West)	B28	-/S	Common (local)	29

[1] E = endangered; ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act; S = strategic stock.

[2] Population status in the Gulf of Mexico from Würsig et al. (2000). Categories include the following: Common – abundant wherever it occurs in the region; Uncommon – may or may not be widely distributed but does not occur in large numbers; Rare – present in such small numbers throughout the region that it is seldom seen; Extralimital – known on the basis of only a few records that probably resulted from unusual wanderings of animals into the region.

Table 4.2-3. Generalized Marine Mammal Hearing Groups, Associated Auditory Bandwidths, and Marine Mammal Species Present in the Area of Interest (Modified from: Southall et al., 2007 per NMFS' 2016 Technical Guidance)

Generalized Hearing Group	Estimated Auditory Bandwidth	Marine Mammal Species Present in the Area of Interest
Low-frequency cetaceans	7 Hz to 35 kHz	Bryde's whale
Mid-frequency cetaceans	150 Hz to 160 kHz	Sperm whale; beaked whales; Stenella dolphins; common bottlenose dolphin; killer whale; pygmy killer whale; false killer whale; Risso's dolphin; long-finned pilot whales; melon headed whale; Fraser's dolphin; rough-toothed dolphin
High-frequency cetaceans	275 Hz to 160 kHz	Pygmy and dwarf sperm whales

Hz = hertz; kHz = kilohertz.

Table 4.2-4. Dual Injury Criteria for Marine Mammals Exposed to Impulsive Noise Over a 24-Hour Period (From: Southall et al., 2007; USDOC, NMFS, 2016b)

Marine Mammal Hearing Group	TTS Onset				PTS Onset			
	Southall et al. (2007)		USDOC, NOAA (2016)		Southall et al. (2007)		USDOC, NOAA (2016)	
	SPL_{peak}[1]	SEL_{cum2}	SPL_{peak}[1]	SEL_{cum}[2]	SPL_{peak}[1]	SEL_{cum}[2]	SPL_{peak}[1]	SEL_{cum}[2]
Low-frequency cetaceans	224	183	213	168	230	198	230	183
Mid-frequency cetaceans	224	183	224	170	230	198	230	185
High-frequency cetaceans	224	183	196	140	230	198	202	155
Manatees (from phocid Pinniped criteria [under water])[3]	212	171	212	170	218	186	235	185

NOAA = National Oceanic and Atmospheric Administration; PTS = permanent threshold shift; SEL_{cum} = cumulative sound exposure level; SPL_{peak} = peak sound pressure level; TTS = temporary threshold shift; USDOC = United States Department of Commerce.

[1] Measured in dB re 1 μPa.

[2] Measured in dB re 1 $\mu Pa^2 \cdot s$.

[3] As discussed in **Section 3.3 of Appendix H,** data suggest that manatees have hearing capabilities similar to phocid seals, except perhaps at the lowest frequencies, with functional hearing between approximately 250 hertz and 80 kilohertz. Based on these data, the extrapolation of dual injury criteria for some pinnipeds (phocid seals) exposed to impulsive noise to manatees, where information is lacking, would seem reasonable and so are used here.

Table 4.2-5. Existing and Proposed Injury and Behavior Exposure Criteria for Cetaceans and Manatees Exposed to Pulsed Sounds

Group	Level A (Injury)		Level B (Behavior)	
	(*Federal Register,* 2000c) SPL_{rms}[1]	Southall et al. (2007) SEL[2]	(*Federal Register,* 2000c) SPL_{rms}[1]	Southall et al. (2007) Single Pulse, SPL_{rms}[1]
Cetaceans	180	198	160	230
Manatees (based on Pinniped criteria)[3]	190	186	160	218

FR = *Federal Register*; NMFS = National Marine Fisheries Service; SEL = sound exposure level; SPL_{rms} = root mean square sound pressure level; USDOC = United States Department of Commerce.

Note: Current regulatory thresholds are shaded.

[1] Measured in dB re 1 µPa.

[2] Measured in dB re 1 $\mu Pa^2 \bullet s$.

[3] As discussed in **Section 3.3 of Appendix H,** data suggest that manatees have hearing capabilities similar to phocid seals, except perhaps at the lowest frequencies, with functional hearing between approximately 250 hertz and 80 kilohertz. Based on these data, the extrapolation of behavior and injury exposure criteria for pinnipeds to manatees, where information is lacking, would seem reasonable and so are used here.

Table 4.2-6. Density Ratios for Each of the Modeling Zones and Seasonal Restrictions/Closure Areas[1]

Species Name	Zone 1			Zone 2	Zone 3	Zone 4			Zone 5	Zone 7
	EPA Closure Density Ratio	Coastal Closure Density Ratio	Combined EPA and Coastal Closures	Coastal Closure Density Ratio	Coastal Closure Density Ratio	EPA Closure Density Ratio	Dry Tortugas Closure Density Ratio	Dry Tortugas and EPA Closure Density Ratio	CPA Closure Density Ratio	CPA Closure Density Ratio
Atlantic spotted dolphin	1.024	1.093	1.119	1.189	1.098	0.988	1.001	1.065	1.304	1.000
Beaked whales (Cuvier/Blainville/Gervais)	0.585	1.103	0.645	1.222	1.000	1.234	0.652	0.827	0.982	0.974
Common bottlenose dolphin	1.051	0.932	0.979	0.919	0.944	0.974	0.868	0.803	0.892	0.982
Bryde's whale	0.442	1.106	0.489	1.191	0.937	0.584	1.170	0.625	1.075	0.953
Clymene dolphin	0.258	1.105	0.285	1.190	0.800	1.191	1.126	1.429	1.094	0.989
False killer whale	0.504	1.106	0.557	1.163	1.059	0.994	0.999	0.978	0.990	1.000
Fraser's dolphin	0.504	1.106	0.557	1.163	1.059	0.994	0.999	0.978	0.990	1.000
Killer whale	0.753	1.094	0.824	1.156	1.074	1.151	0.904	0.986	0.983	1.015
Kogia (dwarf, pygmy sperm whale)	0.500	1.106	0.553	1.172	0.987	1.155	0.820	0.978	0.889	0.994
Melon-headed whale	0.569	1.106	0.629	1.184	1.008	1.219	1.033	1.313	0.965	0.943
Pantropical spotted dolphin	0.532	1.106	0.588	1.172	1.005	1.206	0.782	0.979	0.886	1.002
Pygmy killer whale	0.456	1.106	0.504	1.179	1.020	1.209	0.839	1.039	0.970	0.999
Risso's dolphin	0.396	1.106	0.438	1.166	0.977	1.153	0.681	0.756	0.809	1.022
Rough-toothed dolphin	0.962	1.019	0.980	1.026	1.008	1.068	0.948	0.992	1.019	0.991
Short-finned pilot whale	0.282	1.102	0.311	1.188	0.944	1.259	0.825	1.158	1.094	0.980
Sperm Whale	0.400	1.107	0.443	1.178	1.000	1.246	0.772	1.022	0.827	0.988
Spinner dolphin	0.587	1.106	0.649	1.190	0.799	1.159	0.965	1.199	0.157	0.848
Striped dolphin	0.191	1.106	0.211	1.162	1.047	1.160	1.250	1.542	0.715	0.954

Color Code	0.15	0.31	0.47	0.63	0.79	0.95	1.11	1.27	1.43	1.59

CPA =Central Planning Area; EPA = Eastern Planning Area.

[1] The color coding ranges from a 1.59x (159%) increase in density estimates (dark orange) to a 0.15x (15%) reduction of density estimates (medium blue). Cells that are white are near unity (1.0x or 100%), indicating little or no change from the original density estimate.

Table 4.3-1. Sea Turtles Occurring in the Area of Interest

Scientific Name	Common Name	ESA Status[1]	Occurrence in the AOI	Life Stage	States with Nesting Reported in the AOI	Nesting References	ESA-Designated Critical Habitat in the AOI
Caretta caretta	Loggerhead turtle	E, T[2]	TX – FL	All	FL, AL, MS, TX	Hoggard (1991); Conant et al. (2009); Kraft (2012); Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute (2015)	Yes
Chelonia mydas	Green turtle	T[3]	TX – FL	All	FL, AL (rare), TX (rare)	FWC (2015a); FWC (2015b); USDOI, NPS (2015); Sea Turtle Inc. (2015); USDOI, FWS (2015)	No
Eretmochelys imbricata	Hawksbill turtle	E	TX – FL	All	FL (rare)	USDOC, NMFS and USDOI, FWS (2013)	No
Lepidochelys kempii	Kemp's ridley turtle	E	TX – FL	Juveniles and adults	FL, AL (rare), TX	USDOI, FWS (2008b); USDOC, NMFS et al. (2011)	No
Dermochelys coriacea	Leatherback turtle	E	TX – FL	All	FL	FWC (2015c)	No

AL = Alabama; AOI = Area of Interest; ESA = Endangered Species Act; FL = Florida; FWC = Florida Fish and Wildlife Conservation Commission; FWS = Fish and Wildlife Service; MS = Mississippi; NMFS = National Marine Fisheries Service; NPS = National Park Service; TX = Texas; USDOC = United States Department of Commerce; USDOI = United States Department of the Interior.

[1] Endangered Species Act Status: E = endangered; T = threatened.

[2] Nine distinct population segments (DPSs) of the loggerhead turtle are currently listed as endangered and threatened. Loggerhead turtles occurring in the Area of Interest are part of the Northwest Atlantic Ocean DPS, which is listed under the ESA as threatened *(Federal Register*, 2011b*)*. Critical habitat was established for the Northwest Atlantic Ocean DPS in 2014; in the Area of Interest, loggerhead critical habitat for the Northwest Atlantic Ocean DPS includes nearshore reproductive (in State waters) and *Sargassum* habitats *(Federal Register*, 2014b*)*.

[3] On April 6, 2016, NMFS published a final rule to list 11 distinct population segments (DPSs) of the green turtle and to revise current listings under the ESA (*Federal Register,* 2016d). The North Atlantic DPS, which includes green turtles found in the Gulf of Mexico, is listed as threatened.

Table 4.4-1. Hard Bottom Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (Modified from: GMFMC, 2004)

Family Name	Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
Triggerfishes (*Balistidae*)	Gray triggerfish (*Balistes capriscus*)	Pelagic, occur in upper water column, associated with *Sargassum* and flotsam	Associated with *Sargassum*, flotsam, or found in mangrove estuaries	Offshore in water depths greater than 10 m (33 ft); associated with natural and artificial reefs	Spawn around natural and artificial reefs in water depths greater than 10 m (33 ft); late spring and summer
Jacks (*Carangidae*)	Greater amberjack (*Seriola dumerili*)	Pelagic, associated with floating plants and debris	Pelagic, associated with floating plants and debris	Pelagic and epibenthic, occurring over reefs, wrecks, and around buoys; to water depths of 400 m (1,312 ft)	Little information; spawn in the GOM from May to July
	Lesser amberjack (*Seriola fasciata*)	Pelagic, associated with floating plants and debris	Occur offshore in late summer and fall in the GOM. Associated with *Sargassum* and flotsam	Offshore year round in the GOM; associated with oil and gas platforms and irregular bottom features	Spawn offshore September to December and February to March; likely near oil and gas platforms and irregular bottom features
	Almaco jack (*Seriola rivoliana*)	Unknown	Associated with *Sargassum* in open waters and off barrier islands	Offshore, associated with oil and gas platforms in the GOM	Spawning thought to occur from spring through fall
	Banded rudderfish (*Seriola zonata*)	Pelagic, associated with floating plants and debris	Offshore, associate with jellyfish and floating plants	Pelagic or epibenthic, coastal waters over continental shelf	Spawn offshore in the eastern GOM, Yucatan Channel, and Straits of Florida
Wrasses (*Labridae*)	Hogfish (*Lachnolaimus maximus*)	N/A	Shallow seagrass beds of Florida bay	Moderate- to high-relief hard bottom structure in shelf waters, coral reefs and rocky flats	N/A

Table 4.4-1. Hard Bottom Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Family Name	Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
Snappers (*Lutjanidae*)	Queen snapper (*Etelis oculatus*)	Pelagic, offshore	N/A	Deepwater species in the southern GOM; associate with rocky bottoms and ledges between 135- and 450-m (443- and 1,476-ft) water depth	N/A
	Mutton snapper (*Lutjanus analis*)	Shallow continental shelf waters	Shallow seagrass beds in tidal creeks and bights surrounded by mangroves; protected bays	Offshore reef areas, deep barrier reefs	Spawn on steep drop offs near reef areas
	Schoolmaster (*Lutjanus apodus*)	Pelagic	Shallow and offshore habitats, seagrass beds, mangrove habitats, congregate around jetties, inshore and offshore rocky and coral reefs	Coastal waters out to 90-m (295-ft) water depth; occur over rock, vegetated sand, inshore and offshore reefs, and mud	Offshore reefs
	Blackfin snapper (*Lutjanus buccanella*)	Present year-round in shelf edge waters over spawning areas	Shallow hard bottom areas from 12- to 40-m (39- to 131-ft) water depth	Throughout GOM; shelf edge habitats from 40- to 300-m (131- to 984-ft) water depth	Year round with spring and fall peaks, presumably near shelf edge habitats
	Red snapper (*Lutjanus campechanus*)	Offshore in summer and fall in shelf waters from 17- to 183-m (56- to 600-ft) water depth	Associated with structure, also abundant over sand and mud bottom; from 20- to 46-m (66- to 151-ft) water depth	Throughout GOM; occur in submarine gullies and depressions, over coral reefs, rock outcroppings, and gravel bottom; 7- to 146-m (23- to 479-ft) water depth	Offshore from May to October in 18- to 37-m (59- to 121-ft) water depth over fine sand bottom away from reefs
	Cubera snapper (*Lutjanus cyanopterus*)	Presumed in June and July as a result of spawning aggregations, open water near reefs and wrecks	Streams, canals, seagrass beds, mangrove areas, and lagoons	Most common off southwestern Florida; shallow and deep reefs and wrecks; mangroves; up to 85-m (279-ft) water depth	Spawn in June and July near wrecks and deep reefs in 67- to 85-m (220- to 279-ft) water depth

Table 4.4-1. Hard Bottom Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Family Name	Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
Snappers (*Lutjanidae*) (continued)	Gray snapper (*Lutjanus griseus*)	Occur June through August in offshore shelf waters and near coral reefs; move to estuarine habitats and seagrass beds	Marine, estuarine, and riverine dwellers, prefer *Thalassia* sp. grass beds, marl bottoms, seagrass meadows, and mangrove roots	Estuaries and shelf waters 180-m (591-ft) water depth; demersal and mid-water dwellers; marine, estuarine, and riverine dwellers	Spawn offshore around reefs and shoals from June to August
	Dog snapper (*Lutjanus jocu*)	Pelagic	Shallow water seagrass beds; coastal waters, estuaries, or rivers; mangrove roots, jetties, and pilings	From shallow vegetated areas to deep reefs to 150-m (492-ft) water depth; coral reefs	Spawning aggregations near reefs from 15- to 30-m (49- to 98-ft) water depth
	Mahogany snapper (*Lutjanus mahogoni*)	Pelagic	N/A	Throughout GOM; shallow water down to 30-m (98-ft) water depth; rocky bottoms and reefs	Multiple spawnings, spring and fall
	Lane snapper (*Lutjanus synagris*)	Offshore, on shelf	Mangrove and grassy estuarine areas; shallow areas with sandy and muddy bottoms; grass flats, reefs, and soft bottom to 20-m (60-ft) water depth	Offshore from 4- to 132-m (13- to 433-ft) water depth; occur on sand bottom, natural channels, banks, and artificial reefs and structures	Offshore from March through September
	Silk snapper (Lutj*anus vivanus*)	N/A	Shallow water	Throughout GOM; near the edge of continental and island shelves, common between 90- and 200-m (295- and 656-ft) water depth	Throughout the year with peak spawning from July to August
	Yellowtail snapper (*Ocyurus chrysurus*)		Nearshore areas over vegetated sandy substrate, muddy shallow bays, *Thalassia* sp. beds and mangrove roots, shallow reef areas	Throughout shelf area of GOM, shallow water to 183-m (600-ft) water depth; semi-pelagic wanderers over reef habitat, irregular bottom, coral reefs, banks, and shelves	February through October in offshore areas

Table 4.4-1. Hard Bottom Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Family Name	Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
Snappers (*Lutjanidae*) (continued)	Wenchman (*Pristipomoides aquilonaris*)	Presumed in warmer months along mid to outer shelf water	N/A	Throughout GOM; hard bottom habitats of mid to outer shelf; 19- to 378-m (62- to 1,240-ft) water depth	Presumed warmer months along deep slopes between 80- and 200-m water depth
	Vermilion snapper (*Rhomboplites aurorubens*)	N/A	Reefs, underwater structures and hard bottom habitats 20- to 200-m (66- to 656-ft) water depth	Throughout shelf area of the GOM, demersal, over reefs and rocky bottom from 20- to 200-m (66- to 656-ft) water depth	April to September in offshore areas
Tilefishes (*Malacanthidae*)	Goldface tilefish (*Caulolatilus chrysops*)	N/A	N/A	N/A	N/A
	Blackline tilefish (*Caulolatilus cyanops*)	N/A	N/A	N/A	N/A
	Anchor tilefish (*Caulolatilus intermedius*)	N/A	N/A	Common in the northern and western GOM; irregular bottom, troughs, terraces, sand, mud and rubble, shell hash	N/A
	Blueline tilefish (*Caulolatilus microps*)	Pelagic, offshore	N/A	Eastern and southeastern GOM; epibenthic browsers	N/A
	Golden tilefish (*Lopholatilus chamaeleonticeps*)	Pelagic	Pelagic to benthic; burrow and occupy shafts in the substrate	Throughout the GOM; demersal from 80- to 450-m (262- to 1,476-ft) water depth; rough bottom, steep slopes; burrow	From March to November throughout range

Table 4.4-1. Hard Bottom Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Family Name	Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
Groupers (*Epinephelidae*)	Rock hind (*Epinephelus adscensionis*)	Pelagic, offshore	Early juveniles in shallow waters	Shallow hard bottom, coral and rock reefs, rock piles, oil and gas platforms, steep crevices and ledges; 2- to 100-m (7- to 328-ft) water depth	January to June in Florida middle grounds in spawning aggregations
Groupers (*Epinephelidae*) (continued)	Speckled hind (*Epinephelus drummondhayi*)	Pelagic, offshore	Found in shallow end of depth range	North and eastern GOM on offshore hard bottom habitats, rocky bottom, high and low profile bottom; 25- to 183-m (82- to 600-ft) water depth	Deeper portion of depth range, greater than 146-m (479-ft) depth along shelf edge, April to May, July to September
	Yellowedge grouper (*Hyporthodus flavolimbatus*)	Pelagic, offshore	Inhabit burrows	Throughout deep waters of the GOM; high-relief hard bottom, rocky out croppings, inhabit burrows; 35- to 370-m (115- to 1,214-ft) water depth	Form spawning aggregations, peaks May to September
	Red hind (*Epinephelus guttatus*)	Pelagic, settle and develop in shallow inshore areas	Patch reefs, coral, and limestone rock	Occupy reefs, stony coral, holes, and crevices, sandy bottoms with coral patches; 18- to 110-m (59- to 361-ft) water depth	Late spring and summer on Florida Middle Grounds along seaward side of submerged ridges
	Goliath grouper (*Epinephelus itajara*)	Offshore, late summer, early fall	Bays and estuaries, inshore grassbeds, canals, mangroves, ledges, reefs, and holes	Shallow waters of GOM to 95-m (312-ft) water depth; inshore around docks, bridges, jetties, reef crevices, offshore ledges, and wrecks	June to December around offshore structures, wrecks, and patch reefs

Table 4.4-1. Hard Bottom Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Family Name	Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
	Red grouper (*Epinephelus morio*)	Pelagic as larvae, become benthic by 2-mm (0.8-in) standard length	Inshore hard bottom around 50-m (164-ft) water depth, crevices, grass bets, rock formations, shallow reefs	Demersal throughout the GOM from 3- to 200-m (10- to 656-ft) water depth; rocky outcrops, wrecks, reefs, ledges, crevices and caverns of rock bottom, and live bottom	Spawn on Florida banks during April and May, do not aggregate, near low-relief habitats often near solution holes
	Misty grouper (*Hyporthodus mystacinus*)	N/A	Shallower water than adults	Offshore throughout the GOM; hard bottom slope and shelf substrates, high-relief rocky ledges and pinnacles, 100- to 400-m (328- to 1,312-ft) water depth	April through July
Groupers (*Epinephelidae*) (continued)	Warsaw grouper (H*yporthodus nigritus*)	Pelagic, offshore	Shallow nearshore habitats, bays	Throughout GOM; hard bottom, rocky, high profile, steep cliffs, rocky ledges, from 40- to 525-m (131- to 1,722-ft) water depth	Likely late summer
	Snowy grouper (*Epinephelus niveatus*)	Pelagic, offshore	Shallow, nearshore reefs	Deep water, rocky bottom, offshore around boulders and ridges	April to July off of Florida keys; May to August west Florida
	Nassau grouper (Epinephelus striatus)	December to February, nearshore, 0.8 to 16 km (0.5 to 10 mi) from shore	Inshore seagrass beds, macroalgal mats, tilefish mounds, and small coral clumps	Reefs and crevice caves down to 100-m (328-ft) water depth; primarily along the Florida Keys' reef tract	Spawning offshore reefs and hard bottom outside of the GOM
	Marbled grouper (*Epinephelus inermis*)	N/A	N/A	Nearshore and offshore reefs, 3 to 213 m (10 to 699 ft)	N/A

Table 4.4-1. Hard Bottom Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Family Name	Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
	Black grouper (*Mycteroperca banaci*)	Pelagic, offshore	Shallow water reefs, rocky bottom, patch reefs, muddy bottom, mangrove lagoons, and estuaries	Found along eastern GOM, rare in western GOM, demersal from shore to 150-m (492-ft) water depth; wrecks, rocky coral reefs, irregular bottom, ledges	Late winter through spring and summer, aggregations observed in Florida keys at 18- to 28-m (59- to 92-ft) water depth
	Yellowmouth grouper (*Mycteroperca interstitialis*)	Pelagic, offshore	Mangrove-lined lagoons	Campeche banks, west coast of Florida, Texas Flower Garden Banks, rocky bottoms, and coral reefs	Spring and summer
	Gag grouper (*Mycteroperca microlepis*)	Pelagic, greatest offshore abundance on west Florida shelf December through April	Move through inlets into coastal lagoons, high salinity estuaries in April and May, become benthic and settle into grass flats and oyster beds; later juveniles move to shallow reef habitats from 1- to 50-m (3- to 164-ft) water depth	Demersal; hard bottom substrates, offshore reefs and wrecks, coral and live bottom, depressions, and ledges	Aggregate in 50- to 120-m (164- to 394-ft) water depth along shelf edge breaks from December to April on the west Florida shelf
Groupers (*Epinephelidae*) (continued)	Scamp (*Mycteroperca phenax*)	Pelagic; occur in spring	Inshore hard bottom and reefs, 12- to 33-m (39- to 108-ft) water depth	Demersal, throughout shelf areas of GOM, ledges, high relief hard bottom in water depth from 12 to 189 m (39 to 620 ft)	Late February to early June in aggregations, shelf edge, often spawn on Oculina formations
	Yellowfin (*Mycteroperca venosa*)	N/A	Shallow seagrass beds, move to deeper rocky bottoms with age	Uncommon in the GOM, primarily southern GOM, reef ridge and high-relief spur and groove reefs	March to August in the eastern GOM

ft = feet; GOM = Gulf of Mexico; in = inches; km = kilometers; m = meters; mi = miles; mm = millimeters; N/A = not available.

Table 4.4-2. Coastal Migratory Pelagic Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (Modified from: GMFMC, 2004)

Species Name	Eggs and Larvae	Juvenile	Adult	Spawning
King mackerel (*Scomberomorus cavalla*)	Pelagic eggs offshore over areas of 35- to 180-m (115- to 591-ft) water depth, middle and outer continental shelf	Inshore to the middle shelf	Throughout the GOM, over reefs and coastal waters, generally in less than 80-m (262-ft) water depth	Over the outer continental shelf from May to October
Spanish mackerel (*Scomberomorus maculatus*)	Pelagic eggs over the inner continental shelf at water depths less than 50 m (164 ft) in spring and summer	Estuarine and coastal waters	Throughout the GOM, inshore coastal waters, may enter estuaries, to water depths of 75 m (246 ft)	Over inner continental shelf from May to September
Cobia (*Rachycentron canadum*)	Eggs drift in the top meter of the water column, larvae are found in offshore waters	Coastal and offshore waters	Coastal and offshore waters from bays and inlets to the continental shelf; 1- to 70-m (3- to 230-ft) water depth	In coastal waters from April through September

ft = feet; GOM = Gulf of Mexico; m = meters.

Table 4.4-3. Highly Migratory Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest

Species Name	Eggs and Larvae	Juvenile	Adult	Spawning/Reproduction
Albacore tuna (*Thunnus alalunga*)	N/A	N/A	Epipelagic, oceanic, generally found in surface waters, often associated with *Sargassum* communities and debris	N/A
Bigeye tuna (*Thunnus obesus*)	N/A	School near sea surface with other tuna species, associated with *Sargassum* communities and floating debris	N/A	N/A
Bluefin tuna (*Thunnus thynnus*)	Over continental shelf	Over continental shelf during summer, farther offshore in winter	Epipelagic, oceanic, generally found in surface waters, often associated with *Sargassum* communities and debris	Annual spawn May to June in GOM
Skipjack tuna (*Katsuwonus pelamis*)	N/A	N/A	Epipelagic, oceanic, as deep as 260 m (853 ft) during the day, associate with drifting objects, whales, sharks, and other tuna species	Opportunistic spawning throughout year, most spawning from April to May
Yellowfin tuna (*Thunnus albacares*)	Limited to water temperature greater than 24°C (75°F) and salinity greater than 33 ppt	Nearer to shore than adults	Epipelagic, oceanic, mix with skipjack and bigeye tuna species, occur beyond 500-fathom isobath in the upper 100 m (328 ft) of the water column	Spawning throughout year with peaks in the summer
Swordfish (*Xiphias gladius*)	Present year round in the eastern GOM, also present in the western GOM from March to May and September to November	N/A	Epipelagic to mesopelagic, diurnal vertical migration	N/A
Blue marlin (*Mokaira nigricans*)	Some larvae present in the GOM	N/A	Epipelagic and oceanic	N/A

Table 4.4-3. Highly Migratory Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Species Name	Eggs and Larvae	Juvenile	Adult	Spawning/Reproduction
White marlin (*Tetrapturus albidus*)	N/A	Off west coast of Florida between the 200- and 2,000-m (656- to 6,562-ft) isobaths; off coast of Texas to 50-m (164-ft) isobath	Epipelagic and oceanic, usually occur above thermocline in deep ≥100 m [328 ft]) water with surface temp ≥22°C (72°F) and salinities of 35-37; usually in upper 30 m (98 ft) of the water column	N/A
Roundscale spearfish (*Tetrapturus georgii*)	N/A	N/A	Epipelagic and oceanic	N/A
Sailfish (*Istiophorus platypterus*)	Larvae found in offshore waters from March to October	In all waters of the GOM from the 200- to 2,000-m (656- 6,562-ft) isobath or EEZ boundary	Epipelagic, coastal, and oceanic; usually found above thermocline at a temperature range of 21°C to 28°C (70°F to 83°F); often move to inshore waters and over the shelf edge	Occurs in shallow waters around Florida beyond the 100-m (328-ft) isobath, from April to September
Longbill spearfish (*Tetrapturus pfluegeri*)	N/A	N/A	Relatively rare in the GOM; epipelagic, oceanic species inhabiting waters above the thermocline; generally found in offshore waters	N/A
*Dolphinfish (*Coryphaena hippurus*)	Larvae abundant in *Sargassum* communities, prominent near the Mississippi River delta	Closely associated with *Sargassum* communities and floating debris	Oceanic pelagic; both offshore and coastal inshore; out to 1,800-m (5,906-ft) water depth, common between 40- and 200-m (131- and 656-ft) water depth, closely associated with *Sargassum* communities	Multiple spawning events throughout year; spring and early fall in the GOM; offshore, continental shelf, and upper slope waters
*Wahoo (*Acanthocybium solandri*)	Oceanic and shelf waters	Oceanic and shelf waters, associated with *Sargassum* communities and flotsam	Oceanic and shelf waters, associated with *Sargassum* communities and flotsam	N/A

°C = degrees Celsius; °F = degrees Fahrenheit; EEZ = Exclusive Economic Zone; ft = feet; GOM = Gulf of Mexico; m = meters; N/A = not available; ppt = parts per thousand.

* Species not managed in the GOM by the U.S. Dept. of Commerce, National Marine Fisheries Service.

Table 4.4-4. Shark Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest

Shark Group	Species Name	Neonates/Juvenile	Adult	Reproduction
Small Coastal	Angel shark (*Squatina dumeril*)	Shallow coastal waters	Shallow coastal waters	Up to 16 pup litters
	Bonnethead shark (*Sphyrna tiburo*)	N/A	Shallow coastal waters, sandy and muddy bottoms	Annual reproductive cycle, 8-2 pup litters
	Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)	Shallow coastal waters	Shallow coastal waters	Late June, 4-7 pup litters
	Blacknose shark (*Carcharhinus acronotus*)	Shallow coastal waters	Shallow coastal waters	3-6 pup litters
	Finetooth shark (*Carcharhinus isodon*)	Shallow coastal waters, muddy bottom	Shallow coastal waters	Biennial reproductive cycle, 2-6 pup litters
Large Coastal	Great hammerhead shark (*Sphyrna mokarran*)	Shallow coastal waters	Open ocean and shallow coastal waters	Biennial reproductive cycle, 20-40 pup litters
	Scalloped hammerhead shark (*Sphyrna lewini*)	Shallow coastal waters	Schooling, open ocean and shallow coastal waters	Annual reproductive cycle, 15-31 pup litters
	White shark (*Carcharodon carcharias*)	N/A	N/A	N/A
	Nurse shark (*Ginglymostoma cirratum*)	Shallow *Thalassia* beds and shallow coral reefs, mangrove islands	Littoral waters, congregates in shallow water	June to July in the shallow waters of the Florida Keys, 20-30 pup litters
	Bignose shark (*Carcharhinus altimus*)	N/A	Deepwater species, continental shelf	N/A
	Blacktip shark (*Carcharhinus limbatus*)	Year-round in shallow coastal waters, seagrass beds, and muddy bottoms	Shallow coastal waters and offshore surface waters of continental shelf, throughout the GOM	1-8 pup litters
	Bull shark (*Carcharhinus leucas*)	Low salinity estuaries of the Gulf Coast	Shallow coastal waters and often fresh water	Likely biennial reproductive cycle
	Caribbean reef shark (*Carcharhinus perezi*)	N/A	Shallow coastal waters, bottom-dwelling, near coral reefs	Biennial reproductive cycle, 4-6 pup litters
	Dusky shark (*Carcharhinus obscurus*)	Shallow coastal waters, inlets, and estuaries	Migratory, inshore and outer continental shelf waters	6-14 pup litters

Table 4.4-4. Shark Species and Life Stages with Essential Fish Habitat Identified within the Area of Interest (continued)

Shark Group	Species Name	Neonates/Juvenile	Adult	Reproduction
Large Coastal (Continued)	Lemon shark (*Negaprion brevirostris*)	Shallow coastal water, near mangrove islands	Shallow coastal waters, around coral reefs	Biennial reproductive cycle, 5-17 pup litters
	Night shark (*Carcharhinus signatus*)	N/A	Depths >275-366 m (902-1,201 ft)during the day and 183 m (600 ft) at night	N/A
	Sandbar shark (Carcharhi*nus plumbeus*)	Shallow coastal waters	Shallow coastal waters	Biennial reproductive cycle, March to July, 1-14 pup litters
	Silky shark (*Carcharhinus falciformis*)	Offshore and shallow coastal waters	Offshore, epipelagic	10-14 pup litters
	Spinner shark (*Carcharhinus brevipinna*)	Shallow coastal waters, muddy bottom less than 5-m (16-ft) water depth, seagrass beds	Migratory, coastal-pelagic	Biennial reproductive cycle, 6-12 pup litters
	Tiger shark (*Galeocerdo cuvier*)	N/A	Shallow coastal waters and deep oceanic waters	35-55 pup litters
	Whale shark (*Rhincodon typus*)	N/A	Pelagic waters	N/A
Pelagic	Longfin mako shark (*Isurus paucus*)	N/A	Deepwater species	2-8 pup litters
	Porbeagle shark (*Lamna nasus*)	N/A	Deepwater species	N/A
	Shortfin mako shark (*Isurus oxyrinchus*)	N/A	Oceanic waters	Biennial reproductive cycle, 12-20 pup litters
	Oceanic whitetip shark (*Carcharhinus longimanus*)	Likely offshore over continental shelf	Oceanic waters	Likely biennial, 2-10 pup litters
	Bigeye thresher shark (*Alopias superciliosus*)	N/A	Deep water	2 pup litters
	Common thresher shark (*Alopias vulpinus*)	N/A	Coastal and oceanic waters	Birth annually from March to June, 4-6 pup litters
	Smooth dogfish (*Mustelus canis*)	N/A	Continental and insular shelves from shallow inshore waters to a maximum water depth of 579 m (1,900 ft)	4-20 pup litters

ft = feet; GOM = Gulf of Mexico; m = meters; N/A = not available.

Table 4.5-1. Topographic Features (Banks) of the Gulf of Mexico

Shelf-Edge Banks		Mid-Shelf Banks		South Texas Banks	
Western Planning Area	Central Planning Area	Western Planning Area	Central Planning Area	Western Planning Area	Central Planning Area
• Appelbaum Bank • East Flower Garden Bank • MacNeil Bank • Rankin Bank • West Flower Garden Bank	• Alderdice Bank • Bouma Bank • Bright Bank • Diaphus Bank • Elvers Bank • Ewing Bank • Geyer Bank • Jakkula Bank • McGrail Bank • Parker Bank • Rezak Bank • Sidner Bank • Sweet Bank	• 29 Fathom Bank • 32 Fathom Bank • Claypile Lump • Coffee Lump • Stetson Bank	• Fishnet Bank • Sackett Bank • Sonnier Bank	• Aransas Bank • Baker Bank • Big Dunn Bar • Blackfish Ridge • Dream Bank • Hospital Bank • Mysterious Bank • North Hospital Bank • Small Dunn Bar • South Baker Bank • Southern Bank	• None

Table 4.6-1. Families of Seabirds, Waterfowl, and Shorebirds Occurring in the Area of Interest

Order	Family	General Ecology	General Distribution/Migration
Seabirds			
Charadriiformes	Laridae (Gulls, terns, and phalaropes)	Primarily inhabit coastal or inshore waters. Conspicuous and gregarious in nature. Nest colonially on the ground. Most feed on small fishes with some foraging on insects and crabs. Terns typically forage by hovering above the water's surface and plunge-diving head first into the water from flight. Gulls seldom dive and prefer open areas. Highly adaptable.	Found predominantly along the coast but also inland in both populated and open areas. Found in the Arctic, northern Canada, and northern U.S., with some species migrating south to Mexico and South America.
	Rhyncopidae (Skimmers)	Primarily inhabit coastal and inshore waters. Nest colonially on sandy beaches. Forage for small fishes mainly at night, flying over shallow water with their elongated lower mandible below the water surface.	Year-round coastal distribution throughout the AOI.
Gaviiformes	Gaviidae (Loons)	Medium to large birds that capture prey (fishes, crustaceans, and other aquatic organisms) by diving and pursuing prey underwater. Habitat includes tundra lakes and ponds in summer and coastal waters in winter. Nest on banks of ponds or lakes and winter on the open water.	Holarctic in the summer in freshwater areas. Highly migratory to more marine areas in northern Mexico for winter.
Pelecaniformes	Pelecanidae (Pelicans)	Very large, social water birds that swim buoyantly and feed predominantly on fishes and crustaceans in primarily shallow estuarine waters, occasionally up to 40 miles (64 kilometers) from shore. Plunge bill-first into the water while fishing and often fly just above the water surface looking for prey. Nesting occurs usually on coastal islands, on the ground, or in small bushes and trees.	Found in freshwater and marine coastal waters. Breeding range for the brown pelican extends along Florida to Louisiana. The primary winter range for the white pelican includes Florida and the Gulf Coast. Breeding activities extremely sensitive to human activity.
	Phaethontidae (Tropicbirds)	A mainly pelagic, highly aerial, solitary seabird found far offshore over and resting on warm water. Feed by plunge-diving. Nest in small to large colonies on tropical islands in rocky crevices, holes, or caves.	Distributed in tropical and subtropical waters. Occasionally found within the north Gulf Coast. Breed in Bermuda.

Table 4.6-1. Families of Seabirds, Waterfowl, and Shorebirds Occurring in the Area of Interest (continued)

Order	Family	General Ecology	General Distribution/Migration
Pelecaniformes (Continued)	Phalacrocoracidae (Cormorants)	Large, gregarious water birds found in coastal bays, marine islands, and seacoasts usually within sight of land. Some species are found along rocky shores, while others are found in open water. Eat mostly schooling fishes captured by diving.	Migratory and dispersive. Found along temperate and tropical marine coasts. Cosmopolitan. Northern coastal populations migrate southward for the nonbreeding winter season throughout the Gulf of Mexico and are year-round residents along coastal Florida.
	Sulidae (Boobies)	Gregarious and colonial breeders in marine environment. Fish by plunging from air for fishes and squids. Boobies land-roost. Nest in colonies on islands and rock stacks.	Tropical, subtropical, and temperate oceans. Oceanic, with some found well offshore while others stay close to shore. Occasionally found off the Gulf Coast.
	Fregatidae (Frigatebirds)	Found in offshore and coastal waters. Feeding habits are pelagic and include snatching prey from the sea surface or beach, or in some cases by robbing other seabirds of their catch (kleptoparasitism).	One species (magnificent frigatebird [*Fregatta magnificens*]) occurs within the AOI with breeding range along Florida to Louisiana.
Podicipediformes	Podicipedidae (Grebes)	Found in ponds, lakes, salt bays, and nearshore habitats. Feed by diving. Spend virtually all their time in the water and are clumsy on land.	Cosmopolitan. Migrate from inland breeding areas to temperate nearshore areas. Breed on fresh water.
Procellariiformes	Hydrobatidae (Storm-petrels)	Medium to large seabirds found over the open ocean and come to land only for nesting. Colonial breeders. Feed on plankton, crustaceans, and small fishes. Nest on sea islands.	Breed November-May in the Antarctic and are transequatorial migrants offshore at higher latitudes, Florida and Alabama.
	Procellariidae (Shearwaters)	Highly pelagic and return to land only for breeding. Feed on fishes, squids, and crustaceans. Colonial breeders on marine islands.	Transequatorial. Most breed in the northern Atlantic and migrate south in summer as far as South America. Found at the sea along the Gulf Coast.
Waterfowl			
Anseriformes	Anatidae (Aythyinae) (Diving ducks)	Mainly in freshwater and estuarine environments but species such as the greater scaup become marine during the winter. Breed in marshes. All dive for food that includes aquatic vegetation, mollusks, and crustaceans.	Arctic, circumpolar during nesting season. Migrate into temperate areas in winter. Frequent inland waters, estuaries and bays, and nearshore waters. Rare to scarce in the Gulf Coast States.
	Anatidae (Merginae) (Sea ducks)	Found in marine environment along the seacoast. Breed in marshes. All dive for food that includes mollusks and crustaceans.	Arctic, circumpolar during nesting season. Most migrate into subarctic and northern temperate areas in winter ,including along the Gulf Coast.

Table 4.6-1. Families of Seabirds, Waterfowl, and Shorebirds Occurring in the AOI (continued)

Order	Family	General Ecology	General Distribution/Migration
Shorebirds			
Charadriiformes	Charadriidae (Plovers)	Wading birds found along mud flats, shores, and beaches that feed on small marine life, insects, and some vegetable matter. Nest singly or in loose colonies.	Arctic, circumpolar. Winter along coastal U.S. and Gulf of Mexico to South America, migrate along the coast.
	Haematopodidae (Oystercatchers)	Large wading birds found along coastal shores and tidal flats. Feed on mollusks, crabs, and marine worms.	Found in localized area along the Gulf Coast States.
	Recurvirostridae (Avocets and stilts)	Slim wading birds found along beaches and mud flats. Feed on insects, crustaceans, and other aquatic organisms. Typically nest on open flats or areas with scattered tufts of grass on islands.	Breed in southwest Canada and make seasonal migration to southern U.S., including the Gulf Coast to Guatemala.
	Scolopacidae (Sandpipers, curlews, godwits, turnstones, and yellowlegs)	Small- to medium-sized wading birds found along mud flats, tidal flats, shores, beaches, and salt marshes. Feed on insects, crustaceans, mollusks, and worms.	Cosmopolitan. Migrate along the coast from northern North America south to the Gulf of Mexico and as far as southern South America.

AOI = Area of Interest.

Data from: Peterson, 1980; Harrison, 1983, 1987; Sibley, 2000; Morrison et al., 2001; NatureServe, InfoNatura, 2013.

Table 4.7-1. National System Marine Protected Areas Within or Partially Within the Area of Interest (From: USDOC, NOAA, MPA Centers, 2014)

Site	Government Level	Managing Agency	Primary Conservation Focus	Status	Area within AOI (km^2)	Total Area (km^2)	Percentage within AOI
Offshores MPAs							
National Marine Sanctuaries							
Flower Garden Banks NMS	Federal	ONMS	Natural Heritage	Member	145.14	145.14	100
Florida Keys NMS	Federal	ONMS	Natural Heritage	Member	5,664.07	9,824.83	58
Other Federal Fishery Management Areas							
De Soto Canyon Closed Area	Federal	NMFS	Sustainable Production	Eligible	86,854.46	86,854.46	100
East Florida Coast Closed Area	Federal	NMFS	Sustainable Production	Eligible	12.25	102,862.47	0
Florida Middle Grounds HAPC	Federal	NMFS	Natural Heritage	Eligible	1,159.62	1,159.62	100
Closure of the Madison and Swanson Sites	Federal	NMFS	Sustainable Production	Eligible	393.33	393.33	100
McGrail Bank HAPC	Federal	NMFS	Sustainable Production	Eligible	48.20	48.20	100
Pelagic *Sargassum* Habitat Restricted Area	Federal	NMFS	Sustainable Production	Eligible	63.01	491,548.41	0
Pulley Ridge HAPC	Federal	NMFS	Sustainable Production	Eligible	344.14	344.14	100
Reef Fish Longline and Buoy Gear Restricted Area	Federal	NMFS	Sustainable Production	Eligible	177,932.03	177,934.76	100
Reef Fish Stressed Area	Federal	NMFS	Sustainable Production	Eligible	98,554.25	98,557.81	100
Steamboat Lumps	Federal	NMFS	Sustainable Production	Eligible	364.57	364.57	100
Stetson Bank HAPC	Federal	NMFS	Sustainable Production	Eligible	6.02	6.02	100
Tortugas Marine Reserves	Federal	NMFS	Natural Heritage	Eligible	229.40	229.40	100
West and East Flower Garden Banks HAPC	Federal	NMFS	Sustainable Production	Eligible	220.55	220.55	100

Table 4.7-1. National System Marine Protected Areas Within or Partially Within the Area of Interest (continued)

Site	Government Level	Managing Agency	Primary Conservation Focus	Status	Area within AOI (km^2)	Total Area (km^2)	Percentage within AOI
Coastal MPAs							
National Park Service							
Dry Tortugas National Park	Federal	NPS	Natural Heritage	Member	257.98	261.38	99
Everglades National Park	Federal	NPS	Natural Heritage	Member	775.30	6,205.68	12
Gulf Islands National Seashore	Federal	NPS	Natural Heritage	Eligible	222.28	526.60	42
Padre Island National Seashore	Federal	NPS	Natural Heritage	Member	63.96	528.78	12
National Wildlife Refuges							
Anahuac NWR	Federal	FWS	Natural Heritage	Member	0.73	331.34	0
Aransas NWR	Federal	FWS	Natural Heritage	Member	21.82	471.28	5
Breton NWR	Federal	FWS	Natural Heritage	Member	30.45	30.45	100
Cedar Keys NWR	Federal	FWS	Natural Heritage	Member	3.32	3.32	100
Chassahowitzka NWR	Federal	FWS	Natural Heritage	Member	71.54	148.68	48
Crystal River NWR	Federal	FWS	Natural Heritage	Member	3.90	33.84	12
Delta NWR	Federal	FWS	Natural Heritage	Member	10.68	204.75	5
Great White Heron NWR	Federal	FWS	Natural Heritage	Member	837.79	837.79	100
J.N. Ding Darling NWR	Federal	FWS	Natural Heritage	Member	1.10	32.67	3
Key West NWR	Federal	FWS	Natural Heritage	Member	759.69	850.14	89
Laguna Atascosa NWR	Federal	FWS	Natural Heritage	Eligible	7.49	930.95	1
Lower Rio Grande Valley NWR	Federal	FWS	Natural Heritage	Eligible	17.04	12,129.37	0
Lower Suwannee NWR	Federal	FWS	Natural Heritage	Member	55.31	338.99	16
National Key Deer Refuge	Federal	FWS	Natural Heritage	Member	557.08	557.08	100
San Bernard NWR	Federal	FWS	Natural Heritage	Member	0.02	135.60	0
Shell Keys NWR	Federal	FWS	Natural Heritage	Member	0.02	0.02	100
St. Marks NWR	Federal	FWS	Natural Heritage	Member	107.58	446.90	24
St. Vincent NWR	Federal	FWS	Natural Heritage	Member	0.08	49.13	0
Ten Thousand Islands NWR	Federal	FWS	Natural Heritage	Member	18.03	140.36	13
National Estuarine Research Reserves							
Mission-Aransas NERR	Partnership	UTMSI and NOAA	Natural Heritage	Eligible	15.89	748.66	2
Apalachicola NERR	Partnership	FDEP and NOAA	Natural Heritage	Eligible	1.17	951.21	0

Table 4.7-1. National System Marine Protected Areas Within or Partially Within the Area of Interest (continued)

Site	Government Level	Managing Agency	Primary Conservation Focus	Status	Area within AOI (km^2)	Total Area (km^2)	Percentage within AOI
Rookery Bay NERR	Partnership	FDEP and NOAA	Natural Heritage	Member	134.43	388.21	35
State Designated MPAs							
Alligator Harbor Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	1.80	58.04	3
Anclote Key State Park	State, Florida	FDEP	Natural Heritage	Eligible	34.66	49.23	70
Apalachicola Bay Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	0.11	416.16	0
Atchafalaya Delta WMA and Game Preserve	State, Florida	LDWF	Natural Heritage	Eligible	539.51	555.71	97
Bahia Honda State Park	State, Florida	FDEP	Natural Heritage	Eligible	1.98	1.98	100
Big Bend Seagrasses Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	2,676.31	2,746.92	97
Big Bend WMA	State, Florida	FWC	Sustainable Production	Eligible	0.24	269.97	0
Caladesi Island State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.33	9.96	3
Camp Helen State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.10	0.74	14
Cape Romano – Ten Thousand Islands Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	68.85	207.55	33
Cayo Costa State Park	State, Florida	FDEP	Natural Heritage	Eligible	6.48	9.69	67
Cedar Key Scrub State Reserve	State, Florida	FDEP	Natural Heritage	Eligible	5.26	19.81	27
Cedar Key Scrub WMA	State, Florida	FWC	Sustainable Production	Eligible	4.84	20.19	24
Chassahowitzka WMA	State, Florida	FWC	Sustainable Production	Eligible	8.65	135.78	6
Coupon Bight Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	18.65	18.65	100
Crystal River Preserve State Park	State, Florida	FDEP	Natural Heritage	Eligible	27.67	112.91	25
Curry Hammock State Park	State, Florida	FDEP	Sustainable Production	Eligible	3.91	3.91	100
Don Pedro Island State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.02	1.02	2
Dr. Julian G. Bruce St. George Island State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.38	8.17	5
Econfina River State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.75	18.34	4
Estero Bay Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	0.45	43.26	1
Florida Keys Wildlife and Environmental Area	State, Florida	FWC	Natural Heritage	Eligible	7.43	10.45	71

Table 4.7-1. National System Marine Protected Areas Within or Partially Within the Area of Interest (continued)

Site	Government Level	Managing Agency	Primary Conservation Focus	Status	Area within AOI (km^2)	Total Area (km^2)	Percentage within AOI
Fort Pickens State Park Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	100.05	125.31	80
Fort Zachary Taylor State Historic Site	State, Florida	FDEP	Natural Heritage	Eligible	0.22	0.22	100
Gasparilla Island State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.33	0.51	65
Gasparilla Sound – Charlotte Harbor Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	0.47	338.78	0
Grayton Beach State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.004	8.98	0
Honeymoon Island State Park	State, Florida	FDEP	Natural Heritage	Eligible	4.65	11.44	41
Idle Speed Manatee Protection Zones	State, Florida	FWC	Natural Heritage	Eligible	0.47	14.48	3
Isles Dernieres Barrier Islands Refuge	State, Florida	LDWF	Sustainable Production	Eligible	1.64	12.02	14
Lemon Bay Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	6.13	26.85	23
Lovers Key State Recreation Area	State, Florida	FDEP	Natural Heritage	Eligible	0.94	5.37	18
Marsh Island WMA and Game Preserve	State, Florida	LDWF	Sustainable Production	Eligible	0.01	285.57	0
Maximum 25 mph Manatee Protection Zones	State, Florida	FWC	Natural Heritage	Eligible	0.36	42.84	1
Maximum 30 mph in Channel/Slow Speed or 20 mph Outside Channel Manatee Protection Zones	State, Florida	FWC	Natural Heritage	Eligible	14.03	115.81	12
Pass a Loutre WMA	State, Florida	LDWF	Sustainable Production	Eligible	156.74	465.23	34
Pine Island Sound Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	0.52	227.71	0
Pinellas County Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	1,038.60	1,420.08	73
Regina Underwater Archaeological Preserve	State, Florida	FDHR	Cultural Heritage	Eligible	0.02	0.02	66
Rockefeller WMA and Game Preserve	State, Louisiana	LDWF	Sustainable Production	Eligible	23.59	346.30	7
Rookery Bay Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	65.60	234.18	28
Slow Speed Manatee Protection Zones	State, Florida	FWC	Natural Heritage	Eligible	5.72	474.12	1
SS *Tarpon* Underwater Archaeological Preserve	State, Florida	FDHR	Cultural Heritage	Eligible	0.58	0.58	100
St. Andrews State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.06	4.72	1
St. Andrews State Park Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	71.98	96.38	75
St. Joseph Bay Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	131.96	265.45	50

Table 4.7-1. National System Marine Protected Areas Within or Partially Within the Area of Interest (continued)

Site	Government Level	Managing Agency	Primary Conservation Focus	Status	Area within AOI (km^2)	Total Area (km^2)	Percentage within AOI
St. Martins Marsh Aquatic Preserve	State, Florida	FDEP	Natural Heritage	Eligible	67.33	127.13	53
Stump Pass Beach State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.84	1.02	82
Topsail Hill Preserve State Park	State, Florida	FDEP	Natural Heritage	Eligible	0.09	6.63	1
USS *Massachusetts* (BB-2) Underwater Archaeological Preserve	State, Florida	FDHR	Cultural Heritage	Eligible	0.21	0.21	100
Vamar Underwater Archaeological Preserve	State, Florida	FDHR	Cultural Heritage	Eligible	0.58	0.58	100
Waccasassa Bay State Preserve	State, Florida	FDEP	Natural Heritage	Eligible	19.39	137.49	14
Werner-Boyce Salt Springs State Park	State, Florida	FDEP	Natural Heritage	Eligible	5.55	16.02	35

AOI = Area of Interest; FDEP = Florida Department of Environmental Protection; FDHR = Florida Division of Historical Resources; FWC = Florida Fish and Wildlife Conservation Commission; FWS = Fish and Wildlife Service; HAPC = Habitat Area of Particular Concern; km^2 = square kilometers; LDWF = Louisiana Department of Wildlife and Fisheries; MPA = marine protected area; mph = miles per hour; NERR = National Estuarine Research Reserve; NMFS = National Marine Fisheries Service; NMS = National Marine Sanctuary; NOAA = National Oceanic and Atmospheric Administration; NPS = National Park Service; NWR = National Wildlife Refuge; ONMS = Office of National Marine Sanctuaries; UTMSI = University of Texas at Austin Marine Science Institute; WMA = Wildlife Management Area.

Table 4.9-1. 2014 Economic Impacts of the Gulf of Mexico Region Seafood Industry (thousands of dollars) (From: USDOC, NMFS, 2016d)

State	Revenue Landings	Jobs	Sales	Income	Valued Added
Alabama	68,793	15,069	660,627	251,520	333,185
Florida	203,372	92,858	18,317,052	3,434,238	6,135,060
Louisiana	451,371	44,066	2,220,879	816,203	1,115,858
Mississippi	25,995	4,714	198,608	79,501	102,731
Texas	278,353	33,880	2,857,586	826,213	1,238,477
Totals	1,027,884	190,587	24,254,752	5,407,675	8,925,311

Table 4.9-2. Total Landings and Landings of Key Species/Species Groups (thousands of pounds) (From: USDOC, NMFS, 2016d)

Key Species/ Group	Year									
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Blue Crab	50,041	67,481	57,964	49,258	61,277	41,240	55,606	50,409	46,940	47,765
Menhaden	815,495	901,398	1,005,325	927,517	1,002,579	753,442	1,398,654	1,078,139	1,021,526	769,943
Mullets	9,023	12,727	8,933	10,609	11,303	8,963	14,233	10,772	13,482	13,604
Oysters	20,174	19,674	22,518	20,723	22,829	15,824	18,742	19,948	19,249	16,525
Red Snapper	4,109	4,637	2,998	2,370	2,503	3,259	3,567	3,994	5,306	5,722
Shrimp	216,291	288,973	225,163	188,806	250,572	178,902	221,469	203,328	205,993	206,774
Stone Crab	4,534	4,806	5,893	6,169	5,407	5,112	5,482	5,226	3,778	1,890
Tunas	3,050	2,851	3,426	1,786	2,836	1,322	1,588	3,031	2,094	1,757
Finfish Total	842,453	930,705	1,027,990	950,842	1,025,854	771,856	1,425,029	1,103,909	1,049,688	799,573
Shellfish Total	291,040	380,934	311,538	264,956	340,085	241,078	301,299	278,911	275,960	272,954
Total Landings	1,133,493	1,311,639	1,339,528	1,215,798	1,365,939	1,012,934	1,726,328	1,382,820	1,325,648	1,072,527

Table 4.9-3. Primary Commercial Fishing Methods, Target Species, Seasons, and General Areas Fished in the Gulf of Mexico

Fishing Method	Target Species	Primary Fishing Season	Primary Fishing Area
Bottom trawling (including skimmer nets)	Brown shrimp, pink shrimp, white shrimp, seabob, royal red shrimp, and groundfish	Year-round depending on species and seasonal closures.	Soft bottom, shelf waters from nearshore to the upper slope off all Gulf Coast States depending on closed areas.
Purse netting	Menhaden, butterfish, scads, blue runner, and Spanish sardines	Spring and summer months	Menhaden inner shelf off Louisiana and Mississippi, scads and sardines inner shelf off Florida panhandle
Gillnetting	Coastal sharks, mullet, Spanish mackerel, and black drum	Spring and summer depending on species and seasonal closures	Coastal waters, Alabama, Mississippi, Louisiana, prohibited in Florida and Texas
Hook-and-lining (bottom fishing and trolling)	Snappers, groupers, amberjacks, triggerfishes, sharks, king mackerel, Spanish mackerel, and cobia	Year-round; effort varies with species-specific closures	Oil platforms, artificial reefs, and natural hard bottom areas throughout the Gulf of Mexico's most activity inner and middle shelf.
Surface longlining	Sharks, swordfish, tunas, and dolphinfish	Year-round with summer peaks	Open Gulf of Mexico seaward of 200 m (656 ft)
Bottom longlining	Groupers, snappers, tilefishes, and sharks	Year-round; effort varies with species specific closures	Outer shelf waters from Florida to Texas on suitable bottom type
Trapping	Spiny lobster, stone crab, deep-sea red crab, and reef fishes	Stone crab (October to March); spiny lobster (July to March); fish (year-round)	Florida shelf waters

Table 4.9-4. Summary of Seasonal and/or Area Closures to Commercial Fishing in Federal Waters in the Gulf of Mexico

Closed or Restricted Area	Location	Gear Restrictions or Protection Measures
Closures of the Gulf group king mackerel gillnet fishery	Gulf of Mexico EEZ	Gillnet fishery for Gulf group king mackerel is closed July 1 through Martin Luther King, Jr. holiday, and subsequent weekends and holidays with exceptions
Seasonal closure of the commercial fishery for gag, red, and black grouper	Gulf of Mexico EEZ	February 15-March 15 – no possession or sale of gag, red, and black grouper if only commercial permit; OK if have both charter/ headboat and commercial permit and under bag limit
Closures of the commercial fishery for red snapper	Gulf of Mexico EEZ	Commercial fishery for red snapper closed from January 1 to February 1, and from the 10th of each month until the 1st on the succeeding month until quota met
Texas closure; royal red shrimp exception	Offshore Texas	Trawling is prohibited from May 15 to July 15 (except royal red shrimp beyond the 100-fathom contour)
Reef fish longline and buoy gear restricted area	Offshore Florida Panhandle and big bend areas	If using longline or buoy gear, catch is limited to bag limits for species, or where no bag limit, by 5%, by weight, of fish on board or landed
Reef fish stressed areas	Offshore all Gulf states	A powerhead may not be used to take Gulf reef fish. A roller trawl or fish trap are prohibited.
Southwest Florida seasonal trawl closure	Offshore SW Florida	Trawling is prohibited from January 1 to 1 hour after sunset May 20.
Tortugas shrimp sanctuary	Offshore Florida Dry Tortugas	Closed to trawling
Tortugas shrimp sanctuary	Offshore Florida Dry Tortugas	Closed to trawling except from April 11 to July 31
Tortugas shrimp sanctuary	Offshore Florida Dry Tortugas	Closed to trawling except from April 11 to September 30
Tortugas shrimp sanctuary	Offshore Florida Dry Tortugas	Closed to trawling except from May 26 to July 31
Shrimp/stone crab separation zones, Zone I	Offshore Florida	Unlawful to trawl for shrimp in the EEZ from October 5 to May 20
Shrimp/stone crab separation zones, Zone II	Offshore Florida	Restrictions for Florida's waters are contained in Rule 46-38.001, Florida Administrative Code.
Shrimp/stone crab separation zones, Zone III	Offshore Florida	Unlawful to trawl for shrimp in the EEZ from October 5 to May 20
Shrimp/stone crab separation zones, Zone IV	Offshore Florida	Unlawful to trap stone crab in EEZ from October 5 to December 1 and April 2 to May 20; unlawful to trawl for shrimp in the EEZ from December 2 to April 1.
Shrimp/stone crab separation zones, Zone V	Offshore Florida	Unlawful to trap stone crab in EEZ from October 5 to November 30 and March 16 to May 20; unlawful to trawl for shrimp in the EEZ from December 1 to March 15
Tortugas Marine Reserves Tortugas North and South	Offshore Florida Dry Tortugas	Fishing for any species, and anchoring, are prohibited
Florida Middle Grounds HAPC	Offshore Florida	Fishing with bottom longline, bottom trawl, dredge, pot, or trap is prohibited year-round
Closure provisions applicable to the Steamboat Lumps and Madison and Swanson sites	Offshore Florida	From November to April, possession of Gulf reef fish prohibited except in transit, and fishing is prohibited, except for highly migratory species. From May to October, surface trolling is the only allowable fishing.
East and West Flower Garden Banks HAPC	Offshore Texas	Fishing with bottom longline, bottom trawl, dredge, pot, or trap is prohibited.
Alabama SMZ	Offshore Alabama	Gulf reef fishing restrictions on catch by vessel and gear type

EEZ = Economic Exclusion Zone; GMFMC = Gulf of Mexico Fishery Management Council; HAPC = Habitat Area of Particular Concern; MPA = Marine Protected Area; SMZ = Special Management Zone.
Note that regulations fluctuate on a regular basis and that current information on rules must be obtained from the GMFMC.
Modified from: 50 CFR § 622.34.

Table 4.10-1. 2014 Recreational Gulf of Mexico Fishing Effort by Mode (thousands of dollars and trips) (From: USDOC, NMFS, 2016d)

	Trips	Jobs	Sales ($)	Income($)	Value Added ($)
Alabama	2,169	14,124	1,070,579	540,257	827,849
Louisiana	2,188	15,241	1,619,677	662,470	1,029,281
Mississippi	1,480	4,174	374,063	157,772	247,281
Texas	N/A[1]	16,496	1,825,290	615,713	1,005,040
West Florida	15,179	70,109	7,467,774	3,161,122	4,868,743
Total	21,016	120,144	$12,357,383	$5,137,334	$7,978,194

[1]N/A = not available. The Marine Recreational Program does not collect effort data for Texas.

Table 4.10-2. Economic Impacts of Gulf of Mexico Recreational Fishing Expenditures (thousands of angular trips) (From: USDOC, NMFS, 2016d)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
For-Hire	692	837	852	5,819	823	581	735	884	907	927
Private Boat	13,586	13,620	14,980	15,195	13,443	12,684	12,911	12,782	13,510	11,508
Shore	9,014	8,837	8,458	8,776	8,333	7,783	8,930	9,506	10,817	8,581
Total Trips	23,292	23,294	24,290	29,790	22,599	21,048	22,576	23,172	25,234	21,016

Table 4.10-3. Gulf of Mexico Recreational Harvest and Release of Key Species and Species Groups (thousands of fish) (From: USDOC, NMFS, 2016d)

Key Species/Groups		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Drum (Atlantic croaker)	H	867	1,541	1,408	1,935	1,290	1,635	2,209	1,462	1,883	2,682
	R	2,844	2,314	2,616	3,149	3,858	3,827	5,899	3,922	3,268	2,240
Drum (Gulf and southern kingfish)	H	1,426	1,250	1,137	1,307	1,066	1,420	941	918	1,623	705
	R	781	926	843	729	576	625	539	535	474	356
Drum (sand and silver seatrouts)	H	2,159	2,239	3,185	3,556	4,314	4,700	5,962	5,055	3,013	2,500
	R	724	1,538	1,910	1,989	2,444	1,807	2,541	2,474	1,851	481
Drum (spotted seatrout)	H	10,882	14,272	12,103	15,042	14,146	10,870	14,719	13,593	12,761	5,703
	R	20,124	20,055	18,849	21,017	17,365	14,564	19,120	20,217	19,528	8,931
Porgies (sheepshead)	H	2,081	1,185	1,245	1,613	1,607	1,195	2,274	1,596	1,355	1,381
	R	2,394	1,507	1,223	1,486	1,338	1,739	1,634	1,516	1,672	1,579
Red drum	H	2,548	2,681	3,136	3,560	2,893	3,516	3,889	3,012	4,138	2,096
	R	6,233	6,392	6,222	7,016	5,525	6,468	6,448	6,330	7,699	3,479
Red snapper	H	884	1,035	1,270	720	828	368	557	626	1,291	500
	R	2,194	2,831	3,259	2,112	2,145	1,436	1,521	1,424	2,824	1,785
Southern flounder	H	623	538	701	538	691	801	857	836	1,103	491
	R	195	171	239	121	193	220	222	309	339	72
Spanish mackerel	H	1,192	1,759	1,330	1,895	1,504	1,564	1,534	1,834	3,352	1,718
	R	1,374	2,855	2,104	2,040	1,634	2,477	1,941	1,441	4,158	2,779
Striped mullet	H	1,081	1,103	1,150	1,258	743	1,666	1,900	2,356	2,984	2,365
	R	165	141	158	146	226	127	313	204	194	293

H = harvest; R = release.

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (Data from: USDOC, NOAA, 2015; In the Bite, 2015; and Florida Sportsman, 2015)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
2014																								
Alabama																								
Orange Beach Billfish Classic[1]	Orange Beach	May 14	May 18	X	X		X											X						
Mobile BGFC Memorial Day Tournament	Orange Beach	May 23	May 26	X	X		X	X	X						X	X		X						
Social Saltwater Series	Orange Beach	May 24	Sep 1										X											
Gulf Coast Outboard Classic[1]	Orange Beach	June 28	June 28	X	X													X						
The Gulf Cup Blue Marlin Shootout	Orange Beach	July 4	July 4		X																			
Mobile BGFC Junior Angler Tournament	Orange Beach	July 4	July 5	X	X		X	X	X						X	X		X						
Atlanta Saltwater Sportsman's Club Orange Beach Shootout	Orange Beach	July 6	July 12	X	X		X			X					X	X	X	X						
Blue Marlin Grand Championship[1]	Orange Beach	July 10	July 13	X	X		X											X						
Mississippi Gulf Coast BGFC Ladies Tournament[1]	Orange Beach	July 18	July 20	X	X		X								X	X		X						
Alabama Deep-Sea Fishing Rodeo[1]	Dauphin Island	July18	July 20	X	X		X	X	X	X	X	X	X	X				X						
Mobile BGFC Billfish Limited Tournament[1]	Orange Beach	July 25	July 27	X	X		X	X	X						X	X		X						
Mobile BGFC Ladies Tournament[1]	Orange Beach	Aug 1	Aug 3	X	X		X	X	X						X	X		X						
Gulf Coast White Marlin Shootout[1]	Orange Beach	Aug 14	Aug 17	X	X		X	X	X	X						X		X						
Mobile BGFC Labor Day Tournament	Orange Beach	Aug 29	Sep 1	X	X		X	X	X						X	X		X						

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
Louisiana																								
Louisiana Council of Underwater Dive Clubs Derby Board[1]	Metairie	Jan 1	Dec 31													X	X	X	X					
Houma Oilman's Fishing Invitational[1]	Cocodrie	May 22	May 24		X													X						
New Orleans BGFC Back to the Pass	Port Eads	May 24	May 25	X	X		X	X		X				X				X						
Cajun Canyons Billfish Classic[1]	Venice	May 27	June 1	X	X		X									X		X						
New Orleans BGFC Cajun Canyons	Port Eads	May 30	May 31	X	X		X	X		X				X				X						
Swollfest Fishing Rodeo[1]	Grand Isle	June 5	June 7							X						X		X						
Helldivers Spearfishing Rodeo[1]	Kenner	June 5	June 8													X	X	X	X					
New Orleans BGFC Invitational[1]	Port Eads	June 12	June 14	X	X		X	X		X				X				X						
New Orleans BGFC Ladies Tournament	Port Eads	June 27	June 28	X	X		X	X		X				X				X						
The Gulf Cup Blue Marlin Shootout	Venice	July 4	July 4		X																			
Fourchon Oilman's Association Fishing Tournament[1]	Port Fourchon	July 10	July 12	X	X		X			X		X	X	X				X						
New Orleans BGFC Regular Tournament[1]	Port Eads	July 11	July 12	X	X		X	X		X				X				X						
Faux Pas Lodge Invitational[1]	Venice	July 24	July 26		X													X						
New Orleans BGFC Grand Isle/Faux Pas Tournament[1]	Port Eads	July 25	July 26	X	X		X	X		X				X				X						
New Orleans BGFC Empire Tournament	Port Eads	Aug 8	Aug 9	X	X		X	X		X				X				X						
New Orleans BGFC Labor Day Tournament	Port Eads	Aug 30	Aug 31	X	X		X	X		X				X				X						
New Orleans BGFC Last Tournament	Port Eads	Sep 13	Sep 14	X	X		X	X		X				X				X						
Mississippi																								

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
Mississippi Gulf Coast Billfish Classic[1]	Biloxi	June 5	June 7	X	X		X									X		X						
Mississippi Gulf Coast BGFC Spring Tournament	Biloxi	June 20	June 22	X	X		X								X	X		X						
Mississippi Deep-Sea Fishing Rodeo[1]	Gulfport	July 3	July 6									X	X					X						
The Gulf Cup Blue Marlin Shootout	Gulfport	July 4	July 4		X																			
Carl Legett Memorial Fishing Tournament[1]	Biloxi	Aug 1	Aug 3	X	X		X			X		X	X	X		X	X	X	X					
Texas																								
Texas Shark Rodeo	Texas Coast	Mar 16	Dec 31								X	X	X											
South Texas BGFC Blake Bunk Memorial Day Tournament	South Padre Island	May 24	May 25	X	X		X		X	X				X	X			X	X					
South Texas BGFC Blake Bunk Memorial Day Tournament	Port Mansfield	May 24	May 25	X	X		X		X	X				X	X			X	X					
42nd Annual Hall of Fame[2]	Galveston	May 24	June 1											X										
South Texas BGFC First June Tournament	South Padre Island	June 7	June 7	X	X		X		X	X				X	X			X	X					
South Texas BGFC First June Tournament	Port Mansfield	June 7	June 7	X	X		X		X	X				X	X			X	X					
South Texas BGFC Middle of June Tournament	South Padre Island	June 21	June 21	X	X		X		X	X				X	X			X	X					
South Texas BGFC Middle of June Tournament	Port Mansfield	June 21	June 21	X	X		X		X	X				X	X			X	X					
Texas Billfish Championship[1]	Freeport	June 25	June 28	X	X		X											X						
Tackle Time Fishing Tournament[1]	Texas City	June 27	July 6									X	X											
The Gulf Cup Blue Marlin Shootout	Galveston	July 4	July 4		X																			
The Gulf Cup Blue Marlin Shootout	Port Aransas	July 4	July 4		X																			

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
South Texas BGFC Fourth of July Tournament	South Padre Island	July 4	July 5	X	X		X		X	X				X	X			X	X					
South Texas BGFC Fourth of July Tournament	Port Mansfield	July 4	July 5	X	X		X		X	X				X	X			X	X					
Bastante Tournament	Rockport	July 9	July 12	X	X		X											X						
Deep Sea Round Up[1]	Port Aransas	July 11	July 12	X	X		X		X		X							X						
South Texas BGFC Middle of July Tournament	South Padre Island	July 12	July 12	X	X		X		X	X				X	X			X	X					
South Texas BGFC Middle of July Tournament	Port Mansfield	July 12	July 12	X	X		X		X	X				X	X			X	X					
Poco Bueno[1]	Port O'Connor	July 16	July 19		X													X						
Lone Star Shootout[1]	Port O'Connor	July 25	July 26	X	X		X			X								X						
South Texas BGFC Port Mansfield Fishing Tournament	South Padre Island	July 25	July 26	X	X		X		X	X				X	X			X	X					
South Texas BGFC Port Mansfield Fishing Tournament	Port Mansfield	July 25	July 26	X	X		X		X	X				X	X			X	X					
Texas International Fishing Tournament[1]	Port Isabel	July 30	Aug 3	X	X		X			X			X	X				X						
Texas International Fishing Tournament1	South Padre Island	July 30	Aug 3	X	X		X			X			X	X				X						
Texas Legends Billfish Tournament	Port Aransas	Aug 6	Aug 10	X	X		X	X		X								X						
South Texas BGFC Middle of August Tournament	South Padre Island	Aug 16	Aug 16	X	X		X		X	X				X	X			X	X					
South Texas BGFC Middle of August Tournament	Port Mansfield	Aug 16	Aug 16	X	X		X		X	X				X	X			X	X					
Texas Women Anglers Tournament[1]	Port Aransas	Aug 23	Aug 23	X	X		X											X						

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
South Texas BGFC Labor Day Tournament	South Padre Island	Aug 30	Aug 31	X	X		X		X	X				X	X			X	X					
South Texas BGFC Labor Day Tournament	Port Mansfield	Aug 30	Aug 31	X	X		X		X	X				X	X			X	X					
South Texas BGFC Last Tournament	South Padre Island	Sep 13	Sep 13	X	X		X		X	X				X	X			X	X					
South Texas BGFC Last Tournament	Port Mansfield	Sep 13	Sep 13	X	X		X		X	X				X	X			X	X					
Sharkathon[1]	Corpus Christi	Sep 26	Sep 28								X	X	X											
Florida																								
Crosthwait Fishing Tournament	Palmetto	May 16	May 18	X	X		X	X	X						X	X	X	X	X					
Gulf Breeze Optimist Club 39th Annual Fishing Rodeo[1]	Gulf Breeze	May 17	May 18															X						
7th Annual Fire Charity Fishing Tournament[2]	Palmetto	June 6	June 8	X	X		X			X								X						
Pensacola Junior Anglers Tournament[1]	Pensacola	June 14	June 14	X	X		X	X	X							X		X	X					
Atlanta Saltwater Sportsman's Club Duel at Destin	Destin	June 18	June 21	X	X		X			X					X	X	X	X						
Emerald Coast Blue Marlin Classic at Sandestin[1]	Destin	June 18	June 22	X	X		X		X							X		X						
Fort Walton Beach Sailfish Club Offshore Invitational Tournament[1]	Fort Walton Beach	June 19	June 22	X	X		X	X		X						X		X						
River Energy Shark Frenzy	Tarpon Springs	June 27	June 29										X	X										
The Gulf Cup Blue Marlin Shootout	Anna Maria	July 4	July 4		X																			
The Gulf Cup Blue Marlin Shootout	Destin	July 4	July 4		X																			
Pensacola International Billfish Tournament[1]	Pensacola	July 4	July 5	X	X		X	X	X	X					X	X		X						

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
De Soto Fishing Tournament[1]	Bradenton	July 11	July 13	X	X		X	X	X	X					X			X						
Yellowfin Billfish Classic[1]	Sarasota	July 22	July 26	X	X		X	X	X	X					X	X	X	X	X					
Crosthwait Memorial of Florida, West Coast Triple Crown Billfish Series	Palmetto	Aug 6	Aug 9	X	X		X		X	X								X						
Pensacola Ladies Billfish Tournament[1]	Pensacola	Aug 9	Aug 10	X	X		X	X	X	X						X		X	X					
42nd Annual Old Salt All Release Loop Tournament[1]	St. Petersburg	Aug 19	Aug 28	X	X		X	X	X	X					X	X	X	X	X					
Atlanta Saltwater Sportsman Club[1]	Apalachicola	Aug 21	Aug 23	X	X		X	X										X						
Suncoast Saltwater Shootout	Sarasota	Sep 17	Sep 20	X	X		X		X	X								X						
Atlanta Saltwater Sportsman's Club[1]	Perdido Beach	Sep 19	Sep 20	X	X		X	X	X	X					X	X		X						
Bluewater Bay Marina Complex Swordfish Showdown	Niceville	Sep 27	Oct 25							X														
66th Annual Destin Fishing Rodeo[2]	Destin	Oct 1	Oct 30	X	X		X		X	X		X	X	X				X						
2015 (as of May 2015)																								
Alabama																								
Orange Beach Billfish Classic[1]	Orange Beach	May 13	May 17		X										X			X						
Mobile Big Game Fishing Club Memorial Day and Outboard Shootout	Orange Beach	May 22	May 25	X	X		X	X	X						X	X		X	X					
Mobile BGFC Junior Angler Tournament[1]	Orange Beach	July 3	July 4	X	X		X	X	X						X	X		X	X					
Blue Marlin Grand Championship of the Gulf[1]	Orange Beach	July 7	July 12		X																			
Mobile BGFC Billfish Limited Tournament[1]	Orange Beach	July 24	July 26	X	X		X	X	X	X					X	X		X	X					
Mobile BGFC Ladies Tournament[1]	Orange Beach	July 31	Aug 2	X	X		X	X	X						X	X		X	X					

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
Mobile BGFC Labor Day Tournament and Outboard Shootout	Orange Beach	Sep 4	Sep 7	X	X		X	X	X						X	X		X	X					
Louisiana																								
Madfin Shark Series	Venice	Mar 10	Mar 12										X	X										
Hawk's Nest 10th Annual Wahoo Championship[2,3]	Cat Island	April	April															X			X			
New Orleans BGFC First Tournament[1]	Venice	May 15	May 16	X	X		X	X		X				X				X						
New Orleans BGFC First Tournament[1]	Port Eads	May 15	May 16	X	X		X	X		X				X				X						
Cajun Canyons Billfish Classic[1]	Venice	May 26	May 31	X	X		X		X							X		X						
New Orleans BGFC Regular Club Tournament[1]	Venice	May 29	May 30	X	X		X	X		X				X				X						
Helldivers Spearfishing Rodeo[1]	Kenner	June 4	June 7													X	X	X	X					
Bubba Dove Memorial Fishing Rodeo	Theriot	June 5	June 7															X						
New Orleans BGFC Invitational Tournament[1]	Venice	June 11	June 13	X	X		X	X		X				X				X						
Swollfest Fishing Rodeo[1]	Grand Isle	June 11	June 13															X						
New Orleans BGFC Regular Club Tournament[1]	Venice	July 10	July 11	X	X		X	X		X				X				X						
New Orleans BGFC Grand Isle/Faux Pas Tournament[1]	Venice	July 24	July 25	X	X		X	X		X				X				X						
New Orleans BGFC Ladies Tournament	Venice	June 26	June 27	X	X		X	X		X				X				X						
New Orleans BGFC Regular Club Tournament[1]	Venice	Aug 7	Aug 8	X	X		X	X		X				X				X						
New Orleans BGFC Regular Club Tournament[1]	Venice	Aug 21	Aug 22	X	X		X	X		X				X				X						
New Orleans BGFC Last Tournament	Venice	Sep 5	Sep 6	X	X		X	X		X				X				X						

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
Mississippi																								
Mississippi Gulf Coast Billfish Classic[1]	Biloxi	June 1	June 7	X	X		X									X		X			X	X		
Mississippi Deep Sea Fishing Rodeo[1]	Gulfport	July 2	July 5									X	X					X	X					
Texas																								
4th Annual John Uhr Memorial Billfish Tournament[1]	Rockport	July 8	July 11	X	X		X											X			X	X		
The Lonestar Shootout[1]	Port O'Connor	July 21	July 26	X	X													X			X	X		
Texas International Fishing Tournament[1]	South Padre Island	July 29	Aug 2	X	X		X			X			X	X				X						
Texas International Fishing Tournament[1]	Port Isabel	July 29	Aug 2	X	X		X			X			X	X				X						
Florida																								
Cobia World Championships[3]	Destin	Mar 20	May 10																	X				
Shark Rally	Fort Myers	Mar 28	Mar 29								X	X	X	X										
Bluewater Bay Marina Cobia Tournament[3]	Destin	April 1	April 30																	X				
Bluewater Bay Marina Cobia Tournament[3]	Pensacola	April 1	April 30																	X				
Hog Breaths Cobia Tournament[3]	Destin	April 4	April 4																	X				
Sarasota Sertoma/SKA King Mackerel Tournament[3]	Sarasota	April 12	April 13																				X	
Wild West Kingfish Tournament[3]	Madeira Beach	April 16	April 18																					X
Half-Hitch Tackle Cobia Tournament	Panama City Beach	April 17	April 19																	X				

Table 4.10-4. Summary of Recreational Fishing Tournaments in the Gulf of Mexico (continued)

Tournament Name	Location	Start	End	Targeted Species																				
				White Marlin	Blue Marlin	Black Marlin	Sailfish	Longbill Spearfish	Roundscale Spearfish	Swordfish	Ridgeback Sharks	Non-Ridgeback Sharks	Small Coastal Sharks	Pelagic Sharks	Bluefin Tuna	Bigeye Tuna	Albacore Tune	Yellowfin Tuna	Skipjack Tuna	Cobia	Wahoo	Dolphinfish	King Mackerel	Kingfish
Clearwater Rotary Club's Annual Kingfish Tournament[3]	Clearwater	April 18	April 18																					X
Wild West Kingfish Tournament[3]	Madeira Beach	May 14	May 16																					X
32nd Annual Crosthwait Memorial Tournament[2]	Palmetto	May 15	May 17	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X					
Gulf Breeze Optimist Club 40th Annual Fishing Rodeo[1]	Gulf Breeze	May 16	May 17															X						
Fort Walton Beach Sailfish Club[1]	Shalimar	June 12	June 14	X	X		X	X	X	X					X	X	X	X	X					
Emerald Coast Blue Marlin Classic at Sandestin[1]	Destin	June 17	June 21	X	X		X	X	X							X		X						
Pensacola International Billfish Tournament[1]	Pensacola	June 24	June 28	X	X		X			X								X						
Yellowfin Billfish Classic[1]	Sarasota	July 28	Aug 1	X	X		X	X	X	X					X	X	X	X	X					
Crosthwaits Extreme Billfish Tournament	Bradenton	Aug 11	Aug 15	X	X		X		X	X														
44th Annual Old Salt Loop Billfish Tournament[1]	Madeira Beach	Aug 25	Aug 29	X	X		X	X	X	X					X	X	X	X	X					
Wild West Kingfish Tournament[3]	Madeira Beach	Oct 8	Oct 10																					X
Wild West Kingfish Tournament[3]	Madeira Beach	Oct 15	Oct 17																					X
Gulf Coast States																								
Marlin Duel	Gulf States	April 15	Aug 31		X	X																		

BGFC = Big Game Fishing Club.
[1] Annual tournament – appears in more than 1 year in the table.
[2] Lists annual in the name but does not appear more than once in the table.
[3] A non-sanctioned Atlantic Highly Migratory Species tournament. A sanctioned tournament has been registered with the National Marine Fisheries Service.

Table 4.12-1. Recent Marine Mineral Projects in Florida, Louisiana, and Mississippi (From: USDOI, BOEM, 2016b)

Location	Date Lease or MOA Executed	Cubic Yards Authorized	Miles of Shoreline Restored
Collier County, Florida	May 2015	500,000*	7.5*
Longboat Key, Florida	October 2012	466,500	9.8
Pinellas County, Florida	July 2011	1,800,000	8.07
Whiskey Island, Louisiana	May 2015	13,400,000	4.6
Caminada Headlands II, Louisiana	March 2014	6,100,000	8.0
Caminada Headlands, Louisiana	August 2012	5,200,000	6.0
Cameron Parish, Louisiana	August 2012	5,000,000	8.0
Raccoon Island, Louisiana	December 2010	750,000	1.2
Hancock, Harrison, and Jackson Counties, Mississippi	August 2016	N/A	N/A

MOA = Memorandum of Agreement; N/A = Not available.
* = proposed as project; have not yet obtained Finding of No Significant Impact (FONSI).

Table 4.13-1. 2012 Economic Impact of the Gulf of Mexico on Coastal Communities (From: USDOC, NOAA, n.d.)

Sector	Number of Establishments	Total Employment	Total Wages (in million $)	GDP (in million $)
Living Resources	1,146	12,913	393	1,446
Marine Construction	750	16,984	1,027	2,050
Marine Transportation	2,023	81,003	5,072	11,149
Offshore Mineral Extraction	3,393	131,289	19,513	131,003
Ship and Boat Building	567	40,408	2,289	3,552
Tourism and Recreation	17,267	298,558	5,653	11,977
Totals – All Sectors	25,146	581,155	33,947	161,177

GDP = gross domestic product.

Table 4.13-2. Population Living in Gulf of Mexico Coastal Watershed Communities (1970 to 2010) (From: USDOC, Census Bureau, 2002, 2012; USDOC, NOAA, n.d.)

State	1970	1990	2010	Percent Change 1970-1990	Percent Change 1990-2010
Alabama	3,444,165	4,040,587	4,779,736	17.3	18.2
Gulf Coast Area[1]	531,447	640,468	764,613	20.5	19.4
Florida	6,789,443	12,937,926	18,801,310	90.6	45.3
Gulf Coast Area[1]	4,267,709	7,863,816	10,943,232	84.3	39.2
Louisiana	3,641,306	4,219,973	4,533,372	15.9	7.4
Gulf Coast Area[1]	2,806,882	3,313,024	3,573,854	18.0	7.9
Mississippi	2,216,912	2,573,216	2,967,297	16.1	15.3
Gulf Coast Area[1]	395,504	508,713	628,502	28.6	23.5
Texas	14,229,191	20,851,820	25,145,561	46.5	20.6
Gulf Coast Area[1]	3,607,130	5,581,687	8,287,623	54.7	48.5
State Total	30,321,017	44,623,522	56,227,276	47.2	26.0
Gulf Coast Total[1]	11,608,672	17,907,708	24,197,824	54.3	35.1

BOEM = Bureau of Ocean Energy Management; NOAA = National Oceanic and Atmospheric Administration.
[1] Gulf Coast Area as defined by NOAA differs slightly from the Economic Impact Areas identified by BOEM.

Table 4.13-3. 2012 Minority Populations in Geographic Areas Associated with Ports Serving the Geological and Geophysical Industry in the Area of Interest (From: USDOC, Census Bureau, n.d.)

Port/Location	Total Population	Percent of Total Population								
		White	Black or African American	Alaska Native or American Indian	Asian	Native Hawaiian and Other Pacific Islander	Some Other Race Alone	Two or More Races	Total Percent Racial Minority	Hispanic or Latino[1]
United States	311,609,369	74.0	12.6	0.8	4.9	0.2	4.7	2.8	26.0	16.6
Port Fourchon										
Louisiana	4,573,595	62.9	32.0	0.6	1.6	0.1	1.1	1.7	37.1	4.4
Houma-Bayou Cane-Thibodaux MSA	208,590	75.0	16.0	4.0	0.8	0.3	1.4	2.5	25.0	4.0
Lafourche Parish	96,860	80.2	13.5	2.3	0.7	0.0	1.3	2.0	19.8	3.9
Texas										
Texas	25,644,550	74.6	11.8	0.5	3.9	0.1	6.8	2.3	25.4	38.0
Houston-Sugar Land-Baytown MSA	6,085,873	65.7	17.2	0.4	6.7	0.1	7.9	2.0	34.3	35.7
City of Galveston	47,689	72.9	19.1	0.2	4.1	0.0	1.7	2.0	27.1	30.2

MSA = metropolitan statistical area

[1] Hispanic or Latino origin is considered an ethnicity not a race. Individuals who identify themselves as being of Hispanic or Latino origin may be of any race.

Table 4.13-4. 2012 Low-Income Populations in Geographic Areas Associated with Ports Serving the Geological and Geophysical Industry in the Area of Interest (From: USDOC, Census Bureau, n.d.)

Port/Location	Percent Low Income	Per Capita Income ($)	Median Household Income ($)
United States	15.7	27,385	51,771
Port Fourchon			
Louisiana	19.6	23,792	43,484
Houma-Bayou Cane-Thibodaux MSA	16.4	23,731	48,270
Lafourche Parish	13.9	24,403	47,843
Port of Galveston			
Texas	18.1	25,268	50,776
Houston-Sugar Land-Baytown MSA	13.4	28,059	56,080
City of Galveston	24.7	23,731	48,270

MSA = metropolitan statistical area.

Table 4.13-5. Average Survey Incremental Cost and Percent Cost Change by Alternative

Survey Type	Average Survey Cost*	Alternative A[1]	Alternative B[2]	Alternative C[3,4]	Alternative D[3,5]	Alternative E[3,6]	Alternative F[3,7]
Airgun HRG	$360,000	$0 (0%)	$70,000-$80,000 (18.6%-21.9%)	$70,000-$90,000 (18.6% - 25.6%)	$70,000-$100,000 (18.6%-26.4%)	$70,000-$90,000 (18.6%-25.6%)	$70,000-$90,000 (18.6%-25.6%)
Non-Airgun HRG	$640,000	$0 (0%)	$0 (0%)	$58,000-$68,000 (9.0%-10.7%)	$59,000-$75,000 (9.2%-11.7%)	$58,000-$68,000 (9.0%-10.7%)	$58,000-$68,000 (9.0%-10.7%)
VSP	$300,000	$0 (0%)	$62,000-$71,000 (23.0%-26.3%)	$62,000-$82,000 (23.0%-30.4%)	$63,000-$84,000 (23.3%-31.1%)	$62,000-$82,000 (23.0%-30.4%)	$62,000-$82,000 (23.0%-30.4%)
2D	$22.2 M	$0 (0%)	$2.46-$5.33 M (11.1%-24.1%)	$0.75-$1.50 M (3.4%-6.8%)	$0.88-$1.85 M (4.0%-8.3%)	$0.75-$1.50 M (3.4%-6.8%)	$0.75-$1.50 M (3.4%-6.8%)
3D	$49.8 M	$0 (0%)	$5.52-$12.46 M (11.1%-25.0%)	$1.06-$3.87 M (2.1%-7.8%)	$1.31-$5.25 M (2.6%-10.6%)	$1.06-$3.87 M (2.1%-7.8%)	$1.06-$3.87 M (2.1%-7.8%)
WAZ	$165.7-$170.7 M	$0 (0%)	$22.78-$48.29 M (13.7%-28.3%)	$7.22-$16.46 M (4.4%-9.6%)	$9.32-$22.09 M (5.6%-12.9%)	$7.22-$16.46 M (4.4%-9.6%)	$7.22-$16.46 M (4.4%-9.6%)
OBS	$44.0-$68.0 M	$0 (0%)	$4.48-$17.39 M (10.2%-25.6%)	$0.59-$2.94 M (1.3%-4.3%)	$0.69-$3.59 M (1.6%-5.3%)	$0.59-$2.94 M (1.3%-4.3%)	$0.59-$2.94 M (1.3%-4.3%)

% = percent; 2D = two dimensional; 3D = three dimensional; ft = feet; HRG = high-resolution geophysical; m = meter; M = million; OBS = ocean bottom survey; PAM = passive acoustic monitoring; PSO = protected species observer; WAZ = wide azimuth

* Average survey costs were derived from pre-settlement costs.

[1] The PSO Program was previously required; therefore, for Alternative A, there would be no increase in cost.

[2] The costs for Alternative B include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water. The minimum separation distance mitigation is expected to cost industry a 10-25% loss in efficiency (IAGC, 2014). The ranges reported here include that loss in efficiency. Note that HRG and VSP surveys are not expected to be affected by the minimum separation distance mitigation.

[3] Non-airgun HRG survey protocol are applied to these costs.

[4] The costs for Alternative C include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks.

[5] The costs for Alternative D include mitigations for the expanding the PSO Program to include manatees and dolphins as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks.

[6] The costs for Alternative E include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks. This does not include the 10% and 25% reduction in line miles.

[7] The costs for Alternative F include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks. This does not include the reduction in surveys due to the closure area and associated buffer.

Table 4.13-6. Total Discounted Survey Incremental Cost by Alternative from 2018-2027*

Survey Type	Alternative A[2]	Alternative B[3]	Alternative C[4]	Alternative D[5]	Alternative E[6]	Alternative F[7]
Airgun HRG[1]	$0	$2.17-$3.41 M	$2.17-$3.89 M	$2.14-$4.03 M	$2.87-$3.73 M	$2.17-$3.89 M
Non-Airgun HRG[1]	$0	$0	$16.74-$26.52 M	$17.20-$28.93 M	$22.14-$25.46 M	$16.61-$26,52 M
VSP	$0	$15.27-$25.34 M	$15.27-$28.34 M	$15.52-$29.05 M	$20.94-$27.84 M	$15.27-$28.34 M
2D	$0	$0-$78.63 M	$0-$20.01 M	$0-$25.18 M	$11.06-$19.25 M	$0-$20.01 M
3D	$0	$37.46-$549.82 M	$7.19-$148.57 M	$8.89-$209.55 M	$43.37-$146.85 M	$7.19-$148.57 M
WAZ	$0	$408.45-$1,900.08 M	$129.46-$582.17 M	$167.11-$803.70 M	$290.89-$606.12 M	$129.46-$582.17 M
Total	$0	$463.35-$2,557.28 M	$154.09-$782.98 M	$193.66-$1,071.50 M	$369.12-$803.79 M	$154.09-$782.98 M

% = percent; 2D = two dimensional; 3D = three dimensional; ft = feet; HRG = high-resolution geophysical; m = meter; M = million; PAM = passive acoustic monitoring; PSO = protected species observer; WAZ = wide azimuth

* Costs in this table are based on the forecasted annual number of surveys (**Tables 2.7-1, 2.7-2, and 3.2-1**) and survey incremental cost (**Table 4.13.9-1**). A 7% discount rate was applied.

[1] Based on historical data, BOEM assumed that 90% of forecasted HRG surveys would be non-airgun HRG surveys.

[2] The PSO Program was previously required; therefore, for Alternative A, there would be no increase in cost.

[3] The costs for Alternative B include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water, and lastly to include a 10% loss in efficiency due to buffer zone compliance. This 10% loss in efficiency is only expected to affect 65% of surveys and has been factored into this analysis.

[4] The costs for Alternative C include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks.

[5] The costs for Alternative D include mitigations for the expanding the PSO Program to include manatees and dolphins as well as whales, including PAM in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks.

[6] The costs for Alternative E include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks. This does not include the 10% and 25% reduction in line miles.

[7] The costs for Alternative F include mitigations for the expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks. This does not include the reduction in surveys due to the closure area and associated buffer.

Table 4.13-7. Percent Change in Operational Efficiency by Alternative*

Survey Type	Alternative A[1]	Alternative B[2]	Alternative C[3]	Alternative D[4]	Alternative E[5]	Alternative F[6]
Airgun HRG	0%	0.8%	0.8%-2.5%	1.1%-4.5%	0.8%-2.5%	0.8%-2.5%
Non-Airgun HRG	0%	0%	0.8%-2.5%	1.1%-3.5%	0.8%-2.5%	0.8%-2.5%
VSP	0%	0.8%	0.8%-2.5%	1.1%-3.5%	0.8%-2.5%	0.8%-2.5%
2D	0%	12.4%-27.4%	2.4%-5.0%	3.1%-7.1%	2.4%-5.0%	2.4%-5.0%
3D	0%	11.8%-26.8%	1.8%-7.5%	2.3%-10.6%	1.8%-7.5%	1.8%-7.5%
WAZ	0%	14.3%-29.3%	4.3%-8.7%	5.6%-12.4%	4.3%-8.7%	4.3%-8.7%
OBS	0%	10.8%-25.8%	0.8%-2.5%	1.1%-3.5%	0.8%-2.5%	0.8%-2.5%

% = percent; 2D = two dimensional; 3D = three dimensional; ft = feet; HRG = high-resolution geophysical; m = meter; OBS = ocean bottom survey; PAM = passive acoustic monitoring; PSO = protected species observer; VSP = vertical seismic profile; WAZ = wide azimuth

* These calculations are based on survey delays due to the proposed mitigations.

[1] Assumes same efficiency as a typical survey's reduced efficiency of 10%. Alternative A proposes no new mitigations and would not result in a loss of operational efficiency.

[2] Assumes expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water. These numbers include an additional 10-25% loss in efficiency due to buffer zone compliance for the minimal distance requirement.

[3] Assumes expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks.

[4] Assumes expanding the PSO Program to include manatees and dolphins as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks.

[5] Assumes expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks. This does not include the 10% and 25% reductions in line miles.

[6] Assumes expanding the PSO Program to include manatees as well as whales, including PAM in reduced visibility in >100 m (328 ft) of water and expanding the PAM to include the Mississippi Canyon and De Soto Canyon blocks. This does not include the reduction in surveys due to the closure area and associated buffer.

KEYWORD INDEX

KEYWORD INDEX

APPENDIX A

AGREEMENTS AND COOPERATING AGENCY LETTERS

Memorandum of Agreement
between the
Bureau of Ocean Energy Management
and the
National Oceanic and Atmospheric Administration
regarding completion of a
Programmatic Environmental Impact Statement
for Geological and Geophysical Activities
in the Gulf of Mexico

INTRODUCTION

The Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration (NOAA) (hereinafter, collectively referred to as the "Parties) have partnered to prepare a Programmatic Environmental Impact Statement (PEIS) for geological and geophysical activities in the Gulf of Mexico.

Section 1501.6 of the Council on Environmental (CEQ) regulations emphasizes agency cooperation in the National Environmental Policy Act (NEPA) process when federal agencies either have overlapping jurisdiction or special expertise related to a proposed action.

This Memorandum of Agreement (MOA) is designed to establish expectations between the Parties, with BOEM as the lead agency and NOAA as a cooperating agency, for the PEIS and supersedes the June 2013 MOA that established BOEM and NOAA as co-lead agencies. This MOA outlines the responsibilities agreed to by the Parties for this PEIS project. This MOA does not affect NOAA's role and responsibilities under the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and/or other applicable laws. This MOA does not affect BOEM's responsibilities under the Outer Continental Shelf Lands Act (OCSLA), regulations implementing OCSLA, and/or other applicable laws.

BOEM RESPONSIBILITIES

1) BOEM is the lead agency for this PEIS;

2) BOEM will designate a primary point of contact (POC) for matters related to the MOA;

3) BOEM will have the lead in arranging and holding scoping and public meetings for the Draft PEIS;

4) BOEM will be the POC for all work with the contractor preparing the PEIS;

5) BOEM will ensure that NOAA has the opportunity to participate in monthly meetings, plus any additional meetings on specific content, with the contractor regarding the preparation of the subject PEIS;

6) Recognizing that the review times may be fluid, but the deadlines for completing each task are critical, BOEM will comply with and adhere to the agreed upon schedule for the PEIS, MMPA rulemaking petition, and ESA consultation;

7) BOEM will provide NOAA a copy and summary of all comments received during preparation of the PEIS (including scoping and Draft PEIS public comment periods, and Final PEIS;

8) BOEM will place a copy of the MOA in an appendix to the PEIS;

9) BOEM will ensure that NOAA has the opportunity to fully participate in development of the PEIS so NOAA can ensure that the PEIS fully satisfies its obligations under NEPA. This will include an opportunity for NOAA to contribute to the development of the Draft and Final PEIS and review periods for the preliminary Draft and Final PEIS;

10) BOEM will respond to all comments received from NOAA; and

11) BOEM's responsibilities for compliance with any environmental laws, including consultations, are not affected by this MOA.

NOAA RESPONSIBILITIES

1) NOAA is a cooperating agency for preparation of the PEIS;

2) NOAA will designate a primary POC to represent NOAA in matters related to this MOA;

3) NOAA will participate in the development of the Draft and Final PEIS, including drafting chapters and alternatives, commenting on draft chapters and responding to or reviewing the responses to public comments that relate to NOAA's areas of expertise;

4) Recognizing that the review times may be fluid, but the deadlines for completing each task are critical, NOAA will comply with and adhere to the agreed upon schedule for the PEIS, the MMPA rulemaking petition, and ESA consultation, including all solicited inputs and review periods;

5) NOAA may contribute to the development of and participate in the public hearing process;

6) NOAA may participate in the monthly meetings, plus any additional meetings on specific content, with the contractor regarding the preparation of the subject PEIS;

7) NOAA will participate in the drafting of the PEIS to ensure that the PEIS fully satisfies NOAA's own obligations under NEPA; NOAA will assume, on request of BOEM, the responsibility for developing information and preparing environmental analyses, including drafting portions of the PEIS, for matters in which NOAA has special expertise (e.g., foreseeable impacts to marine mammals);

8) NOAA will be responsible for any expenses incurred by NOAA related to this MOA; and

9) NOAA's responsibilities for compliance with any environmental laws, including consultations, are not affected by this MOA.

TERMINATION

The MOA may be terminated at any time by written notice from any of the signatories below or their successors. This MOA will otherwise terminate automatically 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 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 duly authorized representatives of the Parties. This MOA does not create any right or benefit enforceable against BOEM or NOAA, their officers or employees, or any other person. This MOA does not apply to any person outside the Parties.

RESOLUTION OF DISPUTES

The Parties agree to make every attempt to settle any disputes regarding this MOA at the lowest operational level. In the case of a substantial disagreement between the Parties, each party will designate a senior management official in their respective agencies to seek resolution. If resolution is not reached within 30 days, the Parties will further elevate the matter to the Director of BOEM, and the Deputy Assistant Administrator of NOAA for prompt resolution.

CONFIDENTIAL INFORMATION

To the extent allowed under applicable law, the Parties hereby agree to:

(a) Protect and maintain as confidential all privileged, deliberative, and/or predecisional information and documents created (by or for) and/or shared between BOEM and NOAA as part of the collaboration established in this MOA (hereinafter, referred to as "Confidential Information");
(b) Exercise the same degree of care –but not less than a reasonable degree of care – they would exercise with their confidential information to prevent its unauthorized disclosure;
(c) Use the Confidential Information solely for the purposes of this MOA;

(d) Not disclose the Confidential Information to unauthorized third parties or the general public, unless such disclosure is required and performed in accordance with applicable laws and regulations. However, BOEM and NOAA may disclose or provide access to the Confidential Information to those employees, consultants, contractors or Federal Government personnel who have a need to know such information in order to accomplish the purposes of this MOA, who will be bound and subject to the terms of this section; and
(e) Confidential Information furnished to any of the Parties under this MOA may be subject to applicable statutes and regulations that require its disclosure upon request, including, but not limited to, the Freedom of Information Act (FOIA, 5 U.S.C. § 552). For purposes of FOIA requests, each party will not release Confidential Information provided by the other party directly to a FOIA requester but, rather, will follow FOIA procedures by referring the FOIA request and/or the Confidential Information to the other party for review, determination, and response directly to the requester.

These confidentiality provisions apply to all Confidential Information, including but not limited to: e-mail messages; notes to the file; agendas, pre-meeting materials, presentations, and meeting notes or summaries; letters; technical studies (e.g., modeling); review evaluations; and all documents prepared by or for BOEM, NOAA, and/or a contractor or sub-contractor of either, as part of the collaboration established in this MOA.

The Parties' obligation to protect Confidential Information provided pursuant to this MOA from disclosure will survive the expiration or termination of this MOA. The Parties have the right to expressly waive any privilege with regard to such Confidential Information and will do so by advising the other party in writing of its decision to waive the privilege. Nothing in this section shall be interpreted as requiring the Parties to forgo their statutory and regulatory duties concerning disclosure of Confidential Information.

William Y. Brown
Acting Director
Bureau of Ocean Energy Management

6 AUGUST 2015
Date

Samuel D. Rauch III
Deputy Assistant Administrator
for Regulatory Programs
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

9/8/15
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.

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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

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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

BSEE AKOCS
Chief, Environmental Enforcement Branch (Regional Environmental Officer)
Regional Supervisor for Field Operations

BOEM AKOCS
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

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Carol Borgstrom, Director
United States Department of Energy
Office of NEPA Policy and Assistance
1000 Independence Ave., SW
Washington, DC 20585

Dear Ms. Borgstrom:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of Energy (DOE) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

2

Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with DOE and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. John Matuszak
United States Department of State
Bureau of Oceans and International Environmental and Scientific Affairs
Office of Environmental Policy
2201 C Street, NW
Washington, DC 20520

Dear Mr. Matuszak:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Bureau of Oceans and International Environmental and Scientific Affairs wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

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Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

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BOEM and NMFS look forward to continuing to work with the Bureau of Oceans and International Environmental and Scientific Affairs and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Olson

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Daniel E. Yuska Jr., Environmental Protection Specialist
United States Department of Transportation
Maritime Administration
Office of Environment
400 7th Street, SW
Washington, DC 20590-0003

Dear Mr. Yuska:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of Transportation wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

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We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the Department of Transportation and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior
BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Ann Miles, Director
Federal Energy Regulatory Commission
Division of Environment and Engineering
Office of Energy
888 First Street, NE
Washington, DC 20426

Dear Ms. Miles:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Federal Energy Regulatory Commission (FERC) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with FERC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Obrien

Joseph A. Christopher
Regional Supervisor
Office of Environment

BISON CONNECT

Fwd: FERC as a cooperating agency

Nord, Beth <beth.nord@boem.gov> Fri, Sep 13, 2013 at 2:31 PM
To: Trevis Olivier <trevis.olivier@boem.gov>, Andrea Heckman <andrea.heckman@boem.gov>

---------- Forwarded message ----------
From: **Goeke, Gary** <gary.goeke@boem.gov>
Date: Fri, Sep 13, 2013 at 1:49 PM
Subject: FERC as a cooperating agency
To: Beth Nord <beth.nord@boem.gov>, Kimberly Skrupky Warshaw <kimberly.skrupky@boem.gov>

Just received a phone call from Steve Bullard of FERC (202/502-6861).

FERC is declining our invitation to be a cooperating agency on the Gulf G&G EIS.

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Karen Gregory, Assistant Secretary
Federal Maritime Commission
800 N Capitol Street, NW
Washington, DC 20573-0001

Dear Ms. Gregory:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Federal Maritime Commission wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the Federal Maritime Commission and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Larry Bright, Chief
United States Fish and Wildlife Service
Branch of Conservation Planning Assistance
4401 N. Fairfax Drive, Room 420
Arlington, VA 22203

Dear Mr. Bright:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Fish and Wildlife Service (FWS) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with FWS and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior
BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Helen Serassio, Director
Gulf Coast Ecosystem Restoration Council
Environmental Compliance
1401 Constitution Avenue, NW
Washington, DC 20230

Dear Ms. Serassio:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Gulf Coast Ecosystem Restoration Council wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with Gulf Coast Ecosystem Restoration Council and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Barry Obiol
Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Gilbert Anaya, Chief
International Boundary and Water Commission
Environmental Management
4171 North Mesa
Suite C-100
El Paso, Texas 79902-1441

Dear Mr. Anaya:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the International Boundary and Water Commission (IBWC) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the IBWC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Obrof

Joseph A. Christopher
Regional Supervisor
Office of Environment

INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO

September 13, 2013

Gary D. Goeke
Bureau of Ocean Energy Management
Gulf of Mexico OCS Region
Office of Environment
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

Re: BOEM and NMFS Cooperating Agency Request for Programmatic EIS
Reference No. GM 623E

Dear Mr. Goeke:

The International Boundary and Water Commission, United States Section (USIBWC) appreciates the consideration to participate as a cooperating agency for the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) joint Programmatic Environmental Impact Statement (PEIS). The PEIS will evaluate environmental effects for the proposed action of continued permitting or authorization of geological and geophysical (G&G) activities in the United States portion of the Gulf of Mexico for oil and gas, marine minerals, and renewable energy programs; as well as provide environmental analysis for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities.

The Area of Interest (AOI) for the proposed project is outside of the USIBWC's Lower Rio Grande Flood Control Project and is beyond the jurisdiction of the USIBWC. The proposed project is not anticipated to have an impact to the projects or resources of the USIBWC. Therefore, the USIBWC respectfully declines the opportunity to be a cooperating agency on this PEIS.

Thank you again for your consideration. If you have any questions, please call me at (915) 832-4702.

Sincerely,

Gilbert Anaya
Division Chief
Environmental Management Division

The Commons, Building C, Suite 100 • 4171 N. Mesa Street • El Paso, Texas 79902-1441
(915) 832-4701 • Fax: (915) 832-4166 • http://www.ibwc.gov

United States Department of the Interior
BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Dr. Sue Goodfellow, Cultural Resources Specialist
United States Marine Corps
2 Navy Annex
Washington, DC 20380-1775

Dear Dr. Goodfellow:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Marine Corps wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the United States Marine Corps and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Christopher

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Michael L. Gosliner, General Counsel
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

Dear Mr. Gosliner:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Marine Mammal Commission (MMC) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the MMC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Ms. Rebecca J. Lent, Ph. D, Executive Director
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

AUG 2 3 2013

In Reply Refer To: GM 623E

Ms. Rebecca J. Lent, Ph. D, Executive Director
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

Dear Ms. Lent:

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BOEM and NMFS look forward to continuing to work with the MMC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Mr. Michael L. Gosliner, General Counsel
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

Call with Marine Mammal Commission

Goeke, Gary <gary.goeke@boem.gov> Wed, Sep 25, 2013 at 10:36 AM
To: Joe Christopher <Joseph.Christopher@boem.gov>, Barry Obiol <barry.obiol@boem.gov>, Beth Nord <beth.nord@boem.gov>, Trevis Olivier <Trevis.Olivier@boem.gov>, Andrea Heckman <Andrea.Heckman@boem.gov>

Just spoke with Rebecca Lent. The MMC has decided to NOT be a cooperating agency on the Gulf G&G EIS.

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Tina Norwood, Environmental Protection Specialist
National Aeronautics and Space Administration Headquarters
300 E Street, SW
Washington, DC 20546-0001

Dear Ms. Norwood:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Aeronautics and Space Administration (NASA) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with NASA and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Goeke

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Patmarie S. Nedelka, NOS NEPA Coordinator
National Oceanic and Atmospheric Administration
National Ocean Service
1315 East West Highway
Silver Spring, Maryland 20910

Dear Ms. Nedelka:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Ocean Service (NOS) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with NOS and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

Fwd: GM 623E - PEIS for G&G in Gulf of Mexico

1 message

Goeke, Gary <gary.goeke@boem.gov> Mon, Sep 23, 2013 at 3:17 PM
To: Beth Nord <beth.nord@boem.gov>, Andrea Heckman <Andrea.Heckman@boem.gov>, Trevis Olivier <Trevis.Olivier@boem.gov>

fyi

---------- Forwarded message ----------
From: **Vicki Wedell - NOAA Federal** <vicki.wedell@noaa.gov>
Date: Mon, Sep 23, 2013 at 2:16 PM
Subject: GM 623E - PEIS for G&G in Gulf of Mexico
To: gary.goeke@boem.gov
Cc: Patmarie Nedelka - NOAA Federal <patmarie.nedelka@noaa.gov>, Benjamin Laws - NOAA Federal <benjamin.laws@noaa.gov>, Leila Hatch <leila.hatch@noaa.gov>

Hello,

Thank you for contacting the NOAA National Ocean Service regarding BOEM's EIS for geological and geophysical activities in the Gulf of Mexico. My office - the Office of National Marine Sanctuaries - is interested in reviewing the document and will be coordinating with NOAA Fisheries Office of Protected Resources (OPR), which is already the NOAA lead for the cooperating agency arrangement with BOEM. Although our NEPA comments will be coordinated with OPR, should BOEM's action require consultation pursuant to the National Marine Sanctuaries Act, we would work directly with BOEM.

Thank you,
Vicki

--
Vicki Wedell
National Coordinator for Permitting, Consultations and NEPA
NOAA Office of National Marine Sanctuaries
1305 East-West Highway
Silver Spring, MD 20910

Phone: 301-713-7237
Cell: 240-676-3805
sanctuaries.noaa.gov

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Nicole Pak, NEPA Program Manager, N45
Department of the Navy
Commander Navy Installations Command
716 Sicard Street, SE
Suite 1000
Washington Navy Yard, DC 20374-5140

Dear Ms. Pak:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of the Navy (Navy) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the Navy and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Barry Obiol

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Ms. Karen Foskey
Department of the Navy
Office of the Chief of Naval Operations
Environmental Planning/NEPA Lead Operational Environmental Readiness and Planning
2000 Navy Pentagon
Washington, D.C. 20350-2000

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Karen Foskey
Department of the Navy
Office of the Chief of Naval Operations
Environmental Planning/NEPA Lead Operational Environmental Readiness and Planning
2000 Navy Pentagon
Washington, D.C. 20350-2000

Dear Ms. Foskey:

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BOEM and NMFS look forward to continuing to work with the Navy and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Ms. Nicole Pak, NEPA Program Manager, N45
Department of the Navy
Commander Navy Installations Command
716 Sicard Street, SE
Suite 1000
Washington Navy Yard, DC 20374-5140

Heckman, Andrea <andrea.heckman@boem.gov>

Fwd: Phone call from Navy on co-op agency

Nord, Beth <beth.nord@boem.gov> Fri, Sep 13, 2013 at 2:34 PM
To: Trevis Olivier <trevis.olivier@boem.gov>, Andrea Heckman <andrea.heckman@boem.gov>

---------- Forwarded message ----------
From: **Goeke, Gary** <gary.goeke@boem.gov>
Date: Fri, Sep 13, 2013 at 2:12 PM
Subject: Phone call from Navy on co-op agency
To: Beth Nord <beth.nord@boem.gov>, Kimberly Skrupky Warshaw <kimberly.skrupky@boem.gov>

Got phone call from Royce Kemp, US Navy, Jacksonville (904/542-6899) about co-operating agency status.

He wants to ask me a couple questions, but wasn't at his desk when I called back.

I'll let you know when he calls back.

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

Heckman, Andrea <andrea.heckman@boem.gov> Thu, Sep 19, 2013 at 5:09 PM
To: "Nord, Beth" <beth.nord@boem.gov>, Gary Goeke <Gary.Goeke@boem.gov>
Cc: Trevis Olivier <trevis.olivier@boem.gov>

Gary,

Did you ever get a chance to touch base with Royce Kemp?

Thank you!

Most Sincerely,
Andrea

Andrea Heckman
Environmental Scientist

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Patrick Walsh, Chief
National Park Service
Environmental Planning and Compliance Branch
PO Box 25287
Denver, Colorado 80225-0287

Dear Mr. Walsh:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Park Service wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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2

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BOEM and NMFS look forward to continuing to work with the National Park Service and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Caroline M. Blanco, Assistant General Counsel
National Science Foundation
General Counsel - Environment
11555 Rockville Pike
Rockville, Maryland 20852-2738

Dear Ms. Blanco:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Science Foundation wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

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BOEM and NMFS look forward to continuing to work with National Science Foundation and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

September 12, 2013

Joseph A. Christopher
U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of the Environment
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

RE: GM 623E

Dear Mr. Christopher:

The National Science Foundation (NSF) has received the request to be a cooperating agency from the Bureau of Ocean and Energy Management (BOEM) on a Programmatic Environmental Impact Statement (EIS) for geological and geophysical activities in the Gulf of Mexico (GOM). The NSF staff have been participating informally in scoping activities related to this effort when possible. While NSF appreciates the opportunity to consider formal participation in this BOEM effort, at this time, NSF has decided to not participate formally as a cooperating agency due to current program commitments and limited staff resources.

NSF is, however, interested in the BOEM GOM Programmatic EIS process. NSF will continue to monitor this process and, as resources allow, will participate in relevant GOM Programmatic EIS activities, such as scoping events and workshops.

Sincerely,

Holly Smith

Holly Smith
Environmental Compliance Officer

cc: Horst Greczmiel, CEQ
Caroline Blanco, NSF

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Chip Smith, Assistant for Environment, Tribal, and Regulatory Affairs
United States Army Corps of Engineers
Civil Works
108 Army Pentagon
Washington, DC 20310-0108

Dear Mr. Smith:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Army Corps of Engineers (USACE) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with USACE and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Mr. John C. Furry, Senior Policy Advisor
United States Army Corps of Engineers
Planning and Review
441 G Street NW
Washington, DC 20314-1000

Ms. Jennifer Moyer, Deputy Chief
United States Army Corps of Engineers
Regulatory Program
441 G Street NW
Washington, DC 20314-1000

United States Department of the Interior
BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. John C. Furry, Senior Policy Advisor
United States Army Corps of Engineers
Planning and Review
441 G Street NW
Washington, DC 20314-1000

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BOEM and NMFS look forward to continuing to work with USACE and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary D. Goeke

Joseph A. Christopher 2
Regional Supervisor
Office of Environment

cc: Ms. Jennifer Moyer, Deputy Chief
United States Army Corps of Engineers
Regulatory Program
441 G Street NW
Washington, DC 20314-1000

Mr. Chip Smith, Assistant for Environment, Tribal, and Regulatory Affairs
United States Army Corps of Engineers
Civil Works
108 Army Pentagon
Washington, DC 20310-0108

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

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United States Army Corps of Engineers
Regulatory Program
441 G Street NW
Washington, DC 20314-1000

Dear Ms. Moyer:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Army Corps of Engineers (USACE) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with USACE and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Mr. John C. Furry, Senior Policy Advisor
United States Army Corps of Engineers
Planning and Review
441 G Street NW
Washington, DC 20314-1000

Mr. Chip Smith, Assistant for Environment, Tribal, and Regulatory Affairs
United States Army Corps of Engineers
Civil Works
108 Army Pentagon
Washington, DC 20310-0108

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Ed Wandelt, Chief
United States Coast Guard
Environmental Management Division
2100 2nd Street, SW
Washington, DC 20593-0001

Dear Mr. Wandelt:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Coast Guard (USCG) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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2

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Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the USCG and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Goeke

Joseph A. Christopher
Regional Supervisor
Office of Environment

Heckman, Andrea <andrea.heckman@boem.gov>

GOM G&G - Federal Register, Scoping Presentation, Project Website

Kelley, Kebby CIV <Kebby.Kelley@uscg.mil> Tue, Dec 3, 2013 at 1:25 PM
To: "andrea.heckman@boem.gov" <andrea.heckman@boem.gov>
Cc: "Bock, Edward L CDR" <Edward.L.Bock@uscg.mil>, "Sligh, Kevin M CIV" <Kevin.M.Sligh@uscg.mil>, "Bobick, Andrew L CIV" <Andrew.L.Bobick@uscg.mil>

Andrea,

I have spoken to HQ and field USCG personnel about your cooperating agency request. The USCG is declining to be a cooperating agency; however, we are an interested party and would like to receive all public notice and other publically available information on the NEPA for GOM G&G including the draft NEPA document for comment. To cover USCG HQ interested parties, please use my below contact information, and I will disperse to those interested in our headquarters. For our field, the following USCG contact will disperse to appropriate USCG field folks:

Mr. Andy Bobick
United States Coast Guard
Civil Engineering Unit Miami
15608 SW 117TH AVE
MIAMI, FL 33177-1623
(305) 278-6749

Ms. Kebby Kelley
Environmental Planning Team Lead
ATTN: Office of Environmental Management (CG-47)
United States Coast Guard Headquarters, STOP 7714
2703 Martin Luther King Jr. Avenue. SE
Washington, DC 20593-7714
email: Kebby.Kelley@uscg.mil
Phone: 202-475-5690
Fax: 202-372-8419

-----Original Message-----
From: andrea.heckman@boem.gov [mailto:andrea.heckman@boem.gov]
Sent: Thursday, October 31, 2013 3:18 PM
To: Kelley, Kebby CIV
Cc: Trevis Olivier; Beth Nord; Gary Goeke; Kimberly Skrupky Warshaw; Tamara Arzt
Subject: GOM G&G - Federal Register, Scoping Presentation, Project Website

Dear Ms. Kelley:

Hello, my name is Andrea Heckman. I am one of the NEPA Coordinators assisting Ms. Beth Nord (Lead/Senior NEPA Coordinator) on the GOM G&G PEIS.

We wanted to send some additional information for you to share with your team in your discussions about becoming a cooperating agency. We have included:

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Cliff Rader, Director
United States Environmental Protection Agency
NEPA Compliance Division
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Dear Mr. Rader:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Environmental Protection Agency (USEPA) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

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Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with USEPA and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Esther Eng, Chief
United States Geological Survey
Environmental Management Branch
12201 Sunrise Valley Drive
Reston, Virginia 20192

Dear Ms. Eng:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Geological Service (USGS) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the USGS and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Jack Bush, NEPA Program Manager
Department of the Air Force
1260 Air Force Pentagon
Washington, DC 20330-1260

Dear Mr. Bush:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of the Air Force wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the United States Department of the Air Force and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Goeke
Joseph A. Christopher
Regional Supervisor
Office of Environment

BISON CONNECT

FW: Feedback: Cooperating Agency Point of Contact

Chavers, Thomas L Civ USAF AFMC 96 CEG/CEVSP Wed, Sep 11, 2013 at 8:52 AM
<Thomas.Chavers@eglin.af.mil>
To: trevis.olivier@boem.gov

Trevis
I am the Lead NEPA program manager at Eglin AFB. Please give me a call if you are still interested in having us participate as a cooperating agency on your document

Larry Chavers
Chief, Environmental Analysis
850-882-0143/8391

-----Original Message-----

From: Spaits, Mike GS12 USAF AFMC 96 TW/PA

Sent: Monday, June 17, 2013 1:17 PM

To: Chavers, Thomas L Civ USAF AFMC 96 CEG/CEVSP

Subject: FW: Feedback: Cooperating Agency Point of Contact

Larry,

See below. Do you want to contact him?

Thanks,

Mike Spaits

Eglin Environmental Public Affairs

O - (850) 882-2836

C - (850) 621-3391

-----Original Message-----

Memorandum of Agreement
between the
Bureau of Ocean Energy Management
and the
National Oceanic and Atmospheric Administration
regarding completion of a
Programmatic Environmental Impact Statement
for Geological and Geophysical Activities
in the Gulf of Mexico

INTRODUCTION

The Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration (NOAA) (hereinafter, collectively referred to as the "Parties) have partnered to prepare a Programmatic Environmental Impact Statement (PEIS) for geological and geophysical activities in the Gulf of Mexico.

Section 1501.6 of the Council on Environmental (CEQ) regulations emphasizes agency cooperation in the National Environmental Policy Act (NEPA) process when federal agencies either have overlapping jurisdiction or special expertise related to a proposed action.

This Memorandum of Agreement (MOA) is designed to establish expectations between the Parties, with BOEM as the lead agency and NOAA as a cooperating agency, for the PEIS and supersedes the June 2013 MOA that established BOEM and NOAA as co-lead agencies. This MOA outlines the responsibilities agreed to by the Parties for this PEIS project. This MOA does not affect NOAA's role and responsibilities under the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and/or other applicable laws. This MOA does not affect BOEM's responsibilities under the Outer Continental Shelf Lands Act (OCSLA), regulations implementing OCSLA, and/or other applicable laws.

BOEM RESPONSIBILITIES

1) BOEM is the lead agency for this PEIS;

2) BOEM will designate a primary point of contact (POC) for matters related to the MOA;

3) BOEM will have the lead in arranging and holding scoping and public meetings for the Draft PEIS;

4) BOEM will be the POC for all work with the contractor preparing the PEIS;

5) BOEM will ensure that NOAA has the opportunity to participate in monthly meetings, plus any additional meetings on specific content, with the contractor regarding the preparation of the subject PEIS;

6) Recognizing that the review times may be fluid, but the deadlines for completing each task are critical, BOEM will comply with and adhere to the agreed upon schedule for the PEIS, MMPA rulemaking petition, and ESA consultation;

7) BOEM will provide NOAA a copy and summary of all comments received during preparation of the PEIS (including scoping and Draft PEIS public comment periods, and Final PEIS;

8) BOEM will place a copy of the MOA in an appendix to the PEIS;

9) BOEM will ensure that NOAA has the opportunity to fully participate in development of the PEIS so NOAA can ensure that the PEIS fully satisfies its obligations under NEPA. This will include an opportunity for NOAA to contribute to the development of the Draft and Final PEIS and review periods for the preliminary Draft and Final PEIS;

10) BOEM will respond to all comments received from NOAA; and

11) BOEM's responsibilities for compliance with any environmental laws, including consultations, are not affected by this MOA.

NOAA RESPONSIBILITIES

1) NOAA is a cooperating agency for preparation of the PEIS;

2) NOAA will designate a primary POC to represent NOAA in matters related to this MOA;

3) NOAA will participate in the development of the Draft and Final PEIS, including drafting chapters and alternatives, commenting on draft chapters and responding to or reviewing the responses to public comments that relate to NOAA's areas of expertise;

4) Recognizing that the review times may be fluid, but the deadlines for completing each task are critical, NOAA will comply with and adhere to the agreed upon schedule for the PEIS, the MMPA rulemaking petition, and ESA consultation, including all solicited inputs and review periods;

5) NOAA may contribute to the development of and participate in the public hearing process;

6) NOAA may participate in the monthly meetings, plus any additional meetings on specific content, with the contractor regarding the preparation of the subject PEIS;

7) NOAA will participate in the drafting of the PEIS to ensure that the PEIS fully satisfies NOAA's own obligations under NEPA; NOAA will assume, on request of BOEM, the responsibility for developing information and preparing environmental analyses, including drafting portions of the PEIS, for matters in which NOAA has special expertise (e.g., foreseeable impacts to marine mammals);

8) NOAA will be responsible for any expenses incurred by NOAA related to this MOA; and

9) NOAA's responsibilities for compliance with any environmental laws, including consultations, are not affected by this MOA.

TERMINATION

The MOA may be terminated at any time by written notice from any of the signatories below or their successors. This MOA will otherwise terminate automatically 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 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 duly authorized representatives of the Parties. This MOA does not create any right or benefit enforceable against BOEM or NOAA, their officers or employees, or any other person. This MOA does not apply to any person outside the Parties.

RESOLUTION OF DISPUTES

The Parties agree to make every attempt to settle any disputes regarding this MOA at the lowest operational level. In the case of a substantial disagreement between the Parties, each party will designate a senior management official in their respective agencies to seek resolution. If resolution is not reached within 30 days, the Parties will further elevate the matter to the Director of BOEM, and the Deputy Assistant Administrator of NOAA for prompt resolution.

CONFIDENTIAL INFORMATION

To the extent allowed under applicable law, the Parties hereby agree to:

(a) Protect and maintain as confidential all privileged, deliberative, and/or predecisional information and documents created (by or for) and/or shared between BOEM and NOAA as part of the collaboration established in this MOA (hereinafter, referred to as "Confidential Information");

(b) Exercise the same degree of care –but not less than a reasonable degree of care – they would exercise with their confidential information to prevent its unauthorized disclosure;

(c) Use the Confidential Information solely for the purposes of this MOA;

(d) Not disclose the Confidential Information to unauthorized third parties or the general public, unless such disclosure is required and performed in accordance with applicable laws and regulations. However, BOEM and NOAA may disclose or provide access to the Confidential Information to those employees, consultants, contractors or Federal Government personnel who have a need to know such information in order to accomplish the purposes of this MOA, who will be bound and subject to the terms of this section; and

(e) Confidential Information furnished to any of the Parties under this MOA may be subject to applicable statutes and regulations that require its disclosure upon request, including, but not limited to, the Freedom of Information Act (FOIA, 5 U.S.C. § 552). For purposes of FOIA requests, each party will not release Confidential Information provided by the other party directly to a FOIA requester but, rather, will follow FOIA procedures by referring the FOIA request and/or the Confidential Information to the other party for review, determination, and response directly to the requester.

These confidentiality provisions apply to all Confidential Information, including but not limited to: e-mail messages; notes to the file; agendas, pre-meeting materials, presentations, and meeting notes or summaries; letters; technical studies (e.g., modeling); review evaluations; and all documents prepared by or for BOEM, NOAA, and/or a contractor or sub-contractor of either, as part of the collaboration established in this MOA.

The Parties' obligation to protect Confidential Information provided pursuant to this MOA from disclosure will survive the expiration or termination of this MOA. The Parties have the right to expressly waive any privilege with regard to such Confidential Information and will do so by advising the other party in writing of its decision to waive the privilege. Nothing in this section shall be interpreted as requiring the Parties to forgo their statutory and regulatory duties concerning disclosure of Confidential Information.

William Y. Brown
Acting Director
Bureau of Ocean Energy Management

6 AUGUST 2015
Date

Samuel D. Rauch III
Deputy Assistant Administrator
for Regulatory Programs
National Marine Fisheries Service
National Oceanic and Atmospheric Administration

9/8/15
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

BOEM Deputy Director — 10/3/11 Date

BSEE Deputy Director, Acting — 10/3/11 Date

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Carol Borgstrom, Director
United States Department of Energy
Office of NEPA Policy and Assistance
1000 Independence Ave., SW
Washington, DC 20585

Dear Ms. Borgstrom:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of Energy (DOE) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with DOE and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. John Matuszak
United States Department of State
Bureau of Oceans and International Environmental and Scientific Affairs
Office of Environmental Policy
2201 C Street, NW
Washington, DC 20520

Dear Mr. Matuszak:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Bureau of Oceans and International Environmental and Scientific Affairs wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

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BOEM and NMFS look forward to continuing to work with the Bureau of Oceans and International Environmental and Scientific Affairs and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Obrien

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Daniel E. Yuska Jr., Environmental Protection Specialist
United States Department of Transportation
Maritime Administration
Office of Environment
400 7th Street, SW
Washington, DC 20590-0003

Dear Mr. Yuska:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of Transportation wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

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We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the Department of Transportation and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Ann Miles, Director
Federal Energy Regulatory Commission
Division of Environment and Engineering
Office of Energy
888 First Street, NE
Washington, DC 20426

Dear Ms. Miles:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Federal Energy Regulatory Commission (FERC) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

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Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with FERC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

Fwd: FERC as a cooperating agency

Nord, Beth <beth.nord@boem.gov> Fri, Sep 13, 2013 at 2:31 PM
To: Trevis Olivier <trevis.olivier@boem.gov>, Andrea Heckman <andrea.heckman@boem.gov>

---------- Forwarded message ----------
From: **Goeke, Gary** <gary.goeke@boem.gov>
Date: Fri, Sep 13, 2013 at 1:49 PM
Subject: FERC as a cooperating agency
To: Beth Nord <beth.nord@boem.gov>, Kimberly Skrupky Warshaw <kimberly.skrupky@boem.gov>

Just received a phone call from Steve Bullard of FERC (202/502-6861).

FERC is declining our invitation to be a cooperating agency on the Gulf G&G EIS.

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Karen Gregory, Assistant Secretary
Federal Maritime Commission
800 N Capitol Street, NW
Washington, DC 20573-0001

Dear Ms. Gregory:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Federal Maritime Commission wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the Federal Maritime Commission and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Larry Bright, Chief
United States Fish and Wildlife Service
Branch of Conservation Planning Assistance
4401 N. Fairfax Drive, Room 420
Arlington, VA 22203

Dear Mr. Bright:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Fish and Wildlife Service (FWS) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

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BOEM and NMFS look forward to continuing to work with FWS and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Helen Serassio, Director
Gulf Coast Ecosystem Restoration Council
Environmental Compliance
1401 Constitution Avenue, NW
Washington, DC 20230

Dear Ms. Serassio:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Gulf Coast Ecosystem Restoration Council wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with Gulf Coast Ecosystem Restoration Council and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Barry Obiol

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Gilbert Anaya, Chief
International Boundary and Water Commission
Environmental Management
4171 North Mesa
Suite C-100
El Paso, Texas 79902-1441

Dear Mr. Anaya:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the International Boundary and Water Commission (IBWC) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the IBWC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

INTERNATIONAL BOUNDARY AND WATER COMMISSION
UNITED STATES AND MEXICO

September 13, 2013

Gary D. Goeke
Bureau of Ocean Energy Management
Gulf of Mexico OCS Region
Office of Environment
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

Re: BOEM and NMFS Cooperating Agency Request for Programmatic EIS
Reference No. GM 623E

Dear Mr. Goeke:

The International Boundary and Water Commission, United States Section (USIBWC) appreciates the consideration to participate as a cooperating agency for the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) joint Programmatic Environmental Impact Statement (PEIS). The PEIS will evaluate environmental effects for the proposed action of continued permitting or authorization of geological and geophysical (G&G) activities in the United States portion of the Gulf of Mexico for oil and gas, marine minerals, and renewable energy programs; as well as provide environmental analysis for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities.

The Area of Interest (AOI) for the proposed project is outside of the USIBWC's Lower Rio Grande Flood Control Project and is beyond the jurisdiction of the USIBWC. The proposed project is not anticipated to have an impact to the projects or resources of the USIBWC. Therefore, the USIBWC respectfully declines the opportunity to be a cooperating agency on this PEIS.

Thank you again for your consideration. If you have any questions, please call me at (915) 832-4702.

Sincerely,

Gilbert Anaya

Gilbert Anaya
Division Chief
Environmental Management Division

The Commons, Building C, Suite 100 • 4171 N. Mesa Street • El Paso, Texas 79902-1441
(915) 832-4701 • Fax: (915) 832-4166 • http://www.ibwc.gov

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Dr. Sue Goodfellow, Cultural Resources Specialist
United States Marine Corps
2 Navy Annex
Washington, DC 20380-1775

Dear Dr. Goodfellow:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Marine Corps wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the United States Marine Corps and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Goeke for

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Michael L. Gosliner, General Counsel
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

Dear Mr. Gosliner:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Marine Mammal Commission (MMC) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the MMC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Ms. Rebecca J. Lent, Ph. D, Executive Director
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Rebecca J. Lent, Ph. D, Executive Director
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

Dear Ms. Lent:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the Marine Mammal Commission (MMC) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the MMC and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Mr. Michael L. Gosliner, General Counsel
Marine Mammal Commission
4340 East-West Highway, Suite 700
Bethesda, Maryland 20814

BISON CONNECT

Heckman, Andrea <andrea.heckman@boem.gov>

Call with Marine Mammal Commission

Goeke, Gary <gary.goeke@boem.gov> Wed, Sep 25, 2013 at 10:36 AM
To: Joe Christopher <Joseph.Christopher@boem.gov>, Barry Obiol <barry.obiol@boem.gov>, Beth Nord <beth.nord@boem.gov>, Trevis Olivier <Trevis.Olivier@boem.gov>, Andrea Heckman <Andrea.Heckman@boem.gov>

Just spoke with Rebecca Lent. The MMC has decided to NOT be a cooperating agency on the Gulf G&G EIS.

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Tina Norwood, Environmental Protection Specialist
National Aeronautics and Space Administration Headquarters
300 E Street, SW
Washington, DC 20546-0001

Dear Ms. Norwood:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Aeronautics and Space Administration (NASA) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with NASA and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Patmarie S. Nedelka, NOS NEPA Coordinator
National Oceanic and Atmospheric Administration
National Ocean Service
1315 East West Highway
Silver Spring, Maryland 20910

Dear Ms. Nedelka:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Ocean Service (NOS) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with NOS and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Barry Obiol for

Joseph A. Christopher
Regional Supervisor
Office of Environment

Fwd: GM 623E - PEIS for G&G in Gulf of Mexico

Goeke, Gary <gary.goeke@boem.gov> Mon, Sep 23, 2013 at 3:17 PM
To: Beth Nord <beth.nord@boem.gov>, Andrea Heckman <Andrea.Heckman@boem.gov>, Trevis Olivier <Trevis.Olivier@boem.gov>

fyi

---------- Forwarded message ----------
From: **Vicki Wedell - NOAA Federal** <vicki.wedell@noaa.gov>
Date: Mon, Sep 23, 2013 at 2:16 PM
Subject: GM 623E - PEIS for G&G in Gulf of Mexico
To: gary.goeke@boem.gov
Cc: Patmarie Nedelka - NOAA Federal <patmarie.nedelka@noaa.gov>, Benjamin Laws - NOAA Federal <benjamin.laws@noaa.gov>, Leila Hatch <leila.hatch@noaa.gov>

Hello,

Thank you for contacting the NOAA National Ocean Service regarding BOEM's EIS for geological and geophysical activities in the Gulf of Mexico. My office - the Office of National Marine Sanctuaries - is interested in reviewing the document and will be coordinating with NOAA Fisheries Office of Protected Resources (OPR), which is already the NOAA lead for the cooperating agency arrangement with BOEM. Although our NEPA comments will be coordinated with OPR, should BOEM's action require consultation pursuant to the National Marine Sanctuaries Act, we would work directly with BOEM.

Thank you,
Vicki

--
Vicki Wedell
National Coordinator for Permitting, Consultations and NEPA
NOAA Office of National Marine Sanctuaries
1305 East-West Highway
Silver Spring, MD 20910

Phone: 301-713-7237
Cell: 240-676-3805
sanctuaries.noaa.gov

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Nicole Pak, NEPA Program Manager, N45
Department of the Navy
Commander Navy Installations Command
716 Sicard Street, SE
Suite 1000
Washington Navy Yard, DC 20374-5140

Dear Ms. Pak:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of the Navy (Navy) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the Navy and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Barry Obiol

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Ms. Karen Foskey
Department of the Navy
Office of the Chief of Naval Operations
Environmental Planning/NEPA Lead Operational Environmental Readiness and Planning
2000 Navy Pentagon
Washington, D.C. 20350-2000

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Karen Foskey
Department of the Navy
Office of the Chief of Naval Operations
Environmental Planning/NEPA Lead Operational Environmental Readiness and Planning
2000 Navy Pentagon
Washington, D.C. 20350-2000

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BOEM and NMFS look forward to continuing to work with the Navy and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Ms. Nicole Pak, NEPA Program Manager, N45
Department of the Navy
Commander Navy Installations Command
716 Sicard Street, SE
Suite 1000
Washington Navy Yard, DC 20374-5140

Heckman, Andrea <andrea.heckman@boem.gov>

Fwd: Phone call from Navy on co-op agency

1 message

Nord, Beth <beth.nord@boem.gov> Fri, Sep 13, 2013 at 2:34 PM
To: Trevis Olivier <trevis.olivier@boem.gov>, Andrea Heckman <andrea.heckman@boem.gov>

---------- Forwarded message ----------
From: **Goeke, Gary** <gary.goeke@boem.gov>
Date: Fri, Sep 13, 2013 at 2:12 PM
Subject: Phone call from Navy on co-op agency
To: Beth Nord <beth.nord@boem.gov>, Kimberly Skrupky Warshaw <kimberly.skrupky@boem.gov>

Got phone call from Royce Kemp, US Navy, Jacksonville (904/542-6899) about co-operating agency status.

He wants to ask me a couple questions, but wasn't at his desk when I called back.

I'll let you know when he calls back.

--
Gary D. Goeke
Chief, Environmental Assessment Section
Office of the Environment
Gulf of Mexico Region
504/736-3233

Heckman, Andrea <andrea.heckman@boem.gov> Thu, Sep 19, 2013 at 5:09 PM
To: "Nord, Beth" <beth.nord@boem.gov>, Gary Goeke <Gary.Goeke@boem.gov>
Cc: Trevis Olivier <trevis.olivier@boem.gov>

Gary,

Did you ever get a chance to touch base with Royce Kemp?

Thank you!

Most Sincerely,
Andrea

Andrea Heckman
Environmental Scientist

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Patrick Walsh, Chief
National Park Service
Environmental Planning and Compliance Branch
PO Box 25287
Denver, Colorado 80225-0287

Dear Mr. Walsh:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Park Service wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the National Park Service and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary D. Goeke

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Caroline M. Blanco, Assistant General Counsel
National Science Foundation
General Counsel - Environment
11555 Rockville Pike
Rockville, Maryland 20852-2738

Dear Ms. Blanco:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the National Science Foundation wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with National Science Foundation and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

September 12, 2013

Joseph A. Christopher
U.S. Department of the Interior
Bureau of Ocean Energy Management
Office of the Environment
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

RE: GM 623E

Dear Mr. Christopher:

The National Science Foundation (NSF) has received the request to be a cooperating agency from the Bureau of Ocean and Energy Management (BOEM) on a Programmatic Environmental Impact Statement (EIS) for geological and geophysical activities in the Gulf of Mexico (GOM). The NSF staff have been participating informally in scoping activities related to this effort when possible. While NSF appreciates the opportunity to consider formal participation in this BOEM effort, at this time, NSF has decided to not participate formally as a cooperating agency due to current program commitments and limited staff resources.

NSF is, however, interested in the BOEM GOM Programmatic EIS process. NSF will continue to monitor this process and, as resources allow, will participate in relevant GOM Programmatic EIS activities, such as scoping events and workshops.

Sincerely,

Holly Smith

Holly Smith
Environmental Compliance Officer

cc: Horst Greczmiel, CEQ
Caroline Blanco, NSF

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Chip Smith, Assistant for Environment, Tribal, and Regulatory Affairs
United States Army Corps of Engineers
Civil Works
108 Army Pentagon
Washington, DC 20310-0108

Dear Mr. Smith:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Army Corps of Engineers (USACE) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with USACE and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary Goeke

Joseph A. Christopher
Regional Supervisor
Office of Environment

cc: Mr. John C. Furry, Senior Policy Advisor
United States Army Corps of Engineers
Planning and Review
441 G Street NW
Washington, DC 20314-1000

Ms. Jennifer Moyer, Deputy Chief
United States Army Corps of Engineers
Regulatory Program
441 G Street NW
Washington, DC 20314-1000

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

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United States Army Corps of Engineers
Planning and Review
441 G Street NW
Washington, DC 20314-1000

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2

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Gary Obiol

Joseph A. Christopher 2
Regional Supervisor
Office of Environment

cc: Ms. Jennifer Moyer, Deputy Chief
United States Army Corps of Engineers
Regulatory Program
441 G Street NW
Washington, DC 20314-1000

Mr. Chip Smith, Assistant for Environment, Tribal, and Regulatory Affairs
United States Army Corps of Engineers
Civil Works
108 Army Pentagon
Washington, DC 20310-0108

United States Department of the Interior
BUREAU OF OCEAN ENERGY MANAGEMENT
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Regulatory Program
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Washington, DC 20314-1000

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Office of Environment

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United States Army Corps of Engineers
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United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Ed Wandelt, Chief
United States Coast Guard
Environmental Management Division
2100 2nd Street, SW
Washington, DC 20593-0001

Dear Mr. Wandelt:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Coast Guard (USCG) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with the USCG and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

BISON CONNECT

Heckman, Andrea <andrea.heckman@boem.gov>

GOM G&G - Federal Register, Scoping Presentation, Project Website

Kelley, Kebby CIV <Kebby.Kelley@uscg.mil> Tue, Dec 3, 2013 at 1:25 PM
To: "andrea.heckman@boem.gov" <andrea.heckman@boem.gov>
Cc: "Bock, Edward L CDR" <Edward.L.Bock@uscg.mil>, "Sligh, Kevin M CIV" <Kevin.M.Sligh@uscg.mil>, "Bobick, Andrew L CIV" <Andrew.L.Bobick@uscg.mil>

Andrea,

I have spoken to HQ and field USCG personnel about your cooperating agency request. The USCG is declining to be a cooperating agency; however, we are an interested party and would like to receive all public notice and other publically available information on the NEPA for GOM G&G including the draft NEPA document for comment. To cover USCG HQ interested parties, please use my below contact information, and I will disperse to those interested in our headquarters. For our field, the following USCG contact will disperse to appropriate USCG field folks:

Mr. Andy Bobick
United States Coast Guard
Civil Engineering Unit Miami
15608 SW 117TH AVE
MIAMI, FL 33177-1623
(305) 278-6749

Ms. Kebby Kelley
Environmental Planning Team Lead
ATTN: Office of Environmental Management (CG-47)
United States Coast Guard Headquarters, STOP 7714
2703 Martin Luther King Jr. Avenue. SE
Washington, DC 20593-7714
email: Kebby.Kelley@uscg.mil
Phone: 202-475-5690
Fax: 202-372-8419

-----Original Message-----
From: andrea.heckman@boem.gov [mailto:andrea.heckman@boem.gov]
Sent: Thursday, October 31, 2013 3:18 PM
To: Kelley, Kebby CIV
Cc: Trevis Olivier; Beth Nord; Gary Goeke; Kimberly Skrupky Warshaw; Tamara Arzt
Subject: GOM G&G - Federal Register, Scoping Presentation, Project Website

Dear Ms. Kelley:

Hello, my name is Andrea Heckman. I am one of the NEPA Coordinators assisting Ms. Beth Nord (Lead/Senior NEPA Coordinator) on the GOM G&G PEIS.

We wanted to send some additional information for you to share with your team in your discussions about becoming a cooperating agency. We have included:

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Cliff Rader, Director
United States Environmental Protection Agency
NEPA Compliance Division
Ariel Rios Building
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Dear Mr. Rader:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Environmental Protection Agency (USEPA) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

BOEM is the Federal Agency responsible for managing offshore energy and mineral resources on the Outer Continental Shelf (OCS), and NMFS is the Federal Agency responsible for the management, conservation, and protection of living marine resources within the United States' Exclusive Economic Zone. BOEM and NMFS are acting as co-lead agencies for the preparation of this Programmatic EIS. In addition, the Programmatic EIS would serve as a reference document to implement the "tiering" objective detailed in NEPA's implementing regulations (40 CFR 1502.20) for future site-specific activities.

Our *Federal Register* Notice of Intent to prepare a Programmatic EIS, which was published on May 10, 2013 (78 FR 27427), contained a scoping period and announced public scoping meetings and a request for other Federal Agencies and State, Tribal and local governments to consider becoming cooperating agencies. The proposed G&G activities include the following: deep penetration, shallow hazard, and high-resolution geophysical (HRG) seismic airgun surveys; active acoustic source/HRG surveys (non-airgun) to detect shallow geohazards and marine minerals, archaeological, and benthic resources; surveys and sampling activities including electromagnetic surveys, deep stratigraphic and shallow test drilling, and various remote-sensing methods; and geological and geotechnical bottom sampling used to assess the suitability of seafloor sediments for supporting structures (e.g., platforms, pipelines, cables, wind turbines) or to evaluate the quantity and quality of marine minerals and sand for beach nourishment.

2

Our *Federal Register* Notice of June 5, 2013 (78 FR 33859), corrected the closing date of the scoping period to July 9, 2013.

Should you affirm an interest, we will provide to your contact(s) a draft schedule for our NEPA evaluation and a draft Memorandum of Understanding for your consideration to establish this relationship.

We request that you or a member of your staff respond in writing to Mr. Gary D. Goeke by September 20, 2013, to confirm your participation as a cooperating agency in the preparation of our Programmatic EIS and to provide a point of contact with whom we may initiate discussion. Mr. Goeke can also be reached at (504) 736-3233 or by email at gary.goeke@boem.gov.

BOEM and NMFS look forward to continuing to work with USEPA and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Barry Obiol
Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Ms. Esther Eng, Chief
United States Geological Survey
Environmental Management Branch
12201 Sunrise Valley Drive
Reston, Virginia 20192

Dear Ms. Eng:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Geological Service (USGS) wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the USGS and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Joseph A. Christopher
Regional Supervisor
Office of Environment

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT
Gulf of Mexico OCS Region
1201 Elmwood Park Boulevard
New Orleans, LA 70123-2394

In Reply Refer To: GM 623E

AUG 2 3 2013

Mr. Jack Bush, NEPA Program Manager
Department of the Air Force
1260 Air Force Pentagon
Washington, DC 20330-1260

Dear Mr. Bush:

In accordance with the Council on Environmental Quality's regulations (40 CFR 1501.6), the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) inquires whether or not the United States Department of the Air Force wishes to participate as a cooperating agency in the preparation of a Programmatic Environmental Impact Statement (EIS).

BOEM and NMFS have jointly begun the process of preparing a Programmatic EIS for the proposed action of the continued permitting or authorization of geological and geophysical (G&G) activities in the U.S. portion of the Gulf of Mexico in support of the oil and gas, marine minerals, and renewable energy programs; and to provide environmental analysis under National Environmental Policy Act (NEPA) for NMFS Endangered Species Act consultation and Marine Mammal Protection Act rulemaking governing authorization for unintentional marine mammal takes during G&G activities in Gulf of Mexico waters.

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BOEM and NMFS look forward to continuing to work with the United States Department of the Air Force and with you to assure that the benefits of OCS energy development activities continue in an environmentally sound and safe manner.

Sincerely,

Gary D. Goeke

Joseph A. Christopher
Regional Supervisor
Office of Environment

BISON CONNECT

FW: Feedback: Cooperating Agency Point of Contact

Chavers, Thomas L Civ USAF AFMC 96 CEG/CEVSP <Thomas.Chavers@eglin.af.mil> Wed, Sep 11, 2013 at 8:52 AM
To: trevis.olivier@boem.gov

Trevis
I am the Lead NEPA program manager at Eglin AFB. Please give me a call if you are still interested in having us participate as a cooperating agency on your document

Larry Chavers
Chief, Environmental Analysis
850-882-0143/8391

-----Original Message-----

From: Spaits, Mike GS12 USAF AFMC 96 TW/PA

Sent: Monday, June 17, 2013 1:17 PM

To: Chavers, Thomas L Civ USAF AFMC 96 CEG/CEVSP

Subject: FW: Feedback: Cooperating Agency Point of Contact

Larry,

See below. Do you want to contact him?

Thanks,

Mike Spaits

Eglin Environmental Public Affairs

O - (850) 882-2836

C - (850) 621-3391

-----Original Message-----

APPENDIX B

PROTECTIVE MEASURES AND MITIGATION AND REGULATORY REQUIREMENTS

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ABBREVIATIONS AND ACRONYMS

3D	three-dimensional
4D	four-dimensional
ACAA	Alabama Coastal Area Act
ACAMP	Alabama Coastal Area Management Program
ACHP	Advisory Council on Historic Preservation
ADCNR	Alabama Department of Conservation and Natural Resources
ADEM	Alabama Department of Environmental Management
AOI	area of interest
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CAA	Clean Air Act
CATEX	categorical exclusion
CD-ROM	compact disc-read only memory
CEQ	Council on Environmental Quality
CFDL	Coastal Facilities Designation Line
CFR	Code of Federal Regulation
CHIRP	compressed high-intensity radiated pulse
CMP	Coastal Management Program
CNRA	coastal natural resource area
COA	condition of approval
COP	Construction and Operations Plan
CPA	Central Planning Area
CWA	Clean Water Act
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
dB re 1 μPa	decibels referenced to 1 micropascal
DEP	Department of Environmental Protection
DOCD	Development Operations Coordination Document
DPP	Development and Production Plan
EA	Environmental Assessment
EFH	essential fish habitat
EIS	Environmental Impact Statement
EPA	Eastern Planning Area
EPAct	Energy Policy Act
ESA	Endangered Species Act
FCMP	Florida Coastal Management Program

FMP	Fishery Management Plan
FR	*Federal Register*
FWCA	Fish and Wildlife Coordination Act
FWS	Fish and Wildlife Service (USDOI)
G&G	geological and geophysical
GAP	General Activities Plan
GOM	Gulf of Mexico
H.R.	House Resolution
HRG	high-resolution geophysical
Hz	hertz
IHA	Incidental Harassment Authorization
ITA	Incidental Take Authorization
ITS	Incidental Take Statement
kHz	kilohertz
km	kilometer
LOA	Letter of Authorization
LOCM	Louisiana Office of Coastal Management
m	meter
MARPOL	International Convention for the Prevention of Pollution from Ships
MBTA	Migratory Bird Treaty Act
MCP	Mississippi Coastal Program
mi	mile
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MODU	mobile offshore drilling unit
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MPPRCA	Marine Plastic Pollution Research and Control Act
MPRSA	Marine Protection, Research, and Sanctuaries Act
MSD	marine sanitation device
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
nmi	nautical mile
NMS	National Marine Sanctuary
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration

NOS	National Ocean Service
NPDES	National Pollutant Discharge Elimination System
NTL	Notice to Lessees and Operators
NWP	Nationwide Permit
OBC	ocean bottom cable
OBN	ocean bottom node
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OMB	Office of Management and Budget
ONMS	Office of National Marine Sanctuary
P.L.	Public Law
PAM	passive acoustic monitoring
PSO	protected species observer
rms	root mean square
SAP	Site Assessment Plan
TCMP	Texas Coastal Management Program
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USDOC	U.S. Department of Commerce
USDOD	U.S. Department of Defense
USDOI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
yd	yard

1 PROTECTIVE MEASURES AND MITIGATION

The Bureau of Ocean Energy Management (BOEM) is proposing to authorize geological and geophysical (G&G) activities in connection with its Oil and Gas, Renewable Energy, and Marine Minerals Programs in Federal waters of the Gulf of Mexico (GOM) and adjacent State waters. The area of interest (AOI) for the proposed action includes the Federal OCS waters of the GOM within BOEM's Gulf of Mexico WPA, CPA, and EPA. The AOI also includes the coastal (i.e., State) waters of Texas, Louisiana, Mississippi, Alabama, and Florida, extending from the coastline outside of estuaries seaward 3 nautical miles (nmi) (3.5 miles [mi]; 5.6 kilometers [km]) from Louisiana, Mississippi, and Alabama, and seaward to 9 nmi (10.4 mi; 16.7 km) from the coastlines of Texas and Florida (**Figure B-1**). BOEM does not approve G&G activities in State waters; however, since G&G activities in OCS waters can potentially impact resources in State waters (e.g., sound traveling from OCS areas into State waters), for purposes of impacts analysis in this Programmatic EIS, State waters were included in the AOI.

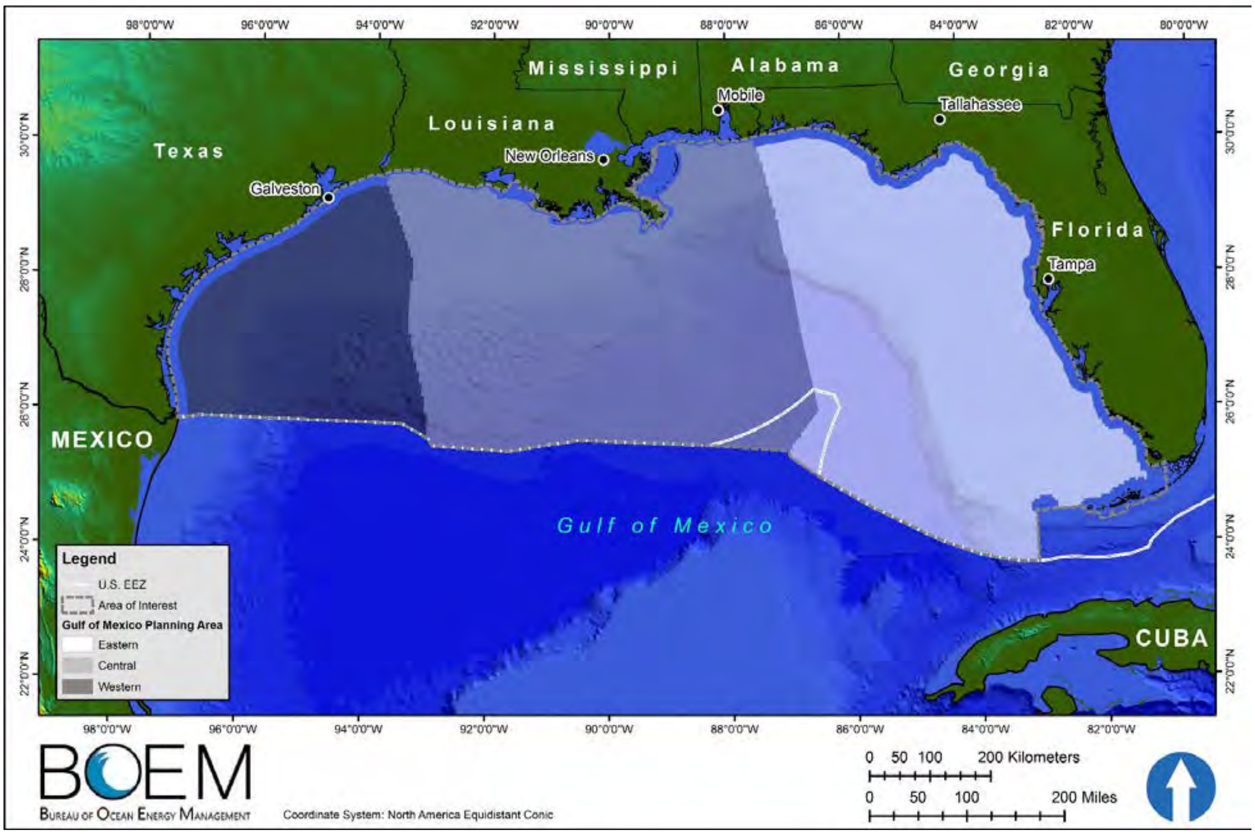

Figure B-1. Area of Interest for the Proposed Action.

All G&G activities authorized by BOEM must comply with existing applicable law as described in **Chapter 1.3** of this Programmatic EIS, including measures to avoid or reduce potential impacts from G&G activities. Compliance with existing applicable law 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 this Programmatic EIS. This appendix describes and discusses the rationale for the measures selected for the proposed action.

1.1 CURRENT REQUIREMENTS

This section identifies current requirements for G&G activities, including G&G operator compliance with lease stipulations and other protective measures,such as applicable guidance documents. These requirements are included in the proposed action.

1.1.1 G&G Requirements Specified in the OCSLA and Its Regulations

The Outer Continental Shelf Lands Act (OCSLA) and implementing regulations at 30 CFR § 551.4 require a permit to conduct pre-lease G&G 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 requirements outlined in 30 CFR § 551.5 and 30 CFR § 551.6, and further guidance provided in Letters to Permittees. The Letter to Permittees, dated January 20, 1989, specifies forms, maps, stipulations, and special provisions applicable to most permit activity. Requirements at 30 CFR part 551 do not apply to G&G activities conducted by, or on behalf of, a lessee in a leased OCS block. Such G&G activities are governed by 30 CFR § 550.201 and by applicable Notices to Lessees and Operators (NTLs). **Table B-1** identifies the appropriate Federal regulations and their applicability to select mineral resources and activity phase.

Table B-1. Federal Regulations Applicable to Pre- and Post-lease Activities by Mineral Resource of Interest.

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

CFR = Code of Federal Regulations.
[a] 30 CFR part 580 applies 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.

The following summarizes key requirements of the OCSLA and its regulations:

- The G&G explorations for mineral resources may not be conducted on the OCS without a permit unless such activities are being conducted pursuant to a lease issued or maintained under the OCSLA.

- The G&G data must be obtained in a technologically 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 OCSLA;
  - cause harm or damage to life (including fishes and other aquatic life), property, or 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.
- The G&G operators conducting activities under 30 CFR part 551 must immediately report to the Director of 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.

1.1.2 BOEM Stipulations, Mitigation, and Protective Measures

BOEM currently requires operators to comply with a series of stipulations and protective measures during G&G activities in addition to requirements specified directly on the OCSLA and its regulations. These requirements generally represent mitigation measures designed to reduce or avoid impacts to sensitive resources. Such measures are implemented through regulations governing pre- and post-lease G&G activities. Key points consist of the following:

- **Explosives Prohibition:** Explosives cannot be used for G&G activities except under written authorization from BOEM's Regional Supervisor. Further protective measures, including those required for compliance with the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA), also apply in the event that explosives are proposed for use.

- **Archaeological Resources:** The permittee must report discovery of any archaeological resource (e.g., shipwreck or 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 (USACE) and the U.S. Coast Guard (USCG).

BOEM provides additional guidance to lessees and operators through NTLs, conditions of approval (COAs), 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 COAs on a plan, authorization, or permit. Mitigation is the effect of conditioned approval, which may originate from programmatic National Environmental Policy Act (NEPA) evaluations such as this one; from BOEM's interpretations 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.

The COAs 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 Programs considered in this Programmatic EIS. The COAs are used to pass on other requirements or advisories to operators, including the following:

(1) other approvals prerequisite to BOEM approval (e.g., Coastal Zone Management Act [CZMA]);

(2) safety precautions (e.g., hydrogen sulfide [H_2S] present);

(3) post-approval submittals (e.g., surveys and interpretive reports);

(4) inspection requirements (e.g., pipeline pressure testing);

(5) pre-deployment notifications (e.g., U.S. Department of Defense [USDOD] space-use or warning areas); and

(6) reduction or avoidance of environmental impacts on biological, physical, or socioeconomic resources identified through NEPA analysis, including mitigation measures developed for this purpose.

There are no programmatic mitigation measures that apply to G&G activities conducted in support of renewable energy development in the GOM; however, best management practices are documented in this Programmatic EIS for the Renewable Energy Program (USDOI, Minerals Management Service, 2007). In addition, standard operating conditions have been developed for G&G activities conducted in support of renewable energy development on the Atlantic OCS. Prior to the issuance of a renewable energy lease, BOEM prepares an environmental assessment (EA) and conducts consultations (i.e., ESA) as required by NEPA. This environmental review considers reasonably foreseeable consequences associated with G&G surveys. Conditions to minimize or eliminate impacts on protected species are included as stipulations of renewable energy leases and include vessel strike avoidance and marine debris awareness measures; protected species observers (PSOs); monitoring and exclusion zones; sound source verification; ramp-up, soft-start, and shutdown procedures; visibility-dependent, seasonal, and frequency-dependent restrictions for various activities; and multiple reporting requirements.

Similarly, at a programmatic level, there are no mitigation measures that apply to G&G activities under the Marine Minerals Program. Section 11 of the OCSLA requires BOEM's authorization for non-energy marine minerals G&G prospecting on the OCS unless a Federal agency is performing the survey. Before authorizing any proposed prospecting, BOEM must undertake 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 or minimize environmental impacts during G&G surveys. Mitigation measures may be implemented as a condition of survey authorization.

1.2 Protective Measures Included in the Alternatives

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

Measures applicable to all G&G surveys for all alternatives (i.e., Alternatives A through G) are as follows:

- guidance for vessel strike avoidance;
- guidance for marine debris awareness;
- avoidance of sensitive benthic resources;
- guidance for shallow hazards survey and reporting;
- regulations for activities in or near National Marine Sanctuaries (NMSs);
- guidance for avoidance of historic and prehistoric sites; and
- guidance for military coordination.

Additional measures applicable to G&G surveys for the Oil and Gas Program are as follows:

- additional guidance for avoidance of historic and prehistoric sites;
- additional guidance for avoidance of shallow hazards; and
- guidance for ancillary activities.

Additional possible measures applicable to specific survey types, based on the selected alternative, include the following:

- Seismic Airgun Survey Protocol, including the use of PSOs and passive acoustic monitoring (PAM);
- Non-Airgun High-Resolution Geophysical (HRG) Survey Protocol, including use of PSOs;
- Expanded PSO Program;
- geographic separation between simultaneous seismic airgun surveys;
- reduced level of activity;
- use of PAM required;
- coastal water seasonal restrictions; and
- area closures.

Table B-2. Applicability of Mitigation Measures to G&G Surveys by Alternative (indicates which mitigation measure is applicable to an alternative).

Survey Type	Mitigation Measures														Survey Protocol		Seasonal Restrictions and Closures		
	Vessel Strike Avoidance	Marine Debris Guidance	Avoidance of Sensitive Benthic Communities	Avoidance of Historic & Prehistoric Sites	Shallow Hazards Guidance	National Marine Sanctuary Regulations	Military Coordination	Ancillary Activity Guidance	Implement PSO Program	Implement Expanded PSO Program	Minimum Separation Distance	Reduced Level of Activity	Use of PAM Strongly Encouraged	Use of PAM Required	Seismic Airgun Survey Protocol	Non-Airgun HRG Survey Protocol	Coastal Waters Seasonal Restriction	Areas of Concern within the EPA[8]	CPA, EPA, Dry Tortugas, and Flower Garden Banks Closure Areas
Seismic Airgun Surveys	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	A-G	A,G	B-F[2] D[3]	B	E	A,G	B-F[4] C-F[5]	A-G	--	B[6], C F[7]	B	F
HRG Non-airgun Surveys with Frequencies >200 kHz	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	--	--	--	--	--	--	--	--	--	--	--	--
HRG Non-airgun Surveys with Frequencies ≤200 kHz	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	--	C-F	--	--	--	--	--	--	C-F	--	--	F
Other G&G Surveys	A-G	A-G	A-G	A-G[1]	A-G[1]	A-G	A-G	--	--	--	--	--	--	--	--	--	--	--	--

CP = Central Planning Area; EPA = Eastern Planning Area; ft = feet; G&G = geological and geophysical; HRG = high-resolution geophysical; kHz = kilohertz; m = meter; PAM = passive acoustic monitoring; PSO = protected species observer; -- = not applicable.

[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] Expanded to include manatees and all water depths.

[3] Expanded from Footnote 2 to include shutdown for all marine mammals except bow-riding or actively approaching dolphins (i.e., bottlenose, Fraser's, Clymene's, rough-toothed, striped, spinner, Atlantic spotted, pantropical, and Risso's) and all water depths..

[4] During periods of reduced visibility for surveys in waters >100 m (328 ft).

[5] PAM required for all airgun surveys at all times in the Mississippi Canyon and DeSoto Canyon OCS lease blocks.

[6] Applies from (1) March 1 to April 30 in Federal coastal waters shoreward of the 20-m (66-ft) isobath (and a 5-km [3-mi] buffer extending seaward from the 20-m [66-ft] isobath) and; (2) from January 1 to April 30 within the portion of these coastal waters falling within the boundaries of the Unusual Mortality Event in the northern GOM.

[7] Applies to all coastal waters shoreward of the 20-m (66-ft) isobath between February 1 and May 31.

[8] Does not apply to currently leased OCS blocks, any portion of the area encompassed by EPA Lease Sale 226, or neighboring OCS lease blocks adjacent to permitted survey areas but within an otherwise off limit area.

1.2.1 Measures Applicable to All Surveys

The mitigation measures detailed here generally are applicable to all G&G surveys and ancillary activities. They are incorporated in lease stipulations, NTLs, or other guidance and implemented through COAs or stipulations during site-specific permit, authorization, and plan reviews.

1.2.1.1 Guidance for Vessel Strike Avoidance

All authorizations for shipboard surveys would include guidance for vessel strike avoidance per NTL 2016-BOEM-G01 ("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 the vessel, regardless of vessel size, to avoid striking protected species.

(2) When whales are sighted, vessels must maintain a distance of 91 meters (m) (100 yards [yd]) or more from the whale. If the whale is believed to be a North Atlantic right whale, vessels should maintain a minimum distance of 457 m (500 yd) from the animal (50 CFR § 2224.103).

(3) When sea turtles or small cetaceans are sighted, vessels must attempt to maintain a distance of 46 m (50 yd) or more whenever possible.

(4) When cetaceans are sighted while a vessel is underway, vessels must attempt to remain parallel to the animal's course. Vessels must avoid excessive speed or abrupt changes in direction until the cetacean has left the area.

(5) Vessels must reduce speed to 10 knots (12 miles per hour) or less when mother and calf pairs, pods, or large assemblages of cetaceans are observed near an underway vessel, when safety permits. A single cetacean at the surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, precautionary measures should always be exercised.

(6) Whales may surface in unpredictable locations or approach slow-moving vessels. When an animal is sighted in the vessel's path or in close proximity to a moving vessel, reduce speed and shift the engine to neutral. Vessels must not engage the engines until the animals are clear of the area.

(7) Vessel crews would be required to report sightings of any injured or dead marine mammals or sea turtles to BOEM and the National Marine Fisheries Service (NMFS) within 24 hours, regardless of whether the injury or death was caused by their vessel.

1.2.1.2 Guidance for Marine Debris Awareness

All authorizations for shipboard surveys include guidance for marine debris awareness under the Bureau of Safety and Environmental Enforcement's (BSEE's) NTL 2015-G03 ("Marine Trash and Debris Awareness and Elimination"). All vessel operators, employees, and contractors actively engaged in G&G surveys must be briefed on marine trash and debris awareness and elimination as described in the NTL. Operators and lessees are required to post placards on all fixed and floating production facilities, and offshore employees must complete marine trash and debris training annually. The NTL 2015-BSEE-G03 provides information that applicants may use for this awareness training.

In addition, 30 CFR §§ 250.300(a) and (b)(6) prohibit the deliberate discharge of containers and other similar materials (i.e., trash and debris) into the marine environment, and 30 CFR §§ 250.300(c) and (d) require durable identification markings on equipment, tools, containers (especially drums), and other materials, as well as the recording and reporting of items lost overboard to the District Manager through facility daily operations reports. Furthermore, the intentional jettisoning of trash has been the subject of strict laws such as the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V and the Marine Plastic Pollution Research and Control Act (MPPRCA), as well as regulations imposed by various agencies such as the USCG and U.S. Environmental Protection Agency (USEPA).

1.2.1.3 Avoidance of Sensitive Seafloor Resources

Avoidance is BOEM's (and the CEQ's) priority for mitigation. To avoid seafloor resources, BOEM must know enough about the nature of the seafloor area where activities are proposed so that activities can be moved to another area if sensitive resources are present. This applies to sensitive cultural resources such as shipwrecks and prehistoric archaeological resources, as well as sensitive benthic communities.

In addition to the cultural resources and benthic communities discussed in the following sections, there are many undersea cables and other infrastructure on the seafloor within the GOM 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 are available from numerous sources, and applicants will have access to these 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, as well as 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.

Avoidance of Sensitive Benthic Communities

BOEM requires site-specific information regarding sensitive benthic communities prior to approving any G&G activities involving seafloor-disturbing activities or placement of bottom-founded equipment or structures in the AOI. Required information includes mapping and avoidance plans as well as pre-deployment photographic surveys of areas where bottom-founded instrumentation and appurtenances are to be deployed. Seafloor-disturbing activities include drilling, anchoring, placing seafloor templates, discharging muds and cuttings, and installing pipelines. BOEM's Renewable Energy Program has developed biological survey protocols that provide guidance for these site-specific surveys.

BOEM's requirements for oil and gas activities in the GOM are set forth in two separate NTLs: one for seafloor communities in water depths <300 m (984 feet [ft]) (NTL 2009-G39, "Biologically-Sensitive Underwater Features and Areas"), and one for seafloor communities in water depths >300 m (984 ft) (NTL 2009-G40, "Deepwater Benthic Communities"). The NTLs should be referred to for specific requirements, including procedures for demonstrating compliance and supporting approval of operation. The resources to be protected and the policies to be applied for protection are summarized here.

The shallower water NTL 2009-G39 addresses four features that are drawn from the Essential Fish Habitat (EFH) programmatic consultation with NMFS and that are defined and afforded protective policies as follows:

(1) **Topographic features** are isolated areas of moderate to high relief that provide habitat for hard bottom communities of high biomass and diversity and for large numbers of plant and animal species that provide support, either as shelter or food, for large numbers of commercially and recreationally important fishes. These features include the Flower Garden Banks and other coral banks. No bottom-disturbing activities may occur within 152 m (500 ft) of the designated "No Activity Zone" of a topographic feature (for maps of the zones, refer to http://www.boem.gov/Topographic-Features-Stipulation-Map-Package/). Also, if more than two wells not from development operations are to be drilled from the same surface location within 3 mi (5 km) of a topographic feature, all drill cuttings and fluids must be shunted to the seabottom through a downpipe terminating no more than 10 m (33 ft) from the bottom. Any exception to these requirements can only be considered through an individual EFH consultation between BOEM and NMFS.

(2) **Live bottoms (pinnacle trend features)** are small, isolated, low- to moderate-relief carbonate reefal features or outcrops of unknown origin, or hard substrates exposed by erosion that provide surface area for the growth of sessile invertebrates and attract large numbers of fish. No bottom-disturbing activities may occur within 30 m (98 ft) of any pinnacle trend feature with a vertical relief of 2 m (8 ft) or more. Any exception to these requirements can

only be considered through an individual EHF consultation between BOEM and NMFS. An individual EHF consultation is also required if a proposed pipeline would transport liquid hydrocarbons with an API gravity of 45° or less within 91 m (299 ft) of any pinnacle trend feature with a vertical relief of 2 m (8 ft) or more.

(3) **Live bottoms (low-relief features)** are seagrass communities; areas that contain biological assemblages consisting of sessile invertebrates living on and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; and areas where hard substrate and vertical relief may favor the accumulation of sea turtles, fishes, or other fauna. No bottom-disturbing activities may cause impacts to live bottoms (low-relief features).

(4) **Potentially sensitive biological features** are features not protected by a biological lease stipulation that are of moderate to high relief (2 m [8 ft] or higher), provide surface area for the growth of sessile invertebrates, and attract large numbers of fish. No bottom-disturbing activities may cause impacts to potentially sensitive biological features.

The deepwater NTL 2009-G40 addresses features or areas that could support high-density chemosynthetic communities, deepwater corals, or other associated high-density hard bottom communities. Any proposed activities that could disturb the seafloor at water depths of >300 m (984 ft) must maintain a distance of at least 76 m (250 ft) between the location of the disturbance and any high-density hard bottom communities, and must maintain a distance of at least 610 m (2,000 ft) between those communities and the location for any proposed discharge of muds and cuttings. BOEM may modify these requirements on a case-by-case basis.

Avoidance and Reporting of Historic and Prehistoric Sites

BOEM and BSEE 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 use this information to ensure that physical impacts to archaeological resources do not occur.

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 in NTL 2005-G07 (“Archaeological Resource Surveys and Reports”), 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 as well as 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 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 Program regulations, archaeological resource surveys are required 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 regulations are applicable to all G&G operations that involve seafloor-disturbing activities, including coring, grab sampling, and placement of ocean-bottom cables (OBCs) or ocean-bottom nodes (OBNs). Equivalent information needs to be provided for the Renewable Energy and Marine Minerals Programs, although equivalent regulations do not expressly exist for renewable energy or marine minerals, but these requirements are included as stipulation in non-competitive lease agreements within these programs. The equivalent is provided through guidance, supported by regulation and/or statutory authority (refer to NHPA Section 106, the 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 that may affect the discovery must be halted immediately and 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. The BSEE will inform the operator when operations may resume (30 CFR § 250.194).

Shallow Hazards Guidance

A portion of BOEM's NTL 2008-G05 ("Guidance for Shallow Hazards Program") applies to all G&G surveys performed. For any activities that involve seafloor-disturbing activities, in accordance with Section VI.B of the NTL, data must be collected to locate existing hazards.

1.2.1.4 Guidance for Military Coordination

The GOM is used extensively by the USDOD for conducting various mission operations, including air-to-air gunnery, rocket and missile research and testing, sonar buoy operations, pilot training, and aircraft carrier operations. These operations are conducted in 11 Military Warning Areas and 6 Eglin Water Test Areas located throughout the GOM (**Figure 4.12-2** of this Programmatic EIS). These areas are multiple-use areas where military operations and OCS exploration and development activities coexist. To ensure personnel safety and to reduce the likelihood of conflicts between military and OCS operations, NTL 2014-G04 ("Guidance for Activities In or Near Military Warning and Water Test Areas") stipulates requirements in which the lessee or designated operator must enter into an agreement with the appropriate individual military command headquarters concerning the control of electromagnetic emissions and use of boats and aircraft in the applicable warning or water test area before commencing such traffic.

1.2.2 Additional Mitigation for Oil and Gas Program Surveys

Additional mitigation measures specifically applicable to Oil and Gas Program surveys include (1) additional guidance for avoidance of archaeological resources, (2) additional shallow hazards guidance, and (3) guidance for conducting ancillary activities. A summary of these additional mitigation measures are provided in the following subsections.

1.2.2.1 Additional Avoidance of Historic and Prehistoric Sites

The additional measures required for seismic airgun surveys include NTL 2011-JOINT-G01 ("Revisions to the List of OCS Lease Blocks Requiring Archaeological Resource Surveys and Reports"), which supersedes NTL 2008-G20 and provides additions to the list of OCS lease blocks that require archaeological resource surveys and reports to be submitted with plans, as well as the required line-spacing for each OCS lease block. In addition, site-specific, remote-sensing surveys of the seafloor are required when the information is deemed essential to making a reasonable determination of the presence of potentially significant resources. The required surveys are analyzed by industry and BOEM archaeologists prior to the authorization of any new or significant seafloor-disturbing impacts and, if necessary, avoidance of potential archaeological resources is prescribed. Archaeological surveys are expected to be highly effective in identifying resources to allow for the protection of the resource during permitted activities.

1.2.2.2 Additional Shallow Hazards Guidance

The remainder of NTL 2008-G05 ("Guidance for Shallow Hazards Program") applies to seismic airgun surveys. The NTL provides guidance regarding shallow hazard reporting and survey requirements for exploration plans and Development Operations Coordination Documents (DOCDs), Applications to Drill, Platform Site Investigation Reports, and pipeline applications. In addition, the NTL (1) specifies the group intervals for acquiring medium-penetration seismic profiler information, (2) discontinues the process of obtaining prior approval if lessees or operators substitute three-dimensional (3D) data and information for HRG subbottom profiler information, (3) clarifies the procedures for submitting shallow hazards reports on compact disc-read only memory (CD-ROMs), (4) amends the format for listing magnetic anomalies and side-scan sonar contacts in shallow hazard reports, (5) clarifies that on-site provisions for mitigation of shallow hazards apply to lift and jack-up boats, and (6) allows a mobile offshore drilling unit (MODU) or other vessel to depart a location without fully raising its legs or mat as long as they are raised sufficiently to ensure no contact with pipelines or other potential hazards.

1.2.2.3 Guidance for Conducting Ancillary Activities

For ancillary G&G activities in depths >200 m (656 ft) or in the EPA at any water depth, as outlined in NTL 2009-G34 ("Guidance for Conducting Ancillary Activities"), operators must notify BOEM at least 30 days before a G&G exploration or development activity involving the use of an airgun or airgun array, independent of water depth, for any OBC, OBN, or time-lapse (four-dimensional [4D]) survey. Operators or lessees must notify BOEM through written notice at least 15 days prior to conducting any other ancillary G&G activity involving the use of airguns or airgun arrays in water depths >200 m (656 ft), or in the EPA at any water depth, as well as any seafloor-disturbing activity (OBC, OBN, and time-lapse [4D] survey), or geotechnical surveys (piston, gravity, grab, or dredging), including retrieval of OBCs, anchors, or other equipment, independent of water depth. No notification to BOEM is required for ancillary activities that do not involve explosives, do not use airguns in water depths <200 m (656 ft) in the CPA and WPA, or do not disturb the seafloor.

1.2.3 Additional Mitigation for Renewable Energy Program Surveys

BOEM does not issue permits for or regulate the acquisition of geophysical data or geotechnical sampling on the OCS for renewable energy development. However, the results of such surveys and testing are required under BOEM's renewable energy regulations at 30 CFR part 585 for the submission of a Site Assessment Plan (SAP) (30 CFR § 585.610(b)), a Construction and Operations Plan (COP) (30 CFR § 585.626(a)), or a General Activities Plan (GAP) (30 CFR § 585.645(a)). Plans submitted to BOEM are required to describe hazards information and information pertinent to archaeological resources that could be affected by the activities proposed in an SAP (30 CFR §§ 585.611(a), (b)(1), and (b)(6)), COP (30 CFR §§ 585.627(a)(1) and (6)), and GAP (30 CFR §§ 585.646(a) and (f)). BOEM recommends following the guidelines to produce the data necessary to readily identify and/or characterize geological conditions, hazardous features, and cultural resources. If an applicant fails to provide the requested information, BOEM may not approve an SAP (30 CFR § 585.613(d)), COP (30 CFR § 585.628(e)), or GAP (30 CFR § 585.648(d)).

Elements of these guidelines may be required under the terms and conditions of a specific lease. A lease also may have requirements that are different from those discussed in these guidelines. Applicants are encouraged to have a pre-survey meeting with BOEM to discuss any proposed plan prior to initiation of survey activities. The guidance also provides recommendations for HRG surveys, including survey patterns (e.g., line spacing, site-specific, transmission cable routes); data acquisition equipment, including navigation, echosounders, side-scan sonar, and magnetometers (specific in that BOEM recommends these surveys be conducted below levels that cause Level A or B auditory impacts to marine mammals); and geotechnical testing.

1.2.4 Seismic Airgun Survey Protocol

The Seismic Airgun Survey Protocol (**Attachment 1**) specifies mitigation measures, including an exclusion zone, ramp-up requirements, visual monitoring by PSOs prior to and during seismic airgun surveys, and array shutdown requirements. The purpose of the protocol is to minimize the potential for injury to marine mammals (as defined in NTL 2016-BOEM-G02) and sea turtles and to avoid most Level A harassment of marine mammals.

The Seismic Airgun Survey Protocol is based on NTL 2016-BOEM-G02 ("Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program"). 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. The protocol provides the requirements applicable to all seismic airgun surveys for all alternatives evaluated in this

Programmatic EIS; however, additional mitigation measures are required for the various alternatives (i.e., Alternatives A through G). Additionally, Alternatives B through F expand the PSO Program portion of the protocol. **Tables B-2 and 2.2-2** of this Programmatic EIS provide information regarding additional mitigation measures.

Although airguns have a frequency range from approximately 10 to 2,000 hertz (Hz), most acoustic energy is radiated at frequencies below 200 Hz. Acoustic pulses from airguns are within the hearing range of all marine mammals in the AOI (**Appendix H, Section 3**). The mysticete species (e.g., Bryde's whale) occurring in the AOI are low-frequency cetaceans (7 Hz to 22 kilohertz [kHz]), and most of the odontocetes are mid-frequency cetaceans (150 Hz to 160 kHz), with the exception of the *Kogia* species (i.e., pygmy sperm whale and dwarf sperm whale), which are high-frequency cetaceans (200 Hz to 180 kHz). Manatees have hearing capabilities similar to phocid pinnipeds (true seals), with functional hearing between approximately 250 Hz and 90 kHz. Airgun pulses are within the hearing range of sea turtles, whose best hearing is below 1,600 Hz (**Appendix I, Section 3**).

All authorizations for seismic airgun surveys (those involving airguns as an acoustic source) conducted in water depths >200 m (656 ft) in the WPA and CPA and in all water depths in the EPA would include a survey protocol that specifies mitigation measures for protected species, including an exclusion zone, ramp-up requirements, visual monitoring by PSOs prior to and during seismic airgun surveys, and array shutdown requirements. The Seismic Airgun Survey Protocol specifies the conditions under which airgun arrays can be started and under which they must be shut down. It also includes the recommended but optional use of PAM to help detect vocalizing marine mammals. The protocol requirements apply specifically to airguns, not non-airgun HRG sources such as side-scan sonars; boomers, sparkers, and compressed high-intensity radiated pulse (CHIRP) subbottom profilers; and single-beam or multibeam echosounders that may be operating concurrently during seismic airgun surveys. Per NTL 2009-G34, no notification is required if airguns are used in water depths <200 m (656 ft) in the CPA and WPA.

1.2.4.1 Ramp-Up

Ramp-up (also known as "soft-start") entails the gradual increase in intensity of an airgun array over a period of 20 minutes or more until maximum source levels are reached. The intent of ramp-up is to 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 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 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; Compton et al., 2007; Parsons et al., 2009).

Ramp-up has become a standard mitigation measure in the U.S. and worldwide. The International Association of Geophysical Contractors (2011) recommends ramp-up in its seismic survey guidelines. BOEM requires ramp-up procedures for seismic airgun surveys operating in the GOM.

1.2.4.2 Exclusion Zone

The Seismic Airgun Survey Protocol includes an exclusion zone (with a 500-m [1,640-ft] radius) centered on the acoustic 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. This exclusion zone applies specifically to airguns, not non-airgun HRG sources such as side-scan sonars; boomers, sparkers, and CHIRP subbottom profilers; and single-beam or multibeam echosounders that may be operating concurrently during seismic airgun surveys.

1.2.4.3 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 on board seismic vessels at all times during daylight hours (i.e., from approximately 30 minutes before sunrise to 30 minutes after sunset) when seismic operations are being conducted, unless conditions (e.g., fog, rain, and darkness) make sea-surface observations impossible. If conditions deteriorate during daylight hours such that 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 engage third-party PSO members who have been trained as observers, or they may use a combination of third-party and trained crew observers. Training requirements are specified in NTL 2016-BOEM-G02 and currently include no minimum qualifications for PSO. However, qualifications were discussed in the 2013 National Standards for Protected Species Observers (Baker et al., 2013) and may be required for future activities.

The PSOs are meant to monitor the exclusion zone for protected species and to observe and document the presence and behavior of protected species. The PSOs 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 PSOs generally survey for protected species using high-powered binoculars. 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. Data are recorded on paper sheets or a laptop computer that has direct input from the vessel’s global positioning system (GPS) navigation system. Observers rotate among the duty stations at regular intervals, and alternate work and rest periods based on 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 (refer to **Attachment 1**).

Visual shipboard monitoring is affected by limitations on visibility of individuals due to poor visibility (e.g., fog, elevated Beaufort sea state, and nighttime operations), species detectability (e.g., cryptic species), and observer fatigue. Routine activities of marine mammals (e.g., diving duration patterns, pod size, and overt behaviors) show considerable variability among species, thereby affecting whether animals are sighted (i.e., availability bias). During nighttime operations or 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 [active and passive]). However, the efficiency of visual monitoring during nighttime hours using shipboard lighting or enhanced vision equipment is limited compared with visual monitoring during daylight hours.

1.2.4.4 Shutdown Requirements

The Seismic Airgun Survey Protocol requires shutdown of the airgun array any time certain marine mammals or sea turtles are 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 for seismic airgun surveys performed in water depths >200 m (656 ft) in the CPA and WPA and for all seismic airgun surveys performed in the EPA. In the event of a shutdown, operations and ramp-up of equipment would recommence only when the sighted animal has cleared the exclusion zone and no other marine mammals or sea turtles have been sighted within the exclusion zone for the required time specified in the protocols. Shutdown would not be required for manatees and marine mammals in the Family Delphinidae (this includes, among others, killer whales, pilot whales, and all of the "dolphin" species) approaching the vessel (or vessel's towed equipment). 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 30 minutes to help ensure the absence of all marine mammals and sea turtles.

1.2.4.5 Passive Acoustic Monitoring

The Seismic Airgun Survey Protocol strongly encourages, but does not require, the use of PAM during monitoring of the exclusion zone when visual observations cannot be used (times of reduced visibility) (refer to **Attachment 1**). This provision is included in NTL 2016-BOEM-G02 ("Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program"). Under the Settlement Agreement, PAM is required during all nighttime and non-visual operations. During low-visibility conditions, PAM can be used to allow ramp-up when it would otherwise not be allowed. Regulations regarding the use of PAM during geophysical surveys vary in other parts of the world and range from no PAM recommendations to requiring PAM at all times during the survey (Weir and Dolman, 2007; Compton et al., 2007; Nowecek et al., 2013; Wright and Cosentino, 2015). 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 or for detecting surfaced animals at night and during periods of high sea state and poor visibility. In some cases, PAM may serve as an effective tool for detecting submerged 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 Survey 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 (e.g., darkness, fog, and rain) when it otherwise would not be permitted using only visual observers.

There are two types of PAM systems commonly used for marine mammal detection: fixed systems and towed systems. Fixed PAM systems can monitor underwater sounds over a wide range of spatial and temporal scales but are rarely used in real-time mitigation during geophysical surveys. There are three categories of fixed systems: autonomous recorders; radio-linked hydrophone systems; and fixed cable hydrophone systems. 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. These recorders 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 seafloor and transmit audio signals via radio waves to a receiving station onshore. Fixed cable hydrophone systems typically are located on the seafloor in a permanent configuration and can continuously send data to a receiving station. Fixed PAM systems often are used for the monitoring of marine mammals and the acoustic environment prior to an activity at a fixed location (Bingham, 2011). For example, the U.S. Navy uses a fixed PAM system to monitor their test ranges over long periods of time to determine species abundances and distribution prior to activities that may impact these species.

Towed PAM systems often are used for real-time mitigation during seismic surveys because they maintain the surveillance area around the moving vessel and airgun sources. The basic configuration of towed PAM systems has not changed significantly since its early implementation as a mitigation tool. Towed systems consist of a hydrophone array, tow cable, deck cable, and data processing and monitoring system that processes, displays, and stores selected data. Tow lengths, depths, and positions depend on the vessel and its airgun and streamer configuration; however, the PAM hydrophone cable usually is independent from any other vessel systems and is towed 200 to 300 m (656 to 984 ft) behind the survey vessel. Exceptions to this configuration are the streamer-integrated PAM systems in which designated marine mammal hydrophones are embedded into the vessel's seismic streamer arrays. The data transmission and processing remain similar between independent and integrated PAM systems. Hydrophone signals are processed for output to the operator with specialized pre-loaded software designed to detect marine mammal impulsive and tonal 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 acoustic source is mobile or covering a large area. However, these systems have limited directional capabilities and face challenges from sound source masking and localization of fast-moving species. They also have limitations from ship availability, can be readily damaged, can interfere with seismic equipment if not deployed correctly, and do not provide accurate detection in front of the vessel. Some of these limitations can be overcome, and new technology is being developed (e.g., beam-forming arrays that enhance low signal-to-noise ratios, marine mammal call detection in chosen "look directions," and 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. The system's performance goals (e.g., detection, classification, and localization) will need to consider the technological and operational limitations to determine the best method for PAM utilization.

The PAM software and hardware technologies that currently exist can perform many marine mammal monitoring and mitigation requirements under a wide range of operational conditions. However, 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 an integrated approach is most likely necessary. In order to be effective for mitigation, the PAM system and operator must be able to detect, classify, and localize an animal very rapidly. This presents limitations in that PAM 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, and there are different propagation properties for each species' vocal characteristics, making some easier to detect. Additionally, PAM operators must be trained and experienced in order to successfully deploy and operate the PAM systems, even with the advancement of auto-detection software capabilities. Although the technology for detecting and locating underwater sounds and their sources is well developed, integrated hardware and software systems specifically designed to locate and track marine mammals as mitigation for seismic airgun surveys are not fully mature and continue to be developed for commercial applications.

1.2.4.6 Summary of Visual Observer Requirements

Several of the preceding sections described requirements for PSOs or other observers. Requirements for observers are summarized in **Table B-3**. All G&G operators must comply with guidance for vessel strike avoidance as explained in **Chapter 2** of this Programmatic EIS. Regardless of the type of G&G survey being conducted, visual observers monitoring solely for vessel strike avoidance can be trained crew members or third-party observers. Visual observers 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 exclusion zone. A PSO for a seismic airgun survey must have completed a PSO training course as specified in NTL 2016-BOEM-G02.

Table B-3. Observer Requirements for G&G Survey Types.

Survey Type	PSO Required?	PSO Affiliation (Third Party, Crew, or Combination)	PSO Watch Requirements	Number of PSOs on Duty when Acoustic Sources Operating	Total Number of PSOs on Board	Vessel Strike Avoidance
Seismic airgun survey with no PAM	Yes[1]	Third party, crew, or combination	1. Other than brief alerts to bridge personnel of maritime hazards, no additional duties during watch. 2. A watch must be no longer than 4 consecutive hours. 3. A break of at least 2 hours must occur between 4-hour watches, with no other duties during this period. 4. A PSO's combined watch schedule must not exceed 12 hours in a 24-hour 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, crew, or combination	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
Non-airgun HRG survey with exclusion zone	Yes	Third party, crew, or combination	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 no exclusion zone (all frequencies >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.

G&G = geological and geophysical; kHz = kilohertz; N/A = not applicable; PAM = passive acoustic monitoring; PSO = protected species observer.

[1] A PSO for a seismic airgun survey is someone who has successfully completed an approved PSO training course.

1.3 Additional Protective Measures Included in the Alternatives

The mitigation measures, as discussed in **Chapter 2** of this Programmatic EIS, that would apply to all alternatives include the following:

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

Additional mitigation measures are included in Alternatives B through G and are listed below, and their applicability to G&G survey types are identified in **Table B-2** and described in **Sections 1.3.1 through 1.3.8**:

- mitigation for non-airgun HRG surveys, including a Non-Airgun HRG Survey Protocol with use of PSOs;
- expanded PSO Program;
- minimum separation of concurrent seismic surveys;
- reduced level of activity;
- a Seismic Airgun Survey Protocol with required use of PAM;
- coastal waters seasonal restrictions; and
- area closures for seismic airgun surveys.

1.3.1 Non-Airgun HRG Survey Protocol

The purpose of the Non-Airgun 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 included in **Appendices H and I**, acoustic sources operating at frequencies >200 kHz are not likely to be within the hearing range of marine mammals or sea turtles. Therefore, there is no need to implement the additional mitigation requirements for such surveys.

For non-airgun HRG surveys using sources operating at and below 200 kHz, the implementation of the Non-Airgun HRG Survey Protocol is required to minimize the potential for injury to marine mammals and sea turtles and avoid most Level A harassment of marine mammals. Ramp-up is not expected to be an effective mitigation measure for non-airgun HRG surveys because electromechanical sources typically are on or off and are not powered up gradually.

The Non-Airgun HRG Survey Protocol is included in Alternatives C through F, depending on the operating frequencies of the non-airgun HRG surveys. The Non-Airgun HRG Survey Protocol is for surveys that use only acoustic sources such as side-scan sonar; boomers, sparkers, and CHIRP subbottom profilers; and single-beam and multibeam echosounders. HRG surveys using airguns operating concurrently with non-airgun sources would be subject to the Seismic Airgun Survey Protocol described in **Attachment 1**.

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

- All non-airgun HRG operators must comply with separate guidance for vessel strike avoidance, marine debris awareness, avoidance of sensitive seafloor resources, activities in or near NMSs, and military coordination.
- If non-airgun HRG sources will operate above 200 kHz, no additional mitigations are required.
- Non-airgun HRG surveys in which one or more active acoustic sources will be operating at frequencies at or below 200 kHz, a pre-survey clearance period (of marine mammals and sea turtles) of 30 minutes before start-up or after a shutdown for any sperm, Bryde's, beaked, or *Kogia* whale(s) or manatee(s) that are within the exclusion zone.
- One PSO and 200-m (656-ft) exclusion zone monitoring for non-airgun HRG surveys in all water depths throughout the GOM operating at or below 200 kHz.
- If seismic airguns are used for HRG surveys, these surveys would be subject to the Seismic Airgun Survey Protocol.

1.3.1.1 Exclusion Zone

For non-airgun HRG surveys in which at least one acoustic source will operate at or below 200 kHz, the Non-Airgun HRG Survey Protocol would establish a 200-m (656-ft) exclusion zone, require visual monitoring by trained PSOs, and specify start-up and shutdown requirements. The exclusion zone applies specifically to non-airgun HRG sources such as side-scan sonar; boomers, sparkers, and CHIRP subbottom profilers; and single-beam or multibeam echosounders.

1.3.1.2 Exclusion Zone Monitoring by Protected Species Observers

All non-airgun HRG surveys using one or more acoustic sources operating at or below 200 kHz must use trained PSOs to monitor a 200-m (656-ft) exclusion zone for a pre-survey clearance period, 30 minutes, for all marine mammals and sea turtles in all water depths throughout the GOM. If there are no acoustic sources operating at frequencies ≤200 kHz, there will be no exclusion zone and no requirements for PSOs or other trained visual observers.

A PSO for a non-airgun HRG survey is defined as someone who has successfully completed a PSO training course. The PSOs can be trained crew members or third-party observers. 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 exclusion zone must be conducted by trained PSOs. At least one PSO would be required on watch on board non-airgun HRG survey vessels at all times during daylight hours (i.e., from approximately 30 minutes before sunrise to 30 minutes after sunset) when survey operations are being conducted, unless conditions make sea surface observations impossible (e.g., fog, rain, and darkness). 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).

Requirements for PSO observers are summarized in **Table B-3**. All G&G operators must comply with guidance for vessel strike avoidance as explained in **Chapter 2** of this Programmatic EIS. Regardless of the type of G&G survey being conducted, visual observers monitoring solely for vessel strike avoidance can be crew members or trained third-party observers. They do not have specific training requirements nor will they need to be approved by BOEM or BSEE.

1.3.1.3 Shutdown Requirements

Monitoring of the exclusion zone would begin no less than 30 minutes prior to start-up and continue until operations cease. Immediate shutdown of the non-airgun HRG source(s) must occur if any sperm, Bryde's, beaked, or *Kogia* whale(s) or manatee(s) are detected entering or within the exclusion zone. After a shutdown, subsequent restart of non-airgun HRG operations may only occur following confirmation that the exclusion zone is clear of all marine mammals and sea turtles for 30 minutes.

1.3.2 Expanded PSO Program

An expanded PSO Program is included in Alternatives B through F. For Alternatives B, C, E, and F, the expanded PSO Program is applicable to all seismic airgun surveys in all water depths and requires shutdown of the airgun array any time a marine mammal (excluding marine mammal species in the Family Delphinidae, which includes killer whales, pilot whales, and all of the dolphin species), including manatees, 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 for all deep-penetration seismic airgun surveys performed in the GOM, regardless of water depth. In the event of a shutdown, operations and ramp-up of equipment would recommence only when the sighted animal has cleared the exclusion zone and no other marine mammals or sea turtles have been sighted within the exclusion zone for the required time specified in the protocols. 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 30 minutes to help ensure the absence of all marine mammals and sea turtles.

For Alternative D, the above would apply; however, shutdown would not be required for dolphins actively approaching the vessel (or the vessel's towed equipment) for the purposes of bow-riding. In the GOM, species known to bow-ride include bottlenose, Fraser's, Clymene's, rough-toothed, striped, spinner, Atlantic spotted, pantropical, and Risso's dolphins.

Although there are no minimum qualification requirements for PSOs, for Alternatives C through F, the qualifications discussed in the 2013 National Standards for Protected Species Observers (Baker et al., 2013) may be required for future activities. These qualifications may include the following:

- a bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences;
- at least one undergraduate course in math or statistics;
- experience with data entry on computers;
- satisfactory completion of a NMFS-approved PSO training course;
- be in good health and have no physical impairments that would prevent performing assigned tasks;
- able to clearly and concisely communicate verbally and in writing in English; and
- be a U.S. citizen, or a non-citizen who has a green card, TN authorization, H1 visa, or valid work visa, and a Social Security card.

1.3.3 Geographic Separation Between Simultaneous Seismic Airgun Surveys

Alternative B would establish a 40-km (25-mi) geographic separation distance between simultaneously operating deep-penetration seismic airgun surveys performed in the designated Areas of Concern (**Figure B-2**). For deep-penetration seismic airgun surveys performed outside the Areas of Concern, a 30-km (18.6-mi) geographic separation distance between simultaneously operating seismic airguns would be required. Additionally, the separation distance would apply within a 5-km (3-mi) buffer zone adjacent to and seaward of the 20-m (66-ft) isobath and to the Areas of Concern that fall within the EPA.

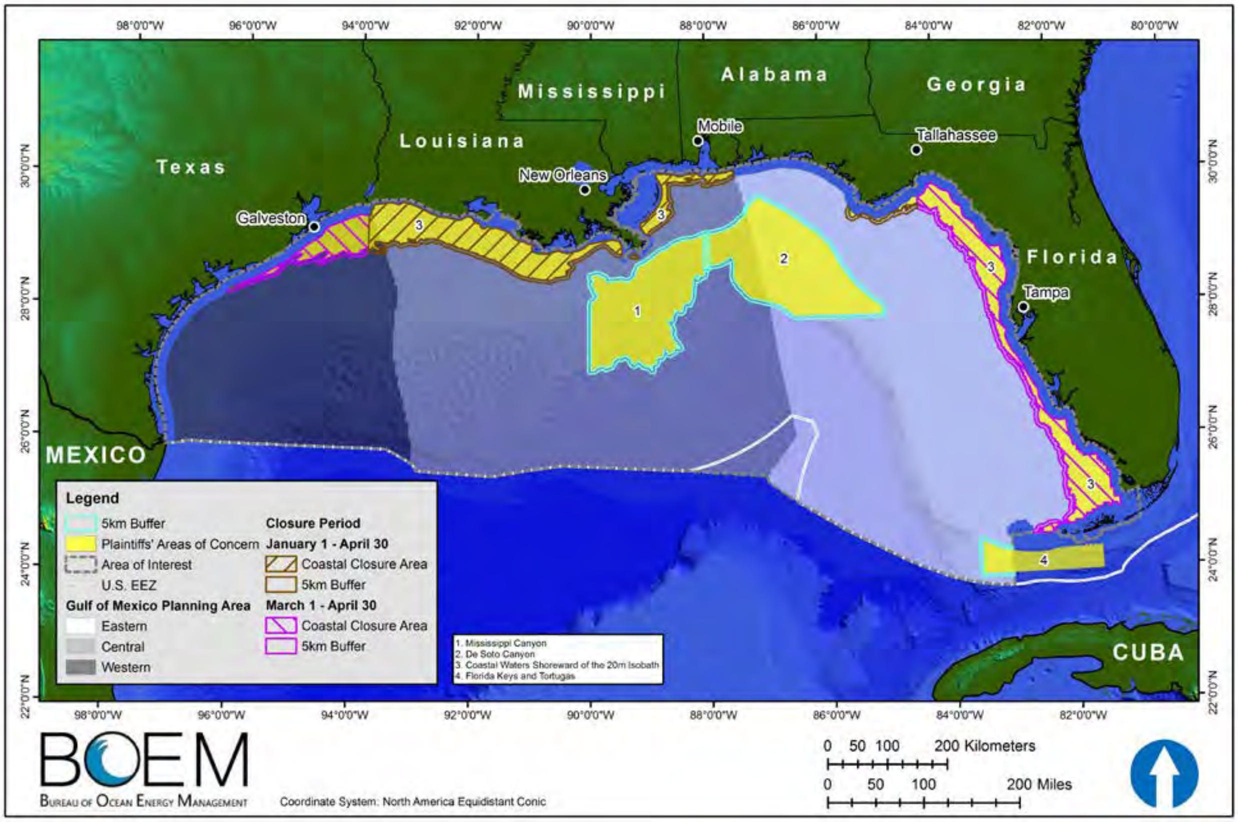

Figure B-2. Alternative B Seasonal Restrictions for Coastal Waters and Other Closure Areas (as defined in the Amended Settlement Agreement as the Areas of Concern).

1.3.4 Reduced Level of Activity

In Alternative E, BOEM would authorize a reduced level of activity. Alternative E has two options: Alternative E1 specifies a reduction of deep-penetration seismic airgun surveys (in line miles) by 10 percent from the estimated levels in a calendar year (**Table 2.7-1** of this Programmatic EIS); and Alternative E2 specifies a reduction of deep-penetration seismic airgun surveys (in line miles) by 25 percent from the estimated levels in a calendar year (**Table 2.7-2** of this Programmatic EIS).

Activities could be conducted in any of the GOM planning areas. When the maximum exploration survey activities are authorized, no additional authorization of activities for airgun exploration would be issued for the remainder of the calendar year. Any specific method of implementation may be specified further through a NTL or other guidance.

1.3.5 Use of PAM Required

Under Alternatives B through F, the use of PAM would be required as part of the Seismic Airgun Survey Protocol (rather than optional or “encouraged” as in Alternative A) for all surveys occurring during periods of reduced visibility in water depths >100 m (328 ft). 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 start-up of airgun arrays until the animals are outside the exclusion zone. Note: Some operators voluntarily implemented PAM prior to the 2013 Settlement Agreement conditions.

Under Alternatives C through F, the use of PAM would be required as part of the Seismic Airgun Survey Protocol (rather than optional or “encouraged” as in Alternative A) for all deep-penetration seismic airgun surveys at all times in the Mississippi Canyon and De Soto Canyon lease blocks. The purpose would be to improve detection of marine mammals prior to and during deep-penetration seismic airgun surveys so that impacts can be avoided by shutting down or delaying start-up of airgun arrays until the animals are outside the exclusion zone. Overall, the requirement for PAM in the canyon lease blocks will reduce the potential for Level A exposures to marine mammals, including Bryde’s whales and ESA-listed sperm whales.

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. An assessment of the usefulness, effectiveness, and problems encountered with the use of PAM as a method of marine mammal detection must be provided after the survey.

1.3.6 Coastal Water Seasonal Restrictions

Alternative B includes a seasonal restriction for airgun surveys in Federal coastal waters from (1) March 1 to April 30 in Federal coastal waters shoreward of the 20-m (66-ft) isobath (and a 5-km [3-mi] buffer extending seaward from the 20-m [66-ft] isobath) and (2) from January 1 to April 30 within the portion of these coastal waters falling within the boundaries of the Unusual Mortality Event in the northern GOM (**Figure B-2**, Areas of Concern Polygon 3). This means that no seismic airgun surveys can be performed in these coastal waters during the time frame identified.

Alternatives C through F include a seasonal restriction for airgun surveys for all coastal waters (Federal and State) shoreward of the 20-m (66-ft) isobath between February 1 and May 31 (**Figure B-3**). This means that no seismic airgun surveys can be performed in these coastal waters during the time frame identified.

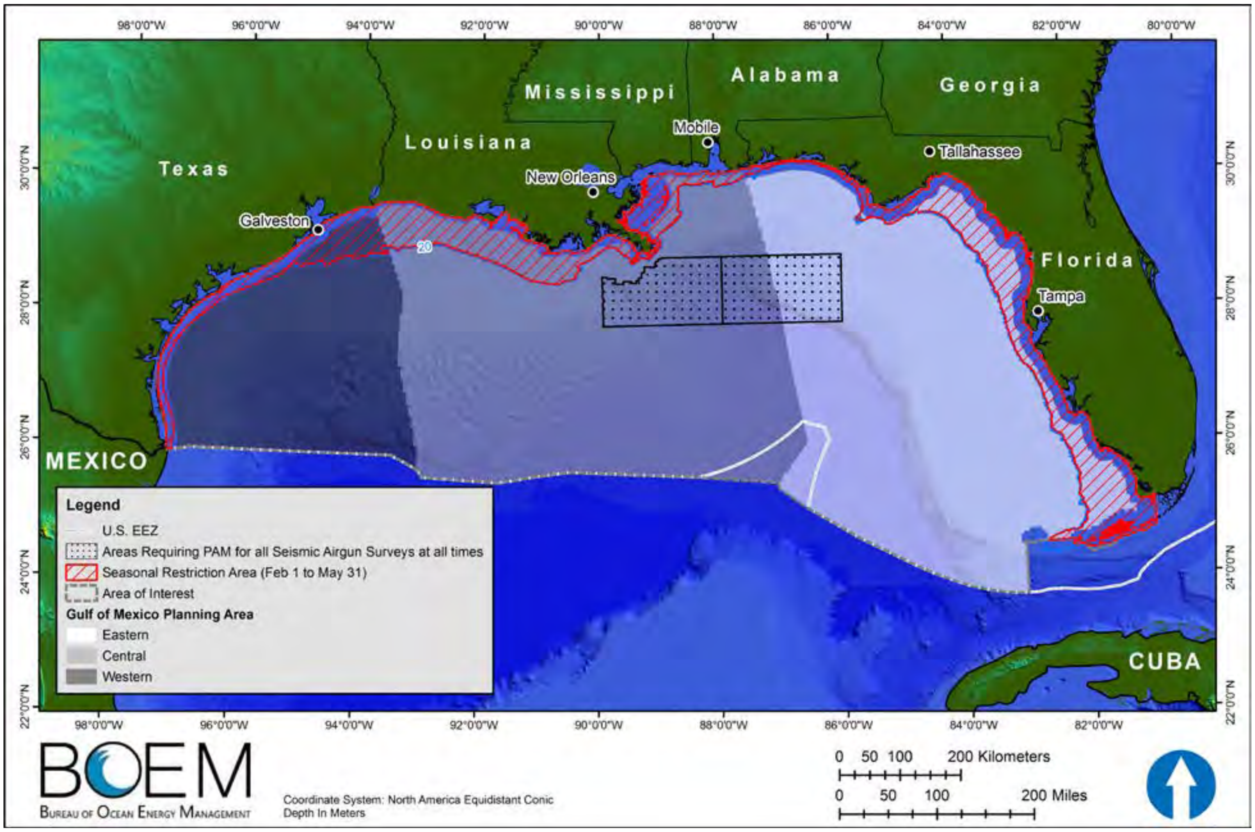

Figure B-3. Coastal Seasonal Restriction Area (Federal and State waters) Between February 1 and May 31 and Areas Requiring Passive Acoustic Monitoring for All Seismic Airgun Surveys for Alternatives C Through F.

1.3.7 Area Closures

Alternatives B and F include closure areas where no new deep-penetration seismic airgun surveys can be performed. Alternative B restricts deep-penetration seismic airgun surveys within the Areas of Concern that fall within the EPA and within the 5-km (3-mi) buffer zone adjacent to portions of Areas of Concern 2 and 4 (**Figure B-2**). This restriction does not apply to currently leased OCS blocks, any portion of the area encompassed by EPA Lease Sale 226, or neighboring OCS lease blocks adjacent to permitted survey areas but within an otherwise off-limit area.

Alternative F restricts all new seismic airgun surveys and non-airgun HRG surveys with equipment operating at or below 200 kHz within the EPA, CPA, Flower Gardens, and Dry Tortugas Closure Areas (**Figure B-4**). Non-airgun HRG surveys with equipment operating at frequencies >200 kHz are permitted in these areas. All existing authorized G&G activities in the closure areas would continue to occur in accordance with the existing permit or authorization. In addition, airgun surveys conducted outside of the closure areas would be required to remain at a distance such that received sound levels at the closed area boundaries would not exceed the threshold for Level B harassment (currently 160 decibels referenced to 1 micropascal [dB re 1 μPa]), as determined by field verification of sound levels or sound field modeling.

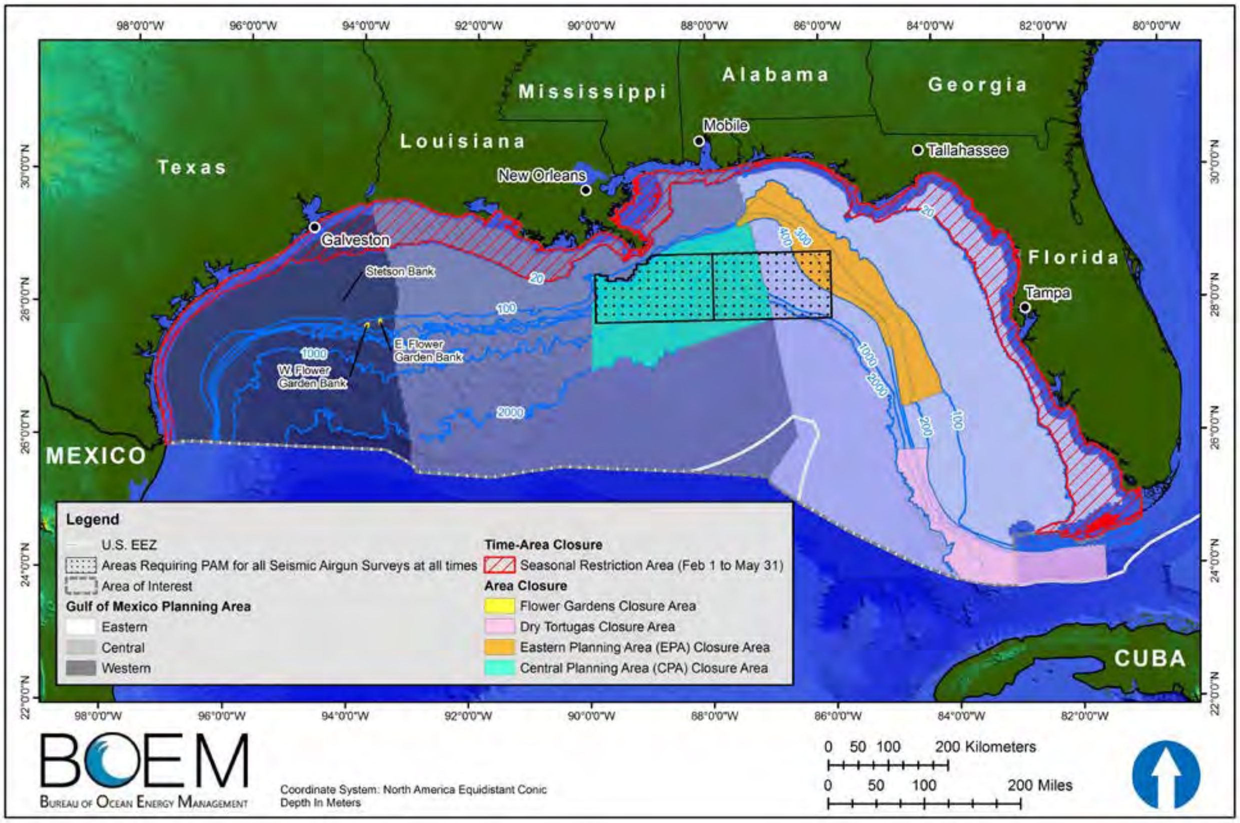

Figure B-4. Alternative F Closure Areas (i.e., the Central Planning Area Closure Area, Eastern Planning Area Closure Area, Dry Tortugas Closure Area, and Flower Gardens Closure Area) and Seasonal Restrictions for Coastal Waters Between February 1 and May 31 and Areas Requiring Passive Acoustic Monitoring for All Seismic Airgun Surveys.

1.3.8 Areas with Additional Restrictions

Alternative B identifies some areas that include additional mitigation measures not previously discussed, including the following:

- When surveying OCS lease blocks neighboring the Areas of Concern, including the 5-km (3-mi) buffer zone, that fall within the EPA, the operators must, in both planning and conducting a survey, limit the active use of airguns in OCS lease blocks that are adjacent to the Areas of Concern that fall within the EPA (**Figure B-2**). Neighboring OCS lease blocks include those located two lease blocks adjacent in any direction from the area being surveyed; and
- Additional G&G survey application requirements submitted to BOEM include:
  - The applicant must provide confirmation of lowest sound source and survey non-duplicity by the following:
    - Written justification explaining why the proposed deep-penetration seismic airgun survey is not unnecessarily duplicative of previously conducted surveys; and

- An estimate of total energy output per impulse in decibels (root mean square [rms]) with respect to each energy source to be used and verify in writing that the airgun arrays, to the furthest extent practicable, use the lowest sound intensity level that still achieves the survey's goals.

2 FEDERAL REGULATIONS AND AGENCIES

2.1 FEDERAL REGULATIONS

2.1.1 National Environmental Policy Act

Signed into law on January 1, 1970, NEPA was the first major environmental law in the U.S. and established the country's national environmental policies. Implementation of NEPA policies occurs through an environmental impact assessment process. Under NEPA, all Federal agencies are required to use a systematic, interdisciplinary approach to protect the human environment and to ensure the integrated use of the natural and social sciences in any planning and decisionmaking that may have an impact on the environment.

In 1979, the CEQ established uniform guidelines for implementing the procedural provisions of NEPA. These regulations (40 CFR parts 1500 through 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. The USDOI regulations to implement NEPA can be found in 43 CFR part 46.

Under NEPA, a detailed EIS must be prepared for major Federal actions that may have a significant impact on the environment. The EIS will fully discuss significant environmental impacts and inform decisionmakers and the public of reasonable alternatives. In addition, the EIS must address any adverse environmental effects that cannot be avoided or mitigated, alternatives to the proposed action, the relationship between short-term uses and long-term productivity of the environment, and any irreversible and irretrievable commitments of resources involved in the proposed action. The NEPA requirement for analysis of major Federal actions is the underlying driver for the production of this Programmatic EIS.

The USDOI Implementation of NEPA's Final Rule (43 CFR part 46) establishes procedures for the Department and its constituent bureaus to use for compliance with NEPA and the CEQ regulations for implementing NEPA. The Final Rule supplements, and is to be used in conjunction with, the CEQ regulations except where it is inconsistent with other statutory requirements.

The USDOI has implementing guidelines that provide agency direction in the application of NEPA. These guidelines include USDOI Departmental Manual Part 516, Chapter 15, which outlines the basic guidelines for implementing NEPA. It delineates NEPA responsibilities within the USDOI, provides guidance to applicants, defines major actions normally requiring an EIS, and identifies actions that have been designated as categorical exclusions (CATEXs).

The USDOI's Environmental Memoranda Series addresses Department environmental responsibilities in three areas: compliance, review, and statement. The Environmental Compliance Memoranda Series provides guidance to bureaus and agencies of the USDOI to ensure compliance with pollution control and environmental protection statutes. The Environmental Review Memoranda Series furnishes information and guidance concerning the receipt, distribution, coordination, and conduct of environmental project reviews requested by other agencies. The Environmental Statement Memoranda Series provides complementary information and guidance to bureaus and offices of the USDOI to ensure compliance with NEPA. The NEPA compliance follows this order of precedence: (1) CEQ regulations; (2) USDOI regulations (43 CFR part 46); (3) USDOI policy (Departmental Manual Part 516); and (4) USDOI guidance provided in the Environmental Memoranda Series.

Since the issuance of an Incidental Take Authorization (ITA) would allow for the taking of marine mammals, consistent with the provisions under the MMPA and incidental to the G&G activities, the National Oceanic and Atmospheric Administration (NOAA) considers this issuance to be a major Federal action subject to NEPA. Therefore, NOAA's National Marine Fisheries Service intends to adopt this Programmatic EIS as the NEPA documentation associated with authorizing incidental take of marine mammals. In addition, NMFS and the Office of National Marine Sanctuaries (ONMS) may rely on the analysis within this Programmatic EIS to support consultation efforts under the ESA, Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and National Marine Sanctuaries Act (NMSA).

2.1.2 Outer Continental Shelf Lands Act

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

(1) establish policies and procedures for managing the oil and natural gas resources of the OCS that are intended to result in expedited exploration and development of the OCS in order to achieve national economic and energy policy goals, assure national security, reduce dependence on foreign sources, and maintain a favorable balance of payments in world trade;

(2) preserve, protect, and develop oil and natural gas resources of the OCS in a manner that is consistent with the need to (a) make such resources available to meet the Nation's energy needs as rapidly as possible; (b) balance orderly resource development with protection of the human, marine, and coastal environments; (c) ensure the public a fair and equitable return on the resources of the OCS; and (d) preserve and maintain free enterprise competition;

(3) encourage development of new and improved technology for energy resource production, which will eliminate or minimize risk of damage to the human, marine, and coastal environments; and

(4) ensure that affected States and local governments have timely access to information regarding OCS activities and opportunities to review, comment, and participate in policy and planning decisions.

Under the OCSLA, the Secretary of the Interior is responsible for the administration of mineral exploration and development of the OCS. Within the USDOI, the Bureau of Ocean Energy Management is charged with the responsibility of managing and regulating the development of OCS oil and gas resources in accordance with the provisions of the OCSLA.

The Energy Policy Act (EPAct) of 2005 (Public Law [P.L.] 109-58) added Section 8(p)(1)(C) to the OCSLA, granting the Secretary of the Interior the authority to issue leases, easements, or rights-of-way on the OCS for the purpose of renewable energy development (43 U.S.C. § 1337(p)(1)(C)). Under the OCSLA, the Bureau of Ocean Energy Management also has jurisdiction over certain geophysical (e.g., seismic, side-scan sonar, bathymetric, and magnetometer) surveying and geological (e.g., vibracoring, boring, and grab sampling) sampling activities that occur in support of the exploration and development of energy and mineral resources on the OCS. BOEM has no jurisdiction over these activities in State waters.

Section 11(a)(1) of the OCSLA states that, "[A]ny agency of the United States and any person authorized by the Secretary of the Interior may conduct geological and geophysical explorations in the outer Continental Shelf, which do not interfere with or endanger actual operations under any lease maintained or granted pursuant to this Act, and which are not unduly harmful to aquatic life in such area." Section 11(a)(2) further provides, "The provisions of paragraph (1) of this subsection will not apply to any person conducting explorations pursuant to an approved exploration plan on any area under lease to such person pursuant to the provisions of the OCSLA."

Section 11(g) specifies that permits for geological explorations must be issued only if the Secretary of the Interior determines that "such exploration will not be unduly harmful to aquatic life in the area…." BOEM's 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."

Section 20 of the OCSLA states the Secretary of the Interior will ". . . conduct such additional studies to establish environmental information as he deems necessary and will monitor the human, marine, and coastal environments of such area or region in a manner designed to provide time-series and data trend information which can be used for comparison with any previously collected data for the purpose of identifying any significant changes in the quality and productivity of such environments, for establishing trends in the area studied and monitored, and for designing experiments to identify the causes of such changes." BOEM's Environmental Assessment Section is responsible for conducting analyses, such as this Programmatic EIS, to assess the environmental impacts of OCS Program activities, involve all stakeholders in the process, and inform the public.

Federal jurisdiction for renewable energy facilities on the OCS was established by Section 8 of the EPAct. In addition to providing the authority to issue leases, easements, and rights-of-way, the EPAct includes 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 seafloor, including use for a fishery, a sea lane, a deepwater port, or navigation;
- public notice and comment on any proposal submitted for a lease, easement, or right-of-way; and
- oversight, inspection, research, monitoring, and enforcement relating to a lease, easement, or right-of-way.

On April 22, 2009, BOEM promulgated final regulations implementing this authority at 30 CFR part 585. The USDOI is required to manage the leasing, site assessment, installation, and production of renewable energy on the Federal OCS. Certain G&G surveys are required to characterize seafloor conditions before installing a renewable energy facility or to verify completion of decommissioning activities. 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 reduce the likelihood of harm or damage to objects of historical or archaeological significance. The applicant has the option to demonstrate through additional investigations that an archaeological resource does not exist or would not be adversely affected by the seafloor-disturbing activities. If an applicant 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, and piles of ballast rock), prehistoric artifacts, and/or relict landforms within the project area while conducting activities, the applicant is to

- immediately halt seafloor-disturbing activities within the area of discovery;
- notify the appropriate BOEM Office of Offshore Alternative Energy Programs Environmental Branch Chief within 72 hours of the 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 benthic habitat, bird, marine mammal, and sea turtle survey information for renewable energy projects on the Atlantic OCS that could be applied to the GOM (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. A Final Programmatic EIS for the OCS renewable energy program was released in 2007 (USDOI, MMS, 2007).

2.1.3 Endangered Species Act

The ESA established protection over and conservation of threatened and endangered species and the ecosystems upon which they depend. An endangered species is a species in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service (FWS) and NMFS jointly administer the ESA and are responsible for the listing of species (designating a species as either threatened or endangered) and designating geographic areas as critical habitat for threatened and endangered species.

The ESA generally prohibits the "take" of an ESA-listed species unless an exception or exemption applies. The term "take," as defined in Section 3 of the ESA, means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Section 7(a)(2) requires each Federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a Federal agency's action may affect a listed species, that agency is required to consult with NMFS and/or the FWS under procedures set out in 50 CFR part 402. The FWS and NMFS can be action agencies under Section 7 as well.

Under Section 7, to initiate consultation, BOEM as the action agency would submit a consultation package, usually referred to as a Biological Assessment, to the appropriate service agency (NMFS and/or FWS) for proposed actions that may affect listed species or critical habitat. The relevant service reviews the Biological Assessment and provides BOEM a determination regarding the nature of any effects on each listed species or critical habitat and whether a formal or informal consultation is required. For each species likely to be adversely affected, formal consultation is required, ending with NMFS and/or FWS issuing a Biological Opinion. If the Biological Opinion concludes jeopardy is not likely, a Incidental Take Statement (ITS) will be issued containing the reasonable and prudent measures necessary or appropriate to minimize the impact of the taking, measures to comply with Section 101(a)(5) of the MMPA, and the terms and conditions to implement those measures. Taking in compliance with the ITS terms and conditions is exempt from the ESA's takings prohibitions.

Informal consultation is sufficient for species the action agency determines are not likely to be adversely affected if NMFS or FWS concurs with the action agency's findings, including any additional measures mutually agreed upon as necessary and sufficient to avoid adverse impacts to listed species and/or designated critical habitat.

2.1.4 Marine Mammal Protection Act

The MMPA established, with certain exceptions, a moratorium on the "taking" of marine mammals in waters or on lands under U.S. jurisdiction, and on the taking of marine mammals on the high seas by vessels or persons under U.S. jurisdiction. The term "take," as defined in the MMPA (16 U.S.C. § 1362 (13)), means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of harassment relevant here: Level A (injury) and Level B (behavioral disturbance). Among the available exceptions to the take moratorium, the MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if NMFS finds that the taking will have a negligible impact on the species or stock(s) and will not have an immitigable adverse impact on the availability of the species or stock(s) for taking for subsistence uses (where relevant). The authorization must set forth the permissible methods of taking; other means of effecting the least practicable adverse impact on the species or stock and its habitat; and requirements pertaining to the mitigation, monitoring, and reporting of such taking. Entities seeking to obtain authorization for the incidental take of marine mammals under NMFS jurisdiction must submit such a request (in the form of an application). The NMFS issued regulations to implement provisions of the MMPA (50 CFR 216 subpart I) and produced Office of Management and Budget (OMB)-approved application instructions (OMB Number 0648-0151) that prescribe the procedures necessary to apply for authorizations.

BOEM has determined that an ITA is warranted for G&G activities involving acoustic sources that could harass marine mammals. Therefore, this Programmatic EIS will support a petition for incidental take regulations under the MMPA. The associated rulemaking would cover G&G activities, generally, within the three GOM planning areas. Industry would then be allowed to apply for individual ITAs under the resulting final regulations, if issued. Since the issuance of an ITA would allow for the taking of marine mammals, consistent with the provisions under the MMPA and incidental to the G&G activities, NOAA considers this issuance to be a major Federal action subject to NEPA. Therefore, NOAA's National Marine Fisheries Service intends to adopt this Programmatic EIS as the NEPA documentation associated with authorizing incidental take of marine mammals. In addition, NMFS and ONMS may rely on the analysis within this Programmatic EIS to support consultation efforts under the ESA, MSFCMA, and NMSA. Additionally, NMFS intends to use this Programmatic EIS to support the issuance of proposed and final rules, respectively. While this Programmatic EIS provides information about the possible locations relevant to requesting an ITA, including potential takes, the specific location and G&G activity details will not be known until BOEM receives an application. BOEM and BSEE's approval for G&G activities will be conditional on the operator obtaining the necessary ITA from NMFS prior to commencing G&G activities.

2.1.5 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972 (16 U.S.C. §§ 1451 *et seq*.) was enacted to develop a national coastal management program that comprehensively manages and balances competing uses of and impacts to any coastal use or resource. The national coastal management program is implemented by individual State coastal management programs in partnership with the Federal Government. The CZMA's Federal consistency regulations require that Federal activities (e.g., OCS lease sales) be consistent to the extent practicable with the enforceable policies of a State's coastal management program. The Federal consistency regulations also require that other federally approved activities (e.g., activities requiring Federal permits such as activities described in OCS plans) be fully consistent with the enforceable policies of a State's federally approved coastal management program. The CZMA is administered by the Office of Ocean and Coastal Resource Management within the National Ocean Service (NOS). The NOS's implementing regulations are found at 15 CFR part 930, with the latest revision published in the *Federal Register* (2006).

The overall program objectives of the CZMA are to "preserve, protect, develop, and where possible, to restore or enhance the resources of the nation's coastal zone." Each of the 34 coastal states (Alaska voluntarily withdrew from the National Coastal Zone Management Program in 2011) have programs to address the balance in competing land and water issues in the coastal zone. A State's jurisdictional purview typically extends 3 nmi (3.5 mi; 5.6 km) offshore of the coast and coastal islands (Texas, the Gulf Coast of Florida, and Louisiana are exceptions). Texas and the Gulf Coast of Florida are extended 9 nmi (10.4 mi; 16.7 km) seaward, and Louisiana is extended 3 imperial nmi (2.6 nmi; 4.8 km). In order to receive a permit from BOEM, an applicant's proposed survey must be fully consistent with the enforceable policies of the State's coastal management program by the affected State coastal zone management (CZM) agencies.

During the review of the survey application under the proposed action, BOEM is to coordinate with the five Gulf Coast States through the CZMA, which helps the States develop coastal management programs to manage and balance competing uses of the coastal zone. The CZMA and implementing regulations require agency actions that are reasonably foreseeable to affect any land or water use, or natural resource of the coastal zone, to be consistent with enforceable policies of the five States' coastal management program. Accordingly, BOEM is to provide the five Gulf Coast States with information on lease sales, as well as exploration and development plans for review during a designated period to conduct a consistency review to determine if the proposed activities are consistent with the States' coastal management policies. If a coastal State determines that a proposed action by BOEM is not consistent with the State's approved CZM program, it can pursue one of several administrative remedies.

2.1.6 Magnuson-Stevens Fishery Conservation and Management Act

The MSFCMA (P.L. 94-265) was enacted to address impacts to fisheries on the U.S. continental shelf. It established U.S. fishery management over fishes within the fishery conservation zone from the seaward boundary of the coastal states out to 200 nmi (230 mi; 370 km) (i.e., boundary of the U.S. Exclusive Economic Zone). The MSFCMA also established regulations for foreign fishing within the fishery conservation zone and issued national standards for fishery conservation and management to be applied by eight regional fishery management councils. Each council is responsible for developing Fishery Management Plans for domestic fisheries within its geographic jurisdiction. In 1996, Congress enacted amendments to the MSFCMA, known as the Sustainable Fisheries Act (P.L. 104-297), to address substantially reduced fish stocks resulting from direct and indirect habitat loss.

The Sustainable Fisheries Act requires BOEM and other agencies to consult with NMFS concerning actions that may adversely impact EFH. The EFH is defined as the waters and substrate necessary to fishes or invertebrates for spawning, breeding, feeding, or growth to maturity. Areas designated as EFH contain habitat essential to the long-term survival and health of U.S. fisheries. EFH for managed fisheries is described in the Fishery Management Plans.

Federal agencies that authorize, fund, or undertake actions that might adversely affect EFH must consult with the Secretary of Commerce, through NMFS, regarding potential effects to EFH. To streamline the process, NMFS combines EFH consultations with existing environmental reviews required by other laws such as NEPA, and as a result, most consultations are completed within the time frames for review of other documents. BOEM requested consultation under the MSFCMA in conjunction with this Programmatic EIS. This Programmatic EIS provides information that will be relevant and applicable to support future consultations on EFH for site-specific G&G actions.

2.1.7 Clean Air Act

The OCSLA (43 U.S.C. § 1334(a)(8)) requires the Secretary of the Interior to promulgate and administer regulations that comply with the National Ambient Air Quality Standards pursuant to the Clean Air Act (CAA) (42 U.S.C. §§ 7401 *et seq.*) and to the extent that authorized activities significantly affect the air quality of any state. Under provisions of the CAA, as amended, the USEPA Administrator, in consultation with the Secretary of the Interior and the Commandant of the USCG, established requirements to control air pollution in OCS areas of the Arctic, Atlantic, Pacific, and parts of the GOM.

The OCS sources within 25 nmi (29 mi; 46.3 km) of the States' seaward boundaries are subject to the same Federal and State requirements as sources located onshore. OCS sources beyond 25 nmi (29 mi; 46.3 km) of the States' boundaries are subject to Federal requirements for Prevention of Significant Deterioration promulgated pursuant to Part C of Title 1 of the CAA, as amended. The CAA, as amended, also established procedures to allow the USEPA Administrator to exempt any OCS source from a control technology requirement if it is technically infeasible or poses an unreasonable threat to health, safety, security, and the environment.

BOEM's air quality regulations (30 CFR part 250 subpart C) assess and control OCS emissions that may impact air quality onshore. BOEM applies defined criteria to determine which OCS plans require an air quality review, and performs an impact-based analysis on the selected plans to determine whether the emission source could cause a significant onshore impact. If an emission source is determined to be significant and therefore requires air quality modeling, the USEPA's preferred model (the Steady-State Gaussian, Offshore and Coastal Dispersion model) should be used.

Because the review under this document is programmatic in nature and does not address project-specific information regarding air quality issues, it will not result in a permit application under the CAA. Future site-specific proposals will be reviewed by BOEM to ensure CAA standards or permit requirements are met and that agreed-upon measures will avoid, minimize, or mitigate potential adverse effects.

2.1.8 Clean Water Act

The Clean Water Act (CWA) (33 U.S.C. §§ 1251 *et seq.*) established the basic structure for regulating discharges of pollutants into U.S. waters and regulating quality standards for surface waters. The basis of the CWA, enacted in 1948, was the Federal Water Pollution Control Act. When the Act was significantly reorganized and expanded with amendments in 1972, the common name became the Clean Water Act. Under the CWA, it is unlawful for any person to discharge any pollutant from a point source into navigable waters without a National Pollutant Discharge Elimination System (NPDES) permit. All waste streams generated from offshore oil and gas activities are regulated by the USEPA, primarily by general permits. The USEPA may not issue a permit for a discharge into ocean waters unless the discharge complies with the guidelines established under Section 403(c) of the CWA. These guidelines are intended to prevent degradation of the marine environment and require an assessment of the effect(s) of the proposed discharges on sensitive biological communities and aesthetic, recreational, and economic values.

Other sections of the CWA also apply to offshore activities. Section 404 of the CWA requires a USACE permit for the discharge or deposition of dredged or fill material in all U.S. waters, including ocean areas and estuaries. Approval by the USACE, with consultation from other Federal and State agencies, is required for installing and maintaining pipelines and OCS seafloor structures in coastal areas. Section 303 of the CWA provides for the establishment of water quality standards that identify a designated use for waters (e.g., fishing and swimming). States (excluding Texas, the Gulf Coast of Florida, and Louisiana) have adopted water quality standards for ocean waters within their jurisdiction (waters of the territorial sea extending out to 3 nmi [3.5 mi; 5.6 km]). Texas and the Gulf Coast of Florida are extended 9 nmi (10.4 mi; 16.7 km) seaward, and Louisiana is extended 3 imperial nmi (2.6 nmi; 4.8 km). Operators would be required to obtain an NPDES permit from the USEPA for any effluent discharges (including drilling fluids and cuttings) from a Continental Offshore Stratigraphic Test (COST) or shallow test well.

The USACE's Nationwide Permit (NWP) Program, also called a general permit (USACE, 2012) was developed to streamline the evaluation and approval process for certain types of activities that have minimal impacts to the aquatic environment. Any applicant that intends to use an NWP must ensure that their proposed activity meets the terms, conditions, and regional conditions of the NWP as well as any additional CZM program or Section 401 water quality requirements. Most G&G survey activities qualify for NWP 5 or NWP 6. The NWP 5 covers the placement of scientific measurement devices such as staff gauges, tide gauges, water recording devices, water quality testing and improvement devices, and similar structures applicable to certain G&G activities such as the temporary installation of meteorological buoys or other data collection devices. The NWP 6 addresses survey activities such as core sampling, seismic exploratory operations, plugging of seismic shot holes and other exploratory-type bore holes, exploratory trenching, soil surveys, sampling, and historic resources surveys. Drilling and discharge of excavated material from test wells for oil and gas exploration are not authorized by NWP 6 and would require a Section 404/Section 10 permit, also called a standard permit.

Because the review under this document is programmatic in nature and does not address project-specific information regarding water quality issues, it will not result in a permit application under the CWA. Future, site-specific proposals will be reviewed by BOEM to ensure CWA standards or permit requirements are met and that agreed-upon measures will avoid, minimize, or mitigate potential adverse effects. The G&G surveys in State waters fall under the jurisdiction of the USACE and would not be subject to BOEM review.

2.1.9 Rivers and Harbors Act

The Rivers and Harbors Act (33 U.S.C. §§ 401, 403, and 407), enacted in 1899, was the first Federal water pollution act in the U.S. It focuses on protecting navigation and waters from pollution and acted as a precursor to the CWA of 1972. Section 10 (33 U.S.C. § 403) prohibits the unauthorized obstruction or alteration of any navigable water of the U.S. (i.e., construction of various structures that hinder navigable capacity of any waters) without the approval of Congress. While the initial purpose of the Rivers and Harbors Act was to prevent obstructions to navigation, a

1959 Supreme Court decision interpreted obstruction to navigation to include water pollution. The Supreme Court found anything that tends to destroy the navigable capacity of a navigable waterway is prohibited by the Rivers and Harbors Act.

Section 10 is applicable for structures, installations, and other devices on the OCS seafloor. Section 10 is not applicable to most actions undertaken for exploration on the OCS, except for drilling and discharge of excavated material from test wells as they fall under NWP 6. An NWP 5 for "Scientific Measurement Devices" and an NWP 6 for "Survey Activities" are both appropriate for Section 10 actions. Because the review under this document is programmatic in nature and does not address project-specific information regarding impacts to navigable waters, it will not result in a permit application under the Rivers and Harbors Act. The USACE 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 USACE permit application and the USACE's decision that the proposed activity is not contrary to the public interest.

2.1.10 National Historic Preservation Act

The National Historic Preservation Act (NHPA) of 1966, as amended (54 U.S.C. §§ 300101 *et seq*.), established a program for the preservation of historic properties. Section 106 of the NHPA (36 CFR part 800), "Protection of Historic Properties," as amended through 2004, requires Federal agencies that have direct or indirect jurisdiction over a proposed Federal, federally assisted, or federally licensed undertaking to take into account the effect of the undertaking on any district, site, building, structure, or object included in or eligible for inclusion in the National Register of Historic Places prior to approval of the expenditure of funds or the issuance of a license. The Advisory Council on Historic Preservation (ACHP), which administers Section 106 (54 U.S.C. § 306108), has issued regulations (36 CFR part 800) defining how Federal agencies are to meet the statutory responsibilities. The head of a Federal agency will afford the ACHP a reasonable opportunity to review and comment on the action.

An action has an effect on a historic property when that action alters the characteristics of the property that led to its inclusion in the National Register of Historic Places. The effects can include physical disturbance, noise, or visual effects. If an adverse effect on historic properties is found, BOEM would notify the ACHP, consult with the State Historic Preservation Office, and encourage the applicant to avoid, minimize, or mitigate the adverse effects. Ground-disturbing activities associated with construction, as well as visual effects of OCS energy infrastructure (e.g., wind turbine generators) are subject to Section 106 review.

Historic properties (i.e., archaeological resources) on the OCS include historic shipwrecks, sunken aircraft, lighthouses, and prehistoric archaeological sites that have become inundated as a result of the 120-m (394-ft) rise in global sea level since the height of the last Ice Age (approximately 19,000 years ago). The OCS is not federally owned land, and the Federal Government has not claimed direct ownership of historic properties on the OCS; therefore, under Section 106 of the NHPA, the Bureau of Ocean Energy Management only has the authority to ensure that their funded and permitted actions do not adversely affect significant historic properties. Beyond avoidance of adverse impacts, BOEM does not have the legal authority to manage historic properties on the OCS.

For the activities within the proposed action, BOEM will make a determination as to whether the actions could affect historic properties, including those already in the National Register of Historic Places and those that meet the criteria for listing. If it is determined the action could affect such properties, BOEM will identify the appropriate State/Tribal Historic Preservation Officer to consult with during the process. Consultation is expected to result in an Memorandum of Agreement, outlining agreed-upon measures that BOEM will take to avoid, minimize, or mitigate adverse effects.

2.1.11 Marine Protection, Research, and Sanctuaries Act

The Marine Protection, Research, and Sanctuaries Act (MPRSA) (33 U.S.C. §§ 1401 *et seq*.), enacted in 1972 and also referred to as the Ocean Dumping Act, generally prohibits (1) transportation of material from the U.S. for the purpose of ocean dumping, (2) transportation of material from anywhere for the purpose of ocean dumping by U.S. agencies or U.S.-flagged vessels, and (3) dumping of material transported from outside the U.S. into the U.S. territorial sea. A permit is required to deviate from these prohibitions.

Under the MPRSA, the standard for permit issuance is whether the dumping will "unreasonably degrade or endanger" human health, welfare, or the marine environment. The USEPA is charged with developing ocean dumping criteria to be used in evaluating permit applications. The MPRSA contains provisions that address marine sanctuaries, which are administered by NOAA.

2.1.12 National Marine Sanctuaries Act

The NMSA authorizes the Secretary of Commerce to designate and manage areas of the marine environment with special national significance. The ONMS, administered by NOAA, has the authority to permit or authorize activities that would occur within or near an NMS. The ONMS manages the uses of the National Marine Sanctuary System through issuing programmatic and site-specific regulations; issuing permits or authorizations for activities that are otherwise prohibited; enforcing regulations and permits; consulting with Federal agencies and recommending alternatives to activities that are likely to injure sanctuary resources; and conducting research, monitoring, education, and outreach for all NMSs. The NMSA and ONMS regulations provide four forms of approval to allow an entity to conduct an activity otherwise prohibited by ONMS regulations:

(1) General permits may be issued to allow activities that are otherwise prohibited by sanctuary regulations (15 CFR part 922). Prohibitions are sanctuary-specific but commonly include disturbance of submerged lands and discharges within or into the sanctuary. General permits are reviewed against specific permit categories and review criteria established in regulation.

(2) Authorizations to implement permits granted by other Federal, State, or local agencies allow otherwise prohibited activities and may include additional terms and conditions, as appropriate.

(3) Special use permits may be issued to establish conditions of access to a sanctuary resource, or promote the public use and understanding of a sanctuary resource. The list of categories of activities applicable to special use permits are published in the *Federal Register*. Special use permits are granted only when the activity is compatible with the purpose for which the sanctuary was designated and sanctuary resources will not be injured. The ONMS may assess fees associated with special use permits for administrative costs, implementation and monitoring costs, and the fair market value of the use of the NMS.

(4) Certifications may be issued to allow otherwise prohibited activities to continue following the designation of a new sanctuary or expansion of an existing sanctuary. Preexisting Federal, State, or local permits may not be terminated pursuant to the NMSA. However, ONMS may regulate the exercise of such permits consistent with the purpose for which the sanctuary was designated. The permit holder seeking a certification from ONMS must comply with the procedures and criteria promulgated at the time of sanctuary designation or expansion.

Most NMS regulations explicitly prohibit harassment of marine mammals, sea turtles, and birds by any means unless authorized by the MMPA, ESA, or Migratory Bird Treaty Act, though additional restrictions vary across sanctuaries. Pursuant to a Presidential directive, NMSs designated as of July 14, 2008, are withdrawn from new oil/gas leases. The Flower Garden Banks NMS allows exploration for developing and producing oil and gas outside of BOEM's "No Activity Zones." The Florida Keys NMS regulations prohibit the exploration for hydrocarbons within the sanctuary. In addition, if G&G activities include the potential for discharge or seafloor disturbance within the sites, permits from the NMS may be required.

Section 304(d) of the NMSA requires interagency consultation on any Federal action "likely to destroy, cause the loss of, or injure a sanctuary resource." "Actions" include direct Federal actions and activities authorized by Federal licenses, leases, or permits. The action can occur internal or external to the boundaries of an NMS. The purpose of Section 304(d) consultation is to provide better protection sanctuary resources by requiring Federal agencies to consider alternatives to proposed actions that will protect sanctuary resources and avoid injury. The ONMS works cooperatively with Federal agencies in proactively identifying actions that may require NMSA consultation and completing sanctuary consultation at the earliest practicable time. BOEM will consult with ONMS under Section 304(d) when they receive an application that indicates a G&G activity may occur within or near the Flower Garden Banks NMS or the Florida Keys NMS. In addition, NMFS consults with the ONMS when an authorization would include takes of marine mammals within the boundaries of an NMS. Upon receipt of ITA applications, NMFS will determine its need to consult with ONMS. Although the determination and responsibility to consult under Section 304(d) resides with the Federal agencies (i.e., NOAA and BOEM), applicants may need to acquire permits directly from ONMS for activities that are prohibited within the sanctuary (refer to the earlier description). Additional information on sanctuary consultation can be obtained at http://sanctuaries.noaa.gov/management/consultations/welcome.html.

2.1.13 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) of 1918 (16 U.S.C. §§ 703-712) is the primary legislation in the U.S. for the conservation of migratory birds. It implements the U.S.'s commitment to four bilateral treaties, or conventions, for the protection of a shared migratory bird resource. The MBTA prohibits the taking, killing, or possessing of migratory birds unless permitted by regulation. The bird species protected by the MBTA appear in the *Federal Register* (2010a). Executive Order 13186 ("Responsibilities of Federal Agencies to Protect Migratory Birds"), signed on January 10, 2001 (*Federal Register,* 2001), requires that Federal agencies taking actions likely to negatively affect migratory bird populations enter into Memorandums of Understanding (MOUs) with the FWS.

On June 4, 2009, BOEM entered into an MOU with the FWS to comply with Executive Order 13186 (USDOI, MMS, 2009). The MOU is meant to strengthen collaboration between BOEM, BSEE, and FWS. Included in the MOU is direction to expand coverage in NEPA environmental reviews of the effects of agency actions on migratory birds, with emphasis on species of concern in furtherance of conservation of migratory bird populations. The original MOU was signed by MMS and FWS. BOEM and BSEE are currently in the process of extending the MOU with FWS and changing the responsible parties from MMS and FWS to BOEM, BSEE, and FWS to reflect the reorganization of duties. Future site-specific proposals will be reviewed by BOEM and BSEE to ensure MBTA standards are addressed in the manner outlined in the MOU.

2.1.14 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. §§ 661-666c), enacted March 10, 1934, is intended to protect fish and wildlife when Federal actions result in the control or modification of a natural stream or body of water. The FWCA provides the basic authority for the involvement of FWS in evaluating impacts to fish and wildlife from proposed water resource development projects. The FWCA requires that all Federal agencies consult with FWS, NMFS, and State wildlife agencies for activities that affect, control, or modify waters of any stream or bodies of water.

2.1.15 CFR Title 30: Mineral Resources

Pre-lease (and some post-lease) G&G exploratory (prospecting) operations for oil, gas, and sulphur resources, or for scientific research on unleased OCS lands and across leases owned by a third party are regulated by 30 CFR part 551. All pre-lease G&G surveys require a permit under 30 CFR part 551. Each permit application is subject to a site-specific NEPA evaluation, which typically is an EA (**Table 1.1-2** of this Programmatic EIS). In the AOI, this Programmatic EIS provides that evaluation, from which site-specific evaluations may be tiered under the NEPA regulations (40 CFR § 1502.20).

On-lease oil and gas activity on the OCS is regulated by 30 CFR part 550 after a lease is acquired. Post-lease activities and G&G activities that are required to support them are governed by a series of OCS plans (**Table 1.1-2** of this Programmatic EIS). An exploration plan guides any exploration activities on a lease or unit, and a DOCD (submitted for the USEPA) or Development and Production Plan (DPP) (submitted for the CPA and EPA) guides any development and production activities on a lease or unit.

A G&G permit must be obtained from BOEM prior to conducting off-lease G&G activities on unleased OCS lands or on lands under lease to a third party (30 CFR §§ 551.4(a) and (b)).

Ancillary activities are post-lease operations by lease owners in furtherance of developing oil and gas resources. Ancillary G&G activities are defined in 30 CFR §§ 250.105 and 550.105 with regulations outlined in 30 CFR §§ 550.207-550.210 (**Table 1.1-1** of this Programmatic EIS). BOEM issued NTL 2009-G34, "Ancillary Activities," to provide guidance and clarification on conducting ancillary activities in BOEM's Gulf of Mexico OCS Region. Guidance for each type of ancillary activity, the type and level of BOEM review, and follow-up post-survey report requirements are provided in NTL 2009-G34. The NTL expired on November 30, 2014, and renewal language has not been issued; however, NTL 2015-N02 was issued in February 2015 and eliminates expiration dates on certain lessees and operators pending review and reissuance.

Regulations governing non-energy (marine) mineral prospecting, leasing, and production are in 30 CFR part 580 (prospecting), part 581 (leasing), and part 582 (production). In 1994, P.L. 103-426 was enacted, allowing BOEM to negotiate, on a noncompetitive basis, the rights to OCS sand, gravel, or shell resources for shore protection, beach or wetlands restoration projects, or for use in construction projects funded in whole or part by or authorized by the Federal Government. The G&G activities associated with these noncompetitive leases for public works are issued authorizations pursuant to Section 11 of the OCSLA. For all other uses, such as private use for commercial construction material, a competitive bidding process is required for issuing leases under Section 8(k) of the OCSLA.

2.1.15.1 Notice to Lessees and Operators

Guidance for each type of ancillary activity, the type and level of BOEM review, follow-up actions, and post-survey report requirements are provided in NTL 2009-G34. The NTL also specifies that operators must notify BOEM in writing at least 30 calendar days (30 CFR § 250.208(a)) before conducting any of the following types of ancillary activities:

- a G&G exploration or development activity involving the use of an airgun or airgun arrays in water depths ≥200 m (656 ft) or in any water depth within the EPA;
- a G&G exploration or development activity involving the use of explosives as an energy source, independent of water depth; and
- a G&G exploration or development activity including OBC, OBN, and time-lapse (4D) surveys, independent of water depth.

Additionally, NTL 2009-G34 specifies that operators must notify BOEM in writing at least 15 calendar days (30 CFR § 250.208(b)(1)) before conducting the following types of ancillary activities:

- any other ancillary activity involving seafloor disturbance, independent of water depth, including OBC, OBN, and time-lapse (4D) surveys; and
- any other ancillary activity involving piston-/gravity-coring or the recovery of sediment specimens by grab sampling or similar technique and/or any dredging or other ancillary activity that disturbs the seafloor (including deployment and retrieval of OBCs, anchors, or other equipment).

Ancillary activities are subject to conditional NEPA reviews (**Table 1.1-2** of this Programmatic EIS) depending on what activity is being proposed. Generally, any G&G survey using an airgun or that involves explosives or seafloor-disturbing activity is evaluated with an EA. If BOEM determines that the type of proposed activity necessitates revising an existing OCS plan, a NEPA review is triggered (usually an EA). In addition to the NEPA review, the operator must have an approved exploration plan, DOCD, or DPP, each of which would have been subject to a NEPA review as part of initial plan approval.

2.1.16 Executive Order 12114 – Environmental Effects Abroad of Major Federal Actions

Issued on January 4, 1979, by President Carter, Executive Order 12114 directs Federal agencies to provide for informed decisionmaking for major Federal actions with effects that occur outside the 50 states, territories, and possessions of the U.S., including marine waters seaward of U.S. territorial seas, the global commons, the environment of a nonparticipating foreign nation, or effects to protected global resources. Global commons are defined as “geographical areas that are outside of the jurisdiction of any nation, and include the oceans outside territorial limits and Antarctica. Global commons do not include contiguous zones and fisheries zones of foreign nations” (32 CFR § 187.3).

An Overseas EIS is required when an action could significantly harm the environment of the global commons. The procedural requirements under Executive Order 12114 largely mirror those of NEPA, except Executive Order 12114 does not require scoping. For this action, the EIS and

Overseas EIS have been combined into one document, as permitted under NEPA and Executive Order 12114, in order to reduce duplication. The AOI for this proposed action is within the Exclusive Economic Zone; specifically, within the WPA, CPA, and EPA as currently defined.

2.1.17 Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations

Signed on February 11, 1994, by President Clinton, Executive Order 12898 requires that each Federal agency, to the extent practicable and permitted by law, make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. The Executive Order required that, within 1 year, each Federal agency develop an environmental justice strategy identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. The CEQ has oversight of the Federal Government's compliance with Executive Order 12898. The CEQ (1997) guidance for implementation of Executive Order 12898 in the context of NEPA identifies a minority population as an affected area where >50 percent of the population belongs to a minority group or where the percentage presence of minority groups is meaningfully greater than in the general population.

Potential environmental justice communities have been identified in this Programmatic EIS (refer to **Appendix E, Section 13.2**). Future environmental reviews of site-specific projects would be expected to identify individual low-income communities (such as fishing communities) and assess any disproportionate human health and environmental effects that these communities could face.

2.1.18 Executive Order 12989 – Economy and Efficiency in Government Procurement through Compliance with Certain Immigration and Naturalization Act Provisions

Signed on February 13, 1996, by President Clinton, Executive Order 12989 was designed to promote economy and efficiency in government procurement (*Federal Register, 1996*). This Executive Order made it the policy of the executive branch that in procuring goods and services, to ensure the economical and efficient administration and completion of Federal Government contracts, contracting agencies should not contract with employers that have not complied with sections of the Immigration and Nationality Act (8 U.S.C. § 1324) prohibiting the unlawful employment of aliens. Since being enacted, this Executive Order has been amended by Executive Order 13286 on February 28, 2003, and by Executive Order 13465 on June 6, 2008.

2.1.19 Executive Order 13089 – Coral Reef Protection Act

Signed on June 11, 1998, by President Clinton, Executive Order 13098 preserved and protected the coral reef ecosystems of the U.S. This Executive Order acts in furtherance of the CWA, CZMA, MSFCMA, NEPA, and NMSA. All Federal agencies whose actions may affect U.S. coral reef ecosystems will (1) identify their actions that may affect U.S. coral reef ecosystems;

(2) utilize their programs and authorities to protect and enhance the conditions of such ecosystems; and (3) to the extent permitted by law, ensure that any actions they authorize, fund, or carry out will not degrade the conditions of such ecosystems (*Federal Register,* 1998). The Secretary of the Interior serves as a co-chair for the U.S. Coral Reef Task Force.

Because the review under this document is programmatic in nature and does not address project-specific information regarding impacts to coral reefs, it will not result in specific stipulations beyond those found in survey protocols (refer to **Chapter 2** of this Programmatic EIS). 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.

2.1.20 Executive Order 13158 – Marine Protected Areas

Signed on May 26, 2000, by President Clinton, Executive Order 13158 strengthened and expanded the Nation's system of Marine Protected Areas (MPAs) (*Federal Register,* 2000a). Specifically, consistent with domestic and international law, the Executive Order was to (1) strengthen the management, protection, and conservation of existing MPAs and establish new or expanded MPAs; (2) develop a scientifically based, comprehensive national system of MPAs representing diverse U.S. marine ecosystems as well as the Nation's natural and cultural resources; and (3) avoid causing harm to MPAs through federally conducted, approved, or funded activities. The South Atlantic Fishery Management Council (2011) defines MPAs within its jurisdiction as a network of specific areas of marine environments reserved and managed for the primary purpose of aiding in the recovery of overfished stocks and to ensure the persistence of healthy fish stocks, fisheries, and associated habitats. Such areas may include naturally occurring or artificial seafloor and water column habitats, and may include prohibition of harvest on seasonal or permanent time periods to achieve desired fishery conservation and management goals.

Because the review under this document is programmatic in nature and does not address project-specific information regarding impacts to MPAs, it will not result in specific stipulations regarding MPAs beyond those found in survey protocols (refer to **Chapter 2** of this Programmatic EIS). BOEM will require site-specific information regarding sensitive benthic communities that might be found in MPAs (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.

2.1.21 Executive Order 13175 – Consultation and Coordination with Federally Recognized Indian Tribes

Signed on November 6, 2000, by President Clinton, Executive Order 13175 established regular and meaningful consultation and collaboration with Tribal officials in the development of Federal policies that have Tribal implications to strengthen the U.S. government-to-government relationships with Indian Tribes and to reduce the imposition of unfunded mandates upon Indian

Tribes. The Executive Order directed Federal agencies to establish procedures to consult and collaborate with Tribal governments when new agency regulations would have Tribal implications. This Executive Order is a directive to all Federal agencies, but it only has persuasive authority for independent regulatory agencies (e.g., Federal Communications Commission and Securities and Exchange Commission) and is not meant to create a right, substantial or procedural, that is enforceable by law.

2.1.22 Executive Order 13547 – Stewardship of the Ocean, Our Coasts, and the Great Lakes

Signed on July 19, 2010, by President Obama, Executive Order 13547 established a national ocean policy and the National Ocean Council (*Federal Register,* 2010b). The Executive Order established a national policy to ensure the protection, maintenance, and restoration of the health of ocean, coastal, and Great Lakes ecosystems and resources; to enhance the sustainability of ocean and coastal economies; to preserve maritime heritage; to support sustainable uses and access; to provide for adaptive management to enhance understanding of and capacity to respond to climate change and ocean acidification; and to coordinate with U.S. national security and foreign policy interests. Where BOEM's actions affect the ocean, the Executive Order requires BOEM to take such action as necessary to implement this policy, the stewardship principles, national priority objectives adopted by the Executive Order, and guidance from the National Ocean Council.

Implementation of the guidelines presented in Executive Order 13547 is still in the planning stages at BOEM and will occur in a three-stage process that will culminate with a final Coastal Marine Spatial Planning process.

2.1.23 U.S./Mexico Transboundary Hydrocarbons Agreement and H.R. 1613 – Outer Continental Shelf Transboundary Hydrocarbon Agreements Authorization Act

The U.S./Mexico Transboundary Hydrocarbons Agreement, signed on February 20, 2012, and ratified by the Mexican Senate in April 2012, established a framework for the cooperative exploration and exploitation of hydrocarbon resources that cross the U.S./Mexico maritime boundary in the GOM (excluding areas under the jurisdiction of Texas). It allows leaseholders on the U.S. side of the boundary to cooperate with the Mexican national oil company, Pemex, in the joint exploration and exploitation of hydrocarbon resources. The Agreement also ends the moratorium on exploitation along the boundary in the Western Gap and provides U.S. leaseholders with legal certainty regarding the exploitation of transboundary reservoirs along the entire boundary so as to encourage investment.

House Resolution (H.R.) 1613, the "OCS Transboundary Hydrocarbon Agreements Authorization Act", would approve the agreement between the U.S. and Mexico regarding the development of oil and gas natural resources on the OCS in the area of the GOM where the two countries share a border. The bill would amend the OCSLA to authorize the Secretary of the Interior to implement any agreement for the management of transboundary hydrocarbon reservoirs. On

June 27, 2013, H.R. 1613 passed in the House of Representatives, and it has moved to the Senate for consideration.

2.2 Federal Agencies

2.2.1 Bureau of Ocean Energy Management

The OCSLA directs BOEM to ensure that G&G data are obtained in a technologically safe and environmentally sound manner. All G&G activities are subject to permits, notices, authorizations, or COAs depending on the specific Program Area and associated regulations and policies. BOEM oversees G&G data acquisition and permitting activities pursuant to 30 CFR parts 550, 551, 580, and 585; Section 11, Subsections 8(k) and 8(p) of the OCSLA; and Section 388(a) of the EPAct of 2005. These regulations, in part, state that G&G activities cannot

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

The regulations under 30 CFR parts 550, 551, 580, and 585 governing G&G surveys are summarized in **Table 1.1-1** of this Programmatic EIS.

2.2.2 Bureau of Safety and Environmental Enforcement

As part of a major reorganization of the USDOI's offshore regulatory structure, BSEE was formally established on October 1, 2011. The BSEE uses the full range of authorities, policies, and tools to compel safety, emergency preparedness, environmental responsibility, and appropriate development and conservation of offshore oil and natural gas resources (refer to **Chapter 1** of this Programmatic EIS for additional information).

The newly created Environmental Compliance Division of BSEE is a first in the Federal offshore energy regulatory program. The Environmental Compliance Division will provide sustained regulatory oversight focused on compliance by operators with all applicable environmental regulations, as well as ensure operators keep promises they make at the time they obtain leases, submit plans, and apply for permits.

The Chief of the Environmental Compliance Division establishes national strategic goals of the environmental compliance program to increase the accuracy and consistency of its environmental compliance activities per NEPA, the OCSLA, and other statutory requirements. The Enviromental Compliance Division establishes national data needs for the environmental compliance program, maintains and monitors national performance standards, and sets national policies regarding environmental compliance activities conducted by BSEE personnel. The Environmental Compliance Division is also responsible for monitoring execution and effectiveness of environmental compliance activity.

2.2.3 National Oceanic and Atmospheric Administration

The NOAA executes its mission and statutory mandates through the following offices:

- National Environmental Satellite, Data, and Information Service;
- National Marine Fisheries Service;
- National Ocean Service;
- National Weather Service;
- Office of Marine & Aviation Operations; and
- Office of Oceanic and Atmospheric Research.

These offices represent the operating branches of NOAA and are responsible for managing the delivery of products and services to meet the needs of the public, various Federal and State agencies, and other stakeholders. The ONMS (under NOS) and NMFS are the primary offices within NOAA that participated in the development of this Programmatic EIS because of their expertise and statutory responsibilities to protect, conserve, and recover marine mammals as well as threatened and endangered species, and to conserve and manage fisheries and the NMSs. Subsequently, early participation of these NOAA offices during the preparation of this Programmatic EIS aided BOEM's analysis of potential impacts to various protected resources within the GOM, including EFH and the NMSs.

Since the issuance of an ITA would allow for the taking of marine mammals, consistent with the provisions under the MMPA and incidental to the G&G activities, NOAA considers this issuance to be a major Federal action subject to NEPA. Therefore, NOAA's National Marine Fisheries Service intends to adopt this Programmatic EIS as the NEPA documentation associated with authorizing incidental take of marine mammals. In addition, NMFS and ONMS may rely on the analysis within this Programmatic EIS to support consultation efforts under the ESA, MSFCMA, and NMSA.

3 STATE REGULATIONS AND AGENCIES

3.1 Coastal Zone Management Act

The CZMA and its amendments were established to develop comprehensive programs to manage and balance competing uses of and impacts to coastal resources. The CZMA emphasizes the importance of State decisionmaking regarding the coastal zone to protect, develop, and where possible restore or enhance the resources of the Nation's coastal zone for current and future generations. The CZMA also encourages and assists States in effectively exercising their responsibilities in the coastal zone through the development and implementation of management programs to wisely use the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and aesthetic values as well as the needs for compatible economic development. Each State's Coastal Management Program (CMP), federally approved by NOAA, is a comprehensive statement setting forth objectives, enforceable policies, and standards for public and private use of land and water resources in the State's coastal zone. The CMP provides for direct State land and water use planning and regulations. The CMP also includes a definition of what constitutes permissible land uses and water uses. 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 latest Federal consistency regulations concerning State coastal zone management programs are found in the *Federal Register* (2000b, 2006).

Each Gulf Coast State's official coastal boundary can be identified from NOAA's website at https://coast.noaa.gov/czm/media/StateCZBoundaries.pdf. Once a State's CMP is federally approved, Federal agencies must ensure that their actions are consistent, to the maximum extent practicable, with the enforceable polices of the approved program. Federal agencies provide feedback to the States through Section 312 evaluations conducted by NOAA.

To ensure conformance with State CMP policies and local land-use plans, BOEM prepares a Federal consistency determination for each proposed OCS lease sale. Through the designated State CZM agency, local land-use entities are provided numerous opportunities to comment on the OCS Program. Local land-use agencies also have the opportunity to comment directly to BOEM at any time, including during formal public comment periods related to the announcement of the Five-Year Program, Call for Information/Notice of Intent, EIS scoping, public hearings on the Draft EIS, and the Proposed Notice of Sale.

A State's approved CMP may provide for the State's review of OCS plans, 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 OCSLA and that affect any land or water use or natural resource within the State's coastal zone (16 U.S.C. § 1456(c)(3)(B)).

The sections below provide an overview of the CMP within each Gulf Coast State bordering the AOI.

3.1.1 State of Florida 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, 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 coastal management program. 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 chapters that NOAA approved for incorporation in the State's program. The 2015 Florida Statutes are the most recent version approved by NOAA.

A network of eight 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 administers State and Federal programs and initiatives to help visitors, citizens, businesses, and communities;
- the Department of 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 Fish and Wildlife Conservation Commission, which protects and regulates freshwater and saltwater fisheries, marine mammals, 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;
- and the Governor's Office of Planning and Budget, which plays a role in the comprehensive planning process.

Effective July 1, 2000, the Governor of Florida assigned the State's responsibilities under the OCSLA to the Secretary of the Florida DEP. The DEP's Office of Intergovernmental Programs 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 OCSLA.

BOEM developed coordination procedures with the State for the submittal of offshore lease sale consistency determinations and plans of operation. In 2003, BOEM and the State revised CZM consistency information for OCS plans, permits, and licenses to conform with the revised CZM regulations that were effective January 8, 2001 (updated on January 5, 2006), and they have incorporated streamlining improvements into the latest NTLs (NTLs 2008-G04, 2009-G27, and 2015-N01). Federal consistency for right-of-way pipelines is addressed in NTL 2007-G20.

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; specific information on the 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's enforceable policies that must be addressed for OCS activities are found at http://www.boem.gov/Environmental-Stewardship/Environmental-Assessment/CZMA/CZM-Program-Policies-for-GOM-States-pdf.aspx. These requirements have been incorporated into the plans and regional oil-spill response NTLs. The State requirements for Federal consistency review are based on the requirements of State statutes, CZMA regulations at 15 CFR part 930, and the USDOI's regulations at 30 CFR parts 250, 254, 256, and 550. BOEM is continuing a dialogue with the State of Florida on reasonably foreseeable coastal effects associated with OCS plans, pipelines, and other permits; the result of these discussions will be incorporated into future updates of BOEM's permitting procedures and/or NTLs.

3.1.2 State of Alabama Coastal Management Program

The Alabama Coastal Area Act (ACAA) provides statutory authority to review all coastal resource uses and activities that have a direct and significant effect on the coastal area. The Alabama Department of Conservation and Natural Resources (ADCNR) Lands Division, Coastal Section Office, the lead coastal management agency, is responsible for the management of the State's coastal resources through the Alabama Coastal Area Management Program (ACAMP). The ADCNR is responsible for the overall management of the program, including fiscal and grants management as well as public education and information. The ADCNR also provides planning and technical assistance to local governments and financial assistance to research facilities and units of local government when appropriate. The State Lands Division, Coastal Section, also has authority over submerged lands in regard to piers, marinas, bulkheads, and submerged land leases.

The Alabama Department of Environmental Management (ADEM) is responsible for coastal area permitting, regulatory, and enforcement functions. Most programs of the ADCNR Coastal

Section that require environmental permits or enforcement functions are carried out by the ADEM, with the exception of submerged land issues. The ADEM is responsible for all permit, enforcement, regulatory, and monitoring activities, and the adoption of rules and regulations to carry out the ACAMP. The ADEM must identify specific uses or activities that require a State permit to be consistent with the coastal policies noted above and the more detailed rules and regulations promulgated as part of the ACAMP. Under the ACAA, State agency activities must be consistent with ACAMP policies and ADEM findings. Furthermore, ADEM must make a direct permit-type review for uses that are not otherwise regulated at the State level. The ADEM also has authority to review local government actions and to assure that local governments do not unreasonably restrict or exclude uses of regional benefit. Ports and major energy facilities are designated as uses of regional benefit. The ADCNR Lands Division manages all lease sales of State submerged lands and regulates structures placed on State submerged lands.

Local governments have the option to participate in the ACAMP by developing local codes, regulations, rules, ordinances, plans, maps, or any other device used to issue permits or licenses. If these instruments are certified to be consistent with ACAMP, the ADEM may allow the local government to administer them by delegating its permit authority, thereby eliminating the need for ADEM's case-by-case review.

The South Alabama Regional Planning Commission provides ongoing technical assistance to the ADCNR for Federal consistency, clearinghouse review, and public participation procedures. Uses subject to the Alabama's CZM program are divided into regulated and nonregulated categories. Regulated uses are those that have a direct and significant impact on the coastal areas. These uses require a State permit or are required by Federal law to be consistent with the management program. Uses that require a State permit must receive a certificate of compliance. Nonregulated uses are those activities that have a direct and significant impact on the coastal areas that do not require a State permit or Federal consistency certification. Nonregulated uses must be consistent with ACAMP and require local permits to be administered by ADEM.

BOEM developed coordination procedures with the State for submittal of offshore lease sale consistency determinations and plans of operation. BOEM and the State of Alabama have revised CZM consistency information for OCS plans, permits, and licenses to conform to the revised CZM regulations effective January 8, 2001 (updated on January 5, 2006), and have incorporated streamlining improvements into the latest NTLs (NTLs 2008-G04, 2009-G27, and 2015-N01). Federal consistency for right-of-way pipelines is addressed in NTL 2007-G20.

The State of Alabama requires an adequate description, objective, and schedule for the project; site-specific information on the 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. The State's requirements for Federal consistency review are based specifically on the USDOI's regulations at 30 CFR parts 250, 254, 256, and 550, and NOAA's Federal consistency requirements at 15 CFR part 930. BOEM is continuing a dialogue with the State of Alabama on reasonably foreseeable coastal effects associated with pipelines and other permits, and the results of these discussions will be incorporated into future updates of BOEM's permitting procedures and/or NTLs.

3.1.3 State of Mississippi Coastal Management Program

The Mississippi Coastal Program (MCP) is administered by the Mississippi Department of Marine Resources. The MCP is built around several enforceable goals that promote comprehensive management of coastal resources and encourage a balance between environmental protection/preservation and development in the coastal zone. The primary coastal management statute is the Coastal Wetlands Protection Law. Other major features of the MCP include statutes related to fisheries, air and water pollution control, surface and groundwater, cultural resources, and the disposal of solid waste in marine waters. The Department of Marine Resources, the Department of Environmental Quality, and the Department of Archives and History are identified collectively as the "coastal program agencies." Mississippi manages coastal resources through regulation and by promoting activities that use resources in compliance with the MCP. The State developed a coastal wetlands use plan, which includes designated use districts in coastal wetlands and Special Management Area Plans that steer development away from fragile coastal resources and help to resolve user conflicts.

For the purposes of the coastal program, the coastal zone encompasses the three coastal counties of Hancock, Harrison, and Jackson and all coastal waters. The Mississippi Gulf Coast has 594 km (359 mi) of shoreline, including the coastlines of offshore barrier islands (Cat, Ship, Horn, and Petit Bois Islands). According to NOAA, there are no approved local CMPs for the State of Mississippi. The Southern Mississippi Planning and Development District serves in an advisory capacity to the State's coastal agencies.

BOEM developed coordination procedures with the State for submittal of offshore lease sale consistency determinations and plans of operation. BOEM and the State of Mississippi revised CZM consistency information for OCS plans, permits, and licenses to conform to the revised CZM regulations effective January 8, 2001 (updated on January 5, 2006), and have incorporated streamlining improvements into the latest NTLs (NTLs 2008-G04, 2009-G27, and 2015-N01). Federal consistency for right-of-way pipelines is addressed in NTL 2007-G20.

The State of Mississippi requires an adequate description, objective, and schedule for the project; site-specific information on the 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. The State's requirements for Federal consistency review are based specifically on the USDOI's regulations at 30 CFR parts 250, 254, 256, and 550, and NOAA's Federal consistency requirements at 15 CFR part 930. BOEM is continuing a dialogue with the State of Mississippi on reasonably foreseeable coastal effects associated with pipelines and other permits, and the results of these discussions will be incorporated into future updates of BOEM's permitting procedures and/or NTLs.

3.1.4 State of Louisiana Office of Coastal Management

The statutory authority for Louisiana's coastal zone management program, the Louisiana Office of Coastal Management (LOCM), is the State and Local Coastal Resources Management Act of 1978 *et seq*. (Louisiana Administrative Code, Volume 17, Title 43, Chapter 7, Coastal Management, June 1990 revised). The State statute puts into effect a set of State coastal policies and coastal use guidelines that apply to coastal land and water use decisionmaking. Numerous existing State regulations are incorporated into the program, including those concerning oil and gas and other mineral operations; leasing of State lands for mineral operations and other purposes; hazardous waste and radioactive materials; management of wildlife, fish, other aquatic life, and oyster beds; endangered species; air and water quality; and the Louisiana Offshore Oil Port.

The State statute authorized establishment of Special Management Areas. The Louisiana Offshore Oil Port and the Marsh Island Wildlife Refuge have been included as Special Management Areas. For purposes of the CZMA, only the portion of the Louisiana Offshore Oil Port within Louisiana's coastal zone is part of the Special Management Area. In April 1989, the Louisiana Legislature created the Wetlands Conservation and Restoration Authority, and established a Wetlands Conservation and Restoration Trust Fund to underwrite restoration projects. The Legislature also reorganized part of the Louisiana Department of Natural Resources by creating the Office of Coastal Restoration and Management.

Local governments (parishes) may assume management of uses of local concern by developing a local coastal program consistent with the State CMP. The State of Louisiana has 10 approved local CMPs (Calcasieu, Cameron, Jefferson, Lafourche, Orleans, St. Bernard, St. James, Plaquemines, Terrebonne, and St. Tammany Parishes). Two additional parishes, St. John the Baptist and St. Charles, have worked towards developing local CMPs. Eight other programs (Assumption, Iberia, Livingston, St. Charles, St. Martin, St. Mary, Tangipahoa, and Vermilion parishes) have not been formally approved by NOAA. The parish planning and/or permits offices often serve as the permitting agency for projects limited to local concern. Parish-level programs, in addition to issuing permits for uses of local concern, function as commenting agencies to Louisiana's CZM agency, the LOCM, regarding permitting of uses of State concern.

Appendix C2 of the LOCM outlines the rules and procedures for the State's local CMP. Under the LOCM, parishes are authorized, though not required, to develop local CMPs. Approval of the CMPs gives parishes greater authority in regulating coastal development projects that entail uses of local concern. Priorities, objectives, and policies of local land use plans must be consistent with the policies and objectives of Act 361, the LOCM, and the State guidelines, except for a variance adopted in Section IV.D of Appendix C2 of the LOCM. The Secretaries of the Department of Natural Resources and Wildlife and Fisheries may jointly rule on an inconsistent local program based on local environmental conditions or user practices. State and Federal agencies review parish programs before they are adopted.

Louisiana's coastal use guidelines are based on eight general policies as outlined in the Louisiana State and Local Coastal Resources Management Act of 1978. State concerns that could be relevant to an OCS lease sale and its possible direct effects or associated facilities and non-associated facilities are (1) any dredge and fill activity that intersects more than one water body, (2) projects involving the use of State-owned lands or water bottoms, (3) national interest projects, (4) pipelines, and (5) energy facility siting and development. Some coastal activities of concern that could be relevant to a lease sale are wetland loss due to channel erosion from OCS traffic; activities near reefs and topographic highs; activities that might affect endangered, threatened, or commercially valuable wildlife; and potential socioeconomic impacts due to offshore development. Secondary and cumulative impacts to coastal resources such as onshore facility development, cumulative impacts from infrastructure development, salt intrusion along navigation channels, and others are of particular concern as well.

Effective August 1993, the LOCM required that any entity applying for permits to conduct activities along the coast must notify the landowner of the proposed activity. An affidavit must accompany any permit application. Through this regulation, the State strives to minimize coastal zone conflicts.

BOEM and the State of Louisiana revised CZM consistency information for OCS plans, permits, and licenses to conform to the revised CZM regulations effective January 8, 2001 (updated on January 5, 2006), and have incorporated streamlining improvements into the latest NTLs (NTLs 2008-G04, 2009-G27, and 2015-N01). Federal consistency for right-of-way pipelines is addressed in NTL 2007-G20.

The State of Louisiana requires an adequate description, objective, and schedule for the project. Also, the State requires site-specific information on the onshore support base, support vessels, shallow hazards, oil-spill response, wastes and discharges (including any disposal of wastes within the State coastal zone and waters and municipal, parish, or State facilities to be used), transportation activities, air emissions, and secondary and cumulative impacts; and a Federal consistency certification, assessment, and findings. In addition, the State receives consistency reviews on a case-by-case basis for decommissioning activities within OCS Significant Sediment Blocks that the State utilizes marine mineral resources for restoration projects. The State's requirements for Federal consistency review are based specifically on the USDOI's regulations at 30 CFR parts 250, 254, 256, and 550, and NOAA's Federal consistency regulations at 15 CFR part 930. BOEM is continuing a dialogue with the State of Louisiana on reasonably foreseeable coastal effects associated with pipelines and other permits, and the results of these discussions will be incorporated into future updates of BOEM's permitting procedures and/or NTLs.

3.1.5 State of Texas Coastal Management Program

The Texas Coastal Management Program's (TCMP) Final EIS was published in August 1996. On December 23, 1996, NOAA approved the TCMP, and the requirements therein were made operational as of January 10, 1997. The TCMP is based primarily on the Coastal

Coordination Act of 1991 (33 Tex. Nat. Res. Code Ann. Ch. 201 *et seq*.), as amended by House Bill 3226 (1995), which calls for the development of a comprehensive coastal program based on existing statutes and regulations. The Coastal Coordination Act established the geographic scope of the program by identifying the program's inland, interstate, and seaward boundaries. The program's seaward boundary is the State's territorial seaward limit (3 marine leagues; 9 nmi; 10.4 mi; 16.7 km). The State's inland boundary is based on the State's Coastal Facilities Designation Line (CFDL). The CFDL was developed in response to the Oil Pollution Act of 1990 and delineates areas within which oil spills could affect coastal waters or resources. For the purposes of the TCMP, the CFDL has been modified to capture wetlands in upper reaches of tidal waters. The geographic scope also extends upstream 200 mi (322 km) from the mouths of rivers draining into coastal bays and estuaries in order to manage water appropriations on those rivers. The TCMP's boundaries encompass all or portions of 18 coastal counties (Cameron, Willacy, Kenedy, Kleberg, Nueces, San Patricio, Aransas, Refugio, Calhoun, Victoria, Jackson, Matagorda, Brazoria, Galveston, Harris, Chambers, Jefferson, and Orange), roughly 8.9 million acres (3.6 million hectares) of land and water.

Within this coastal zone boundary, the scope of the TCMP's regulatory program is focused on the direct management of 16 generic "Areas of Particular Concern," called coastal natural resource areas (CNRAs). The CNRAs are associated with valuable coastal resources or with vulnerable or unique coastal areas, and include the following: waters of the open GOM; waters under tidal influence; submerged lands; coastal wetlands; seagrasses; tidal sand and mud flats; oyster reefs; hard substrate reefs; coastal barriers; coastal shore areas; GOM beaches; critical dune areas; special hazard areas; critical erosion areas; coastal historic areas; and coastal preserves.

The State has designated the WPA as the geographical area in which Federal consistency will apply outside of the coastal boundary. The TCMP also identifies Federal lands excluded from the State's coastal zone, such as USDOD facilities and wildlife refuges.

Land and water uses subject to the TCMP include the siting, construction, and maintenance of electric-generating and transmission facilities; oil and gas exploration and production; and the siting, construction, and maintenance of residential, commercial, and industrial development on beaches, critical dune areas, shorelines, and within or adjacent to critical areas and other CNRAs. Associated activities subject to the program include canal dredging; filling; placement of structures for shoreline access and shoreline protection; on-site sewage disposal, stormwater control, and waste management for local governments and municipalities; the siting, construction, and maintenance of public buildings and public works such as dams, reservoirs, flood control projects, and associated activities; the siting, construction, and maintenance of roads, highways, bridges, causeways, airports, railroads, and non-energy transmission lines and associated activities; certain agricultural and silvicultural activities; water impoundments and diversions; and the siting, construction, and maintenance of marinas, State-owned fishing cabins, artificial reefs, public recreational facilities, structures for shoreline access and shoreline protection, boat ramps, and fishery management measures in the GOM.

The TCMP is a networked program implemented primarily through 8 State agencies, 18 local governments, and the Coastal Coordination Advisory Committee (Committee). The program relies on direct State control of land and water uses, although local governments will implement State guidelines related to beach and dune management. Implementation and enforcement of the coastal policies is primarily the responsibility of the networked agencies and local governments through their existing statutes, regulatory programs, or other authorizations. Networked agencies include the General Land Office/School Land Board, Texas Commission on Environmental Quality, Railroad Commission of Texas, Texas Parks and Wildlife Commission, Texas Department of Transportation, Texas Water Development Board, Texas State Soil and Water Conservation Board, and Texas Sea Grant College Program at Texas A&M University. Other members on the Council include four gubernatorial appointees: (1) a coastal business representative; (2) an agriculture representative; (3) a local elected official; and (4) a coastal citizen. Similarly, 18 county and municipal governments, in counties with barrier islands, are networked entities with responsibilities for program implementation vis-a-vis beaches and dunes.

Regulations, programs, and expertise of State, Federal, and local government entities are linked to the management of Texas CNRAs in the TCMP. Local governments are notified of relevant TCMP decisions, including those that may conflict with local land-use plans or zoning ordinances. The Committee includes a local government representative as a full-voting member. An additional local government representative can be added to the Committee as a non-voting member for special local matters under review. The Committee established a permanent advisory committee to ensure effective communication for local governments with land-use authority.

In 1994, BOEM entered into an MOU with the Texas General Land Office to address mineral resource management responsibilities, encourage cooperative efforts, and promote consistent regulatory practices. The MOU, which encompasses a broad range of issues and processes, outlines the responsibilities and cooperative efforts, including leasing and CZMA review processes, agreed to by the respective agencies. Effective January 10, 1997, all operators were required to submit to BOEM certificates of consistency with the TCMP for proposed operations in the WPA.

BOEM developed coordination procedures with the State of Texas for submittal of offshore lease sale consistency determinations and plans of operation. The WPA Lease Sale 168 was BOEM's first Federal action subject to State consistency review. BOEM and the State of Texas revised CZM consistency information for OCS plans, permits, and licenses to conform to the revised CZM regulations that were effective January 8, 2001 (updated on January 5, 2006), and have incorporated streamlining improvements into the latest NTLs (NTLs 2008-G04, 2009-G27, and 2015-N01).

The State of Texas requires an adequate description, objective, and schedule for the project; site-specific information on the 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. The State's requirements for Federal consistency review are based specifically on the USDOI's regulations at 30 CFR parts 250, 254, 256, and 550, and NOAA's Federal consistency regulations at 15 CFR part 930. BOEM will be continuing a dialogue with the State of Texas on reasonably foreseeable coastal effects for pipelines and other permits, and the results of these discussions will be incorporated into future updates of this agency's NTLs and/permitting procedures.

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ATTACHMENT 1: SEISMIC AIRGUN SURVEY PROTOCOL

The requirements of NTL 2016-BOEM-G02 ("Implementation of Seismic Survey Mitigation Measures and Protected Species Observer Program") are summarized below.

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, the ramp-up procedures described here should be used to allow any marine mammal or sea turtle to depart the exclusion zone before seismic surveying begins.

Measures to conduct ramp-up procedures during all seismic airgun survey operations in water depths >200 m (656 ft) in the WPA and CPA and in all water depths in the EPA, including airgun testing, are as follows:

(1) Visually monitor the exclusion zone and adjacent waters for the absence of marine mammals and sea turtles for at least 30 minutes before initiating ramp-up procedures. If none are detected, ramp-up procedures may be initiated. Operators may not initiate ramp-up procedures at night or when the exclusion zone cannot be visually monitored for marine mammals and sea turtles if the minimum source level drops below 160 dB re 1 μPa-m (rms) or any other Level B acoustic thresholds set by NMFS for behavioral harassment (i.e., Level B harassment). Altering the survey vessel's course to water depths <200 m (656 ft) in the CPA and WPA to circumvent ramp-up requirements of the 200-m (656-ft) isobath will be considered noncompliant.

(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 minutes, but no longer than 40 minutes, until the desired operating level of the airgun array is obtained.

(4) Immediately shut down all airguns, ceasing seismic operations any time a whale is detected entering or within the exclusion zone. Ramp-up of airguns and seismic operations may recommence only when the exclusion zone has been visually inspected for at least 30 minutes to ensure the absence of marine mammals and sea turtles.

(5) Operators 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) (or any other Level B acoustic threshold set by NMFS) for the

duration of certain activities (thresholds stated here [e.g., the 160 dB Level B harassment threshold] may be superseded by any future thresholds set by NMFS). By maintaining the minimum source level, operators will not be required to conduct the 30-minute visual clearance of the exclusion zone before ramping back up to full output. Activities appropriate for maintaining the minimum source level are as follows:

(a) 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

(b) 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 repairs are completed. There may be other occasions when this practice is appropriate, but use of the minimum source level to avoid the 30-minute 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.

Exclusion Zone

The exclusion zone is the primary mechanism to minimize the potential for injury (Level A harassment) of marine mammals to the maximum extent practicable. The operator will monitor an exclusion zone within a radius of 500 m (1,640 ft). The exclusion zone means the area at and below the sea surface with a radius of 500 m (1,640 ft) surrounding the center of an airgun array and the area within the immediate vicinity of the survey vessel. Each survey vessel must maintain its own exclusion zone and cannot enter another vessel's exclusion zone to avoid the mitigation measures set forth in their permit.

While there are no noise exposure criteria for sea turtles, the protocol is expected to similarly reduce the risk of injury in sea turtles.

Shutdown Requirements

(1) In the event that any whale(s) (defined as baleen, beaked, sperm, or dwarf and pygmy sperm whales) observed within the exclusion zone, whether due to the whale's movement, the vessel's movement, or because the whale surfaced inside the exclusion zone, the PSO will call for the immediate shutdown of the seismic operation, including airgun firing (the vessel may continue on its course but all airgun discharge's must cease).

(2) Shutdown would not be required for manatees or marine mammals in the Family Delphinidae (this includes, among others, killer whales, pilot whales, and all of the "dolphin" species).

(3) The vessel operator must comply immediately with such a call by the PSO. Any disagreement or discussion should occur only after shutdown.

(4) When no marine mammals or sea turtles are sighted for at least a 30 minutes, 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 30 minutes prior to commencement of ramp-up (unless passive acoustic monitoring [PAM] is used). Thus, ramp-up cannot begin after dark or in conditions that prohibit visual inspection (e.g., fog and rain) of the exclusion zone after a shutdown.

(5) Any shutdown due to a whale(s) (baleen, beaked, sperm, or dwarf and pygmy sperm whales) sighting within the exclusion zone must be followed by a 30-minute all-clear period and then a standard, full ramp-up. Any shutdown for other reasons, including mechanical or electronic failure, resulting in the cessation of the acoustic source for a period longer than 20 minutes, must 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 minutes** in duration will not require ramp-up for the resumption of seismic operations if

(a) visual surveys are continued diligently throughout the silent period (requiring daylight and reasonable sighting conditions); and

(b) no whales, other marine mammals, or sea turtles are observed in the exclusion zone.

If whales, other 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.

Protected Species Observer Program

Basic Requirements

Visual observers who have completed a PSO training program as described below are required on all seismic vessels conducting operations in water depths >200 m (656 ft) throughout the GOM. Visual observers are required on all seismic vessels conducting operations in OCS water depths <200 m (656 ft) in the GOM waters east of 88.0° W. longitude.

(1) Operators may engage trained third-party observers, utilize crew members after training as observers, or use a combination of third-party and crew observers.

(2) All PSOs must have completed a PSO training course. BOEM and BSEE will not sanction particular trainers or training programs. However, basic training criteria have been established. All training programs offering to fulfill the PSO training requirements must

(a) furnish to BSEE, a course information packet that includes the name and qualifications of the instructor(s), the course outline or syllabus, and course reference material;

(b) furnish each trainee with a document stating successful completion of the course; and

(c) provide BSEE with names, affiliations, and dates of course completion of trainees.

(3) At least two PSOs will be required on seismic airgun vessels to monitor the exclusion zone at all times during daylight hours (dawn to dusk) when seismic operations are being conducted, unless conditions (e.g., fog, rain, and darkness) make sea surface observations impossible. If conditions deteriorate during daylight hours such that sea surface observations are halted, visual observations must resume as soon as conditions permit.

(4) The PSO will monitor the exclusion zone (according to the requirements of the following elements) for protected species and will observe and document their presence and behavior, searching the area around the vessel using hand-held reticule binoculars and the unaided eye.

(5) If a marine mammal or sea turtle is observed, the PSO should note and monitor the position until the animal dives or moves out of visual range.

(6) The PSO must prepare an observer effort report and survey report for each day during which seismic operations are conducted and airguns are being discharged. These reports are to be submitted to BSEE on the 1st and 15th of each month.

(7) The following schedule limitations will apply to PSOs during survey activities:

(a) other than brief alerts to bridge personnel of maritime hazards, no additional duties can be assigned to PSOs during their watch;

(b) a watch will be no longer than 4 consecutive hours;

(c) a break of at least 2 hours must occur between 4-hour watches and no other duties will be assigned during this period; and

(d) a PSO's combined watch schedule must not exceed 12 hours during a 24-hour period.

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 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 http://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 15th of each month for each day seismic acquisition operations are conducted. These reports must include the following information:

(1) vessel name;

(2) observers' names and, affiliations;

(3) survey type (e.g., site, 3D, and 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 15th of the month for each day seismic acquisition operations are conducted and airguns are discharged. These reports must include the following information:

(1) vessel name;

(2) survey type (e.g., site, 3D, and 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 that sound source (airguns or non-airgun 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 (e.g., survey delayed and airguns shut down)?

(12) reason that marine mammals and sea turtles might not have been observed (e.g., swell, glare, and fog); and

(13) time that sound source (airgun array or non-airgun HRG equipment) stops firing.

Sighting Report: BOEM will require the submission of reports to BSEE for marine mammals and sea turtles sighted during seismic and non-airgun HRG surveys on the 1st and 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 information:

(1) vessel name;

(2) survey type (e.g., site, 3D, and 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 animal(s) 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 hours 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 15th of each month (with one exception, noted above). Forms should be scanned (or 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 **Appendix F, Section 1.1.5**). Because of this key difference, the following mitigation measures apply only to borehole surveys:

(1) During daylight hours, when visual observations of the exclusion zone are being performed as required in this NTL, borehole seismic operations will not be required to ramp-up for shutdowns of 30 minutes or less in duration as long as no whales, other marine mammals, or sea turtles are observed in the exclusion zone (500 m [1,640 ft]) during the shutdown. If a whale, other 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 30 minutes.

(2) During nighttime or when conditions prohibit visual observation of the exclusion zone, ramp-up will not be required for shutdowns of 20 minutes or less in duration.

(3) For borehole seismic surveys that utilize PAM during nighttime and periods of poor visibility, ramp-up is not required for shutdowns of 30 minutes or less.

(4) Nighttime or poor visibility ramp-up is allowed only when PAM is used to ensure that no whales 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.

(5) During daylight hours, PSOs must be used as required in this NTL, and may be stationed 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.

(6) All other mitigations and provisions for seismic surveys as set forth in this NTL will apply to borehole seismic surveys.

(7) Reports should reference a Plan Control Number, OCS Lease Number, Area/Block, and Borehole Number or BOEM permit number, as applicable.

Passive Acoustic Monitoring

Inclusion of PAM does **not** relieve an operator of any of the mitigations (including PSOs) **with the following exception**: monitoring for whales with PAM will allow ramp-up and the subsequent start of a seismic airgun survey during times of reduced visibility (e.g., darkness, fog, and rain) when such ramp-up otherwise would not be permitted using only PSOs. If PAM is used, the operator must include an assessment of the usefulness, effectiveness, and problems encountered with the use of that method of marine mammal detection in the reports. A description of the PAM system, software used, and Monitoring Plan should be reported to BSEE at the beginning of its use.

ATTACHMENT 2: NON-AIRGUN HRG SURVEY PROTOCOL

The Non-Airgun HRG Survey Protocol applies to HRG surveys conducted using only acoustic sources such as side-scan sonar; boomers, sparkers, and CHIRP subbottom profilers; and single-beam and multibeam depth sounders (**Appendix F, Section 1.3**). Other HRG surveys using airguns are excluded from this protocol and must comply instead with the Seismic Airgun Survey Protocol. The non-airgun HRG Survey Protocol requirements can be summarized as follows:

- non-airgun HRG surveys in which one or more active acoustic sources will be operating at frequencies ≤200 kHz, a pre-survey clearance period (of marine mammals and sea turtles) of 30 minutes before start-up or after a shutdown for sperm, Bryde's, beaked, *Kogia* whale(s) or manatee(s) that are within the exclusion zone;
- one PSO and 200-m (656-ft) exclusion zone monitoring for non-airgun HRG surveys in all water depths throughout the GOM operating at or below 200 kHz; and
- if seismic airguns are used for HRG surveys, these surveys would be subject to the Seismic Airgun Survey Protocol.

Exclusion Zone

All non-airgun HRG surveys conducted with one or more acoustic sources operating at frequencies ≤200 kHz will be required to establish an exclusion zone. An exclusion zone is not required for non-airgun HRG surveys in which all acoustic sources would operate at frequencies >200 kHz. The exclusion zone would be a 200-m (656-ft) radius zone around the sound source.

Protected Species Observer Program

All non-airgun HRG surveys having an exclusion zone (i.e., those conducted using one or more acoustic sources operating at or below 200 kHz) must use PSOs to monitor the 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.

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 ≤200 kHz. If there are no acoustic sources operating at frequencies ≤200 kHz, there will be no exclusion zone and there are no requirements for PSOs. However, all non-airgun HRG operators must comply with all other mitigation measures applicable to all G&G surveys described in **Chapter 2** of this Programmatic EIS.

Visual monitoring of the 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 (i.e., from approximately 30 minutes before sunrise to 30 minutes after sunset) when survey operations are being conducted, unless conditions (e.g., fog, rain, and 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:

- At least one PSO will be required on duty at all times to monitor the exclusion zone when acoustic sources are operating.
- The PSO(s) will monitor an exclusion zone for protected species and observe and document their presence and behavior, searching the area around the vessel using handheld 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 exclusion zone using shipboard lighting, enhanced vision equipment, and night-vision equipment.

The following schedule limitations will apply to PSOs during HRG survey activities:

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

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

Startup and Shutdown Requirements

Monitoring of the exclusion zone must begin no less than 30 minutes prior to start-up and continue until operations cease. Immediate shutdown of the acoustic source(s) would occur if any sperm, Bryde's, beaked, *Kogia* whale(s), or manatee(s) is detected entering or within the 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 30 minutes.

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 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 http://www.jncc.gov.uk). At a minimum, the items below 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:

- vessel name;
- observers' names, affiliations, and resumes;
- date;
- time and latitude/longitude when daily visual survey began;
- time and latitude/longitude when daily visual survey ended;
- average environmental conditions during visual surveys, including:
  - wind speed and direction;
  - sea state (glassy, slight, choppy, rough, or Beaufort scale);
  - swell (low, medium, high, or swell height in meters); and
  - overall visibility (poor, moderate, good).
- species (or identification to lowest possible taxonomic level);
- certainty of identification (sure, most likely, best guess);
- total number of animals;
- number of calves and juveniles (if distinguishable);
- 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);
- direction of animal's travel – related to the vessel (drawing preferably);

- behavior (as explicit and detailed as possible; note any observed changes in behavior); and
- activity of vessel when sighting occurred.

Note: If this sighting was of a marine mammal 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 hours of the shutdown**. These sightings also should 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 15th of each month (with one exception, noted above). Forms should be scanned (or 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.

APPENDIX C

SETTLEMENT AGREEMENT
AND
STIPULATION TO AMEND SETTLEMENT AGREEMENT

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF LOUISIANA

NATURAL RESOURCES DEFENSE COUNCIL INC., *et. al*, **Plaintiffs,** **v.** **S.M.R. JEWELL, Secretary of the Department of the Interior, *et. al*,** **Defendants,** **and** **AMERICAN PETROLEUM INSTITUTE, *et al.*,** **Intervenor-Defendants.**	**CIVIL ACTION NO. 2:10-cv-01882** **SECTION "A"** **JUDGE JAY C. ZAINEY** **MAGISTRATE JOSEPH C. WILKINSON**

SETTLEMENT AGREEMENT

Plaintiffs (Natural Resources Defense Council, Center for Biological Diversity, Gulf Restoration Network, and Sierra Club), Federal Defendants ((S.M.R. Jewell, Secretary of the Department of the Interior; the Bureau of Ocean Energy Management ("BOEM"); and Tommy Beaudreau, Director, BOEM), and their successors), and Intervenor-Defendants (American Petroleum Institute, International Association of Geophysical Contractors, Independent Petroleum Association of America, U.S. Oil and Gas Association, and Chevron U.S.A., Inc.), collectively the "Parties," by and through undersigned counsel, enter into the following Settlement Agreement ("Agreement") for the purpose of resolving the above-captioned litigation.

I. DEFINITIONS

For purposes of this Agreement only, the terms listed below are defined as follows:

A. "Deep Penetration Seismic Surveys"

"Deep Penetration Seismic Surveys" means seismic exploration and development surveys in the Gulf of Mexico, as defined in BOEM's 2004 Programmatic Environmental Assessment ("PEA") challenged in Plaintiffs' Complaint in the above action, excluding the following types of surveys: deep-tow or autonomous underwater vehicle side-scan sonar surveys, electromagnetic surveys, geological and geochemical sampling, remote sampling, vertical seismic profiling (*i.e.*, borehole surveys), high-resolution site surveys that are intended for pipeline emplacement, and any on-lease seismic activities that do not require a permit from BOEM under 30 C.F.R. Part 551, such as high-resolution site surveys that are intended for drilling rig and platform emplacement.

B. BOEM's Marine Mammal Protection Act ("MMPA") Application

"BOEM's MMPA Application" means either (1) BOEM's pending MMPA application described in 76 Fed. Reg. 34656 (June 14, 2011) ("Pending Application") or (2) any revised application submitted by BOEM to the National Marine Fisheries Service ("NMFS") that is substantively the same in scope as the Pending Application.

C. "Final Action" With Respect to BOEM's MMPA Application

"Final Action" with respect to BOEM's MMPA Application means either: (1) a final decision by NMFS denying BOEM's MMPA Application; (2) BOEM's withdrawal of the Pending Application or any revision thereof, unless a revised application that is substantively the same in scope as the Pending Application is submitted to NMFS within 14 days after the Pending Application or any revision thereof is withdrawn; or (3) NMFS's issuance of an MMPA take authorization in response to BOEM's MMPA Application, preceded or accompanied by (a) a biological opinion or "not likely to adversely affect" concurrence letter from NMFS concluding consultation pursuant to Section 7(a)(2) of the Endangered Species Act ("ESA") and (b) an Environmental Impact Statement ("EIS")/Record of Decision ("ROD") or Environmental Assessment ("EA")/Finding of No Significant Impact ("FONSI") prepared pursuant to the National Environmental Policy Act ("NEPA").

D. "Plaintiffs' Areas of Concern"

"Plaintiffs' Areas of Concern" refers to the following four areas: the De Soto Canyon, defined as limited to the area bounded by the 200 meter isobath to the north, the 28 degree latitude line to the south, the 2000 meter isobath to the west, and the 85 degree longitude line to the east; the Mississippi Canyon, defined as limited to the area bounded by the 200 meter isobath to the north, the 2000 meter isobath to the south, the 90 degree longitude line to the west, and the 88 degree longitude line to the east; coastal waters shoreward of the 20 meter isobath; and an area west of the Florida Keys and Tortugas, defined as limited to the area bounded by the 200 meter isobath to the north, the 24 degree latitude line to the south, the 83 degree 30 minute longitude line to the west, and the 81 degree 30 minute longitude line to the east. A map indicating these four areas is attached as Exhibit 1; however, in the event of any conflict between the map and the boundaries defined in this paragraph, the defined boundaries control.

E. "Effective Date"

The "Effective Date" refers to the date upon which this Agreement becomes effective. This Agreement shall become effective only when both of the following conditions have been met: (1) the Agreement is executed by an authorized representative of each party; and (2) the Court enters an Order, substantively identical to the proposed order attached as Exhibit 2, approving the Agreement and Staying the litigation in accordance with the terms of the Agreement.

F. "Stay"

The "Stay" refers to the stay of proceedings described in Section II below resulting from the entry of the Order described in the above definition of Effective Date.

G. "Encourage or Assist"

"Encourage or Assist" refers to the instigation or material support of specific lawsuits or formal administrative actions, and does not include any other activities, such as making public statements about the impacts or regulation of seismic surveys in the Gulf of Mexico, or the filing of administrative comments on BOEM's MMPA Application or on individual permits pursuant to notice and comment provisions in the Administrative Procedure Act and other statutes.

II. STAY OF PROCEEDINGS

A. All proceedings in this action shall be stayed for 30 months from the Effective Date or until Final Action occurs, whichever occurs first, except as provided in paragraphs II.D, II.E, and II.H below. Federal Defendants shall make their best effort to facilitate completion of Final Action on BOEM's MMPA Application within 30 months of the Effective Date.

B. During the Stay, and except as provided in paragraphs II.D and II.E below, no Plaintiff shall file or fund any lawsuit or formal administrative action asserting any of the following claims: (1) a claim against NMFS alleging unreasonable delay in processing, or failure to act upon, BOEM's MMPA Application; (2) a claim concerning seismic surveys challenging the 2004 PEA referenced in the Complaint, the June 29, 2007 Biological Opinion on the Five-Year (2007-2012) Outer Continental Shelf Oil and Gas Leasing Plan for the Western and Central Planning Areas of the Gulf of Mexico (Ref. F/SER/2006/02611), or any other existing programmatic document to the extent that they are related to approval of Deep Penetration Seismic Surveys; (3) a claim challenging a decision by Federal Defendants to issue a permit for conducting a seismic survey in the Gulf of Mexico, including but not limited to Deep Penetration Seismic Surveys; or (4) a claim challenging an action by any permittee implementing a permit to conduct a seismic survey, including but not limited to Deep Penetration Seismic Surveys, in the Gulf of Mexico (collectively, "Prohibited Claims by Plaintiffs"). Nothing in this paragraph precludes Plaintiffs (a) from continuing litigation challenging Lease Sales 218 and 216/222 in *Oceana v. BOEM*, Case No. 1:12-cv-00981 (D.D.C. filed June 18, 2012), provided, however, that Plaintiffs may not amend their complaint in that case to bring any claims described in the first sentence of this paragraph; (b) from filing or funding litigation or formal administrative actions challenging lease sales or other agency actions on bases other than the approval or conduct of seismic surveys; or (c) from challenging seismic surveys that are conducted by a federal agency and that do not require a permit from BOEM.

C. During the Stay, and except as provided in paragraphs II.D and II.E below, no Plaintiff shall Encourage or Assist any other person or entity to file any lawsuit or formal administrative action asserting the Prohibited Claims by Plaintiffs set forth in paragraph II.B, above. In the event of an alleged breach of this paragraph II.C, the party alleging breach shall provide the allegedly breaching party with written notice and a 30-day opportunity to cure the alleged breach. The allegedly breaching party shall then cure the breach by providing the individual or individuals who are alleged to have caused the breach with a letter in substantially the same form as the letter attached to this Agreement as Exhibit 3.A. The provision of such a letter to the individuals alleged to have caused a breach shall constitute a full and complete cure of the alleged breach.

D. If (1) Federal Defendants issue a permit for Deep Penetration Seismic Surveys during the Stay that does not require each of the mitigation measures described in Section V below, <u>and</u> (2) the permittee does not implement each of those mitigation measures pursuant to the commitment of the Intervenor-Defendants contained in Section VI below, Plaintiffs may either: (i) partially terminate the Stay for the purpose of amending their Complaint in this action to challenge the specific permit as set forth in paragraph II.J, subject to any and all defenses Federal Defendants and Intervenor-Defendants may have; or (ii) fully terminate the Stay, recommence the instant litigation, and file an amended complaint as set forth in paragraph II.K below, subject to any and all defenses Federal Defendants and Intervenor-Defendants may have. If the Parties are all in agreement that the two conditions in the preceding sentence have been met, the Parties shall, upon Plaintiffs' request, submit a stipulation for the Court's approval terminating the Stay in whole or in part, as authorized by paragraph XI.B below. If all Parties do not agree that the two conditions in the first sentence of this paragraph have been met, then Plaintiffs may request that the Court terminate the Stay in whole or in part pursuant to the dispute resolution procedures set forth in paragraph XI.A below.

E. If Plaintiffs believe that Federal Defendants have violated any provision of this Agreement, Plaintiffs may seek to terminate the Stay as set forth in this paragraph, recommence the litigation, and file an amended complaint as set forth in paragraph II.K below, subject to any and all defenses Federal Defendants and Intervenor-Defendants may have. If all Parties are in agreement that Federal Defendants have violated a provision of this Agreement, the Parties shall, upon Plaintiffs' request, submit a stipulation for the Court's approval terminating the Stay, as authorized by paragraph XI.B below. If all Parties do not agree that Federal Defendants have violated a provision of this Agreement, then Plaintiffs may request that the Court terminate the Stay pursuant to the dispute resolution procedures set forth in paragraph XI.A below.

F. Except as provided in paragraph II.H below, during the Stay, no Intervenor-Defendant shall file or fund any lawsuit or formal administrative action asserting any of the following claims: (1) any claim against NMFS alleging unreasonable delay in processing, or failure to act upon, BOEM's MMPA Application; or (2) any claim challenging a decision by Federal Defendants to issue a permit for conducting a Deep Penetration Seismic Survey based upon the inclusion of the mitigation measures identified in Section V of this Agreement (collectively, "Prohibited Claims by Intervenor-Defendants").

G. During the Stay, and except as provided in paragraph II.H below, no Intervenor-Defendant shall Encourage or Assist any other person or entity to file any lawsuit or formal administrative action asserting the Prohibited Claims by Intervenor-Defendants set forth in paragraph II.F, above. In the event of an alleged breach of this paragraph II.G, the party alleging breach shall provide the allegedly breaching party with written notice and a 30-day opportunity to cure the alleged breach. The allegedly breaching party shall then cure the breach by providing the individual or individuals who are alleged to have caused the breach with a letter in substantially the same form as the letter attached to this Agreement as Exhibit 3.B. The provision of such a letter to the individuals alleged to have caused a breach shall constitute a full and complete cure of the alleged breach.

H. If, during the Stay, Federal Defendants issue a permit for Deep Penetration Seismic Surveys that contains additional mitigation measures beyond those described in Section V below, or NMFS mandates additional mitigation measures beyond those described in Section V below, Intervenor-Defendants may terminate the Stay, and/or file a separate action challenging the permit, subject to any and all defenses Federal Defendants may have. If all Parties are in agreement that the condition set forth in the preceding sentence has been met, the Parties shall, upon Intervenor-Defendants' request, submit a stipulation for the Court's approval terminating the Stay, as authorized by paragraph XI.B below. If all Parties do not agree that the condition in the first sentence of this paragraph has been met, then Intervenor-Defendants may request that the Court terminate the Stay pursuant to the dispute resolution procedures set forth in paragraph XI.A below.

I. Unless extended by Order of the Court, the Stay shall automatically terminate 30 months after the Effective Date or immediately after Final Action is taken on BOEM's MMPA Application, whichever occurs first.

J. If the Stay is partially terminated under paragraph II.D(i), Plaintiffs may file an amended complaint against Federal Defendants challenging the specific permit(s) at issue that does not contain all of the mitigation measures identified in Section V. Federal Defendants and Intervenor-Defendants hereby reserve all defenses they may have to any claims or allegations contained in any such amended complaints. Federal Defendants agree to file or lodge the certified administrative record or records, if any, for up to five challenged permits, within 30 days after the amended complaint is filed, provided that Plaintiffs identify such permits to Federal Defendants on or before the filing date of the amended complaint. The administrative records for any remaining challenged permits will be filed or lodged within 60 days after the amended complaint is filed. The Parties also agree to jointly request an expedited litigation schedule with respect to any such challenges.

K. If the Stay is fully terminated under paragraph II.D(ii), II.E or II.H above, or as a result of either (1) a final decision by NMFS denying BOEM's MMPA Application; (2) BOEM's withdrawal of the Application without timely submission of a revised application pursuant to paragraph I.C; or (3) the expiration of 30 months from the Effective Date (as may be extended by

Order of the Court), Plaintiffs may file an amended complaint containing all claims in their existing Complaint and challenging any permit for Deep Penetration Seismic Surveys issued during the Stay that does not require all of the mitigation measures described in Section V; but may not challenge any permit for Deep Penetration Seismic Surveys issued during the Stay that does require all of the mitigation measures described in Section V. Federal Defendants and Intervenor-Defendants hereby reserve all defenses they may have to any claims or allegations contained in any such amended complaint. Federal Defendants agree to file or lodge the certified administrative record or records, if any, for the 2004 PEA (to the extent challenged in the amended complaint) and the 2007 Biological Opinion (to the extent the amended complaint challenges the 2007 Biological Opinion and names NMFS as a defendant) within 30 days after the amended complaint is filed. Additionally, Federal Defendants agree to file or lodge the certified administrative record or records, if any, for up to five challenged permits, within 30 days after the amended complaint is filed, provided that Plaintiffs identify such permits to Federal Defendants on or before the filing date of the amended complaint. The administrative records for any remaining challenged permits will be filed or lodged within 60 days after the amended complaint is filed. The Parties also agree to jointly request an expedited litigation schedule with respect to any such challenges.

III. DISMISSAL OF THE LAWSUIT

A. Should the Stay automatically terminate as a result of Final Action in the form of NMFS's issuance of an MMPA take authorization in response to BOEM's Application (preceded or accompanied by (a) a biological opinion or "not likely to adversely affect" concurrence letter from NMFS concluding consultation pursuant to ESA Section 7(a)(2) and (b) the completion of an EIS/ROD or EA/FONSI pursuant to NEPA), Plaintiffs shall, within seven days after receiving notice of the issuance of the MMPA take authorization from Federal Defendants, file a notice of dismissal of the above-captioned action pursuant to Federal Rule of Civil Procedure 41. The dismissal shall be with prejudice, except that nothing shall prohibit Plaintiffs from filing a new lawsuit challenging the MMPA take authorization or any related analysis or decision document prepared pursuant to NEPA, the ESA, or the MMPA, and/or any new permit for Deep Penetration Seismic Surveys issued by BOEM after the date of dismissal. Any such challenge must be brought in a separate action, and Federal Defendants and Intervenor-Defendants reserve their right to assert any and all available defenses to any such challenge.

B. Upon the filing of the dismissal required under paragraph III.A, and without limiting the scope, effect, or legal consequences of the dismissal, Plaintiffs shall be prohibited from filing or funding any lawsuit or formal administrative action challenging (a) any permit for conducting a seismic survey in the Gulf of Mexico, including but not limited to Deep Penetration Seismic Surveys, issued by BOEM prior to the filing of the dismissal, or (b) any action by any permittee, taken prior or subsequent to the filing of the dismissal, implementing a permit, issued prior to the filing of the dismissal, to conduct a seismic survey, including but not limited to Deep Penetration Seismic Surveys, in the Gulf of Mexico.

C. Upon the filing of the dismissal required under paragraph III.A, and without limiting the scope, effect, or legal consequences of the dismissal, no Plaintiff shall Encourage or Assist any other person or entity to file any lawsuit or formal administrative action asserting the Prohibited Claims by Plaintiffs set forth in paragraph III.B, above. In the event of an alleged breach of this paragraph III.C, the party alleging breach shall provide the allegedly breaching party with written notice and a 30-day opportunity to cure the alleged breach. The allegedly breaching party shall then cure the breach by providing the individual or individuals who are alleged to have caused the breach with a letter in substantially the same form as the letter attached to this Agreement as Exhibit 3.C. The provision of such a letter to the individuals alleged to have caused a breach shall constitute a full and complete cure of the alleged breach.

IV. NEW SEISMIC PERMIT APPLICATION REQUIREMENTS

So long as the Stay is in effect, and without limiting (1) BOEM's discretion or authority to request whatever additional information not described in this section that BOEM may deem necessary or appropriate, or (2) Intervenor-Defendants' ability to challenge such request for additional information, BOEM shall require any applicant for a permit authorizing Deep Penetration Seismic Surveys to provide the following information:

A. Non-Duplicative Surveys

The applicant must provide a written justification explaining why the proposed Deep Penetration Seismic Survey is not unnecessarily duplicative of previously conducted Deep Penetration Seismic Surveys, taking into account differences in imaging technology, acquisition design and technology, targeted subsurface formations, the geographic area of the proposed survey or parts thereof, or other relevant considerations. An applicant's written justification shall not be subject to legal challenge, provided that this limitation shall cease to apply if BOEM and/or NMFS adopt and implement a legally enforceable standard during the Stay for evaluating unnecessary Deep Penetration Seismic Survey duplication.

B. Lowest Practicable Source Levels

The applicant must provide an estimate of the total energy output per impulse in decibels (Root Mean Square (RMS) as described in BOEM's Permit Application, Section D) with respect to each energy source to be used. The applicant will verify in writing prior to conducting Deep Penetration Seismic Surveys that the proposed airgun arrays to be used are, to the extent practicable, of the lowest sound intensity level that still achieves the survey's goals. The written verification must include confirmation that the airgun array has been calibrated/tuned to maximize subsurface illumination and minimize, to the extent practicable, horizontal propagation of noise. An applicant's verification shall not be subject to legal challenge, provided that this limitation shall cease to apply if BOEM and/or NMFS were to adopt and implement a legally enforceable standard during the Stay for evaluating or minimizing sound source levels.

V. CONSIDERATION OF INTERIM MITIGATION MEASURES

So long as the Stay is in effect, and without limiting (1) BOEM's discretion or authority to consider whatever additional measures not described in this section that BOEM may deem necessary or appropriate, or (2) Intervenor-Defendants' ability to challenge such additional measures, BOEM shall analyze in EAs specific to permitting decisions for individual Deep Penetration Seismic Surveys the following mitigation measures as conditions of approval of any permits for Deep Penetration Seismic Surveys. Federal Defendants' commitment to analyze the following mitigation measures in no way obligates Federal Defendants to require the measures in any resulting permit:

A. Seasonal Restriction for Coastal Waters

With respect to Deep Penetration Seismic Surveys as defined herein, the permittee shall not, between March 1 and April 30, operate any airguns or any airgun arrays within federal coastal waters in the Gulf of Mexico shoreward of the 20 meter isobath. This seasonal limitation shall not apply to Deep Penetration Seismic Survey preparations, including but not limited to the laying of receiver cables, that do not involve the use of airguns or airgun arrays, or sub-bottom profilers (such as in archeological resources surveys that may be required precedent to some Deep Penetration Seismic Surveys).

B. Expansion of JOINT NTL No. 2012-G02

The permittee shall comply with JOINT NTL 2012-G02, with the following modifications: (1) The shut down provision set forth on page 3, paragraph 4 of JOINT NTL 2012-G02 shall apply to manatees as well as whales; and (2) The mitigation measures set forth in JOINT NTL 2012-G02, along with the modification described in this paragraph, shall apply to all Deep Penetration Seismic Surveys conducted in Federal waters in the Gulf of Mexico regardless of water depth.

C. Minimum Separation Distances

1. Except as set forth in paragraph V.C.3, when operating in one of Plaintiffs' Areas of Concern, pursuant to a Deep Penetration Seismic Survey permit, and engaged in active seismic source operations the permittee shall maintain a minimum separation distance of 40 kilometers between any of its active seismic energy sources (airguns or airgun arrays) and any active seismic energy source that is operating pursuant to a separate Deep Penetration Seismic Survey permit issued by BOEM (or its predecessor agency).

2. Except as set forth in paragraph V.C.3 below, when operating in areas outside of Plaintiffs' Areas of Concern, and engaged in active seismic source operations pursuant to a Deep Penetration Seismic Survey permit the permittee shall maintain a minimum separation distance of 30 kilometers between any of its active seismic energy sources (airguns or airgun arrays) and any active seismic energy source that is operating pursuant to a separate Deep Penetration Seismic Survey permit issued by BOEM (or its predecessor agency).

3. The separation requirements set forth in paragraphs V.C.1 and V.C.2 above shall not apply with respect to separation between multiple vessels engaged in a coordinated operation under the same permit (e.g., wide azimuth surveys). In addition, the

separation requirements set forth in paragraphs V.C.1 and V.C.2 above need not be maintained when doing so would be unsafe or when temporary narrowing of the separation distance is caused by a meteorological or weather event.

D. Seismic Restriction in Eastern Planning Area

1. Except as set forth in paragraph V.D.2 below, the permittee shall not conduct Deep Penetration Seismic Surveys while operating within those portions of Plaintiffs' Areas of Concern that fall within the Eastern Planning Area, as defined in Exhibit 4.

2. The restriction set forth in paragraph V.D.1 shall not apply to Deep Penetration Seismic Surveys of: (a) any currently leased blocks; (b) any portion of the geographic area encompassed by the originally proposed Lease Sale 224 demarcated on Exhibit 5; or (c) with respect to the surveying of Neighboring Blocks being surveyed in order to achieve full subsurface imaging of areas in either the Central Planning Area, the portions of the Eastern Planning Area that are outside Plaintiffs' Areas of Concern, any currently leased blocks, or the geographic area within the originally proposed Lease Sale 224. Neighboring Blocks shall consist of the two lease blocks adjacent in any direction to the area being imaged.

3. When surveying Neighboring Blocks as described in paragraph V.D.2.(c), the permittee shall, in both planning and conducting a survey, limit the active use of airguns in neighboring blocks to that which is reasonably necessary to conduct such full subsurface imaging. BOEM will notify Plaintiffs of any permits authorizing Deep Penetration Seismic Surveys of Neighboring Blocks as described in paragraph V.D.2.(c).

E. Passive Acoustic Monitoring

While engaging in active seismic source operations in water depths of 100 meters or greater during times of reduced visibility (darkness, fog, rain, etc.), the permittee shall include passive acoustic monitoring ("PAM") as part of its protected species observer program. Applicants will be required to provide BOEM with a description of the passive acoustic system, the software used, and the monitoring plan prior to its use. After completion of the project, the permittee will provide an assessment of the usefulness and effectiveness of the use of PAM for marine mammal detection, including any problems encountered.

F. Reporting Requirements

The permittee shall be required to provide, on a bi-weekly basis (every two weeks), a written report describing:

1. The dates, locations in tracklines, leasing blocks, or geographic coordinates, and duration of any Deep Penetration Seismic Surveys conducted during the reporting period.

2. Any circumstances that caused the total energy output of the airgun arrays to exceed that set forth in the application.

3. Confirmation that the operator maintained the minimum separation distances described in paragraph V.C above while conducting Deep Penetration Seismic Surveys. If the operator did not maintain the minimum separation distances, the operator shall provide a written explanation. Nothing in this paragraph shall be construed to limit or waive the operator's duties under paragraph V.C above.

4. Confirmation that the operator complied with the other terms of Section V of this Agreement.

VI. INTERVENOR-DEFENDANTS' COMMITMENT REGARDING INTERIM MITIGATION MEASURES

So long as the Stay is in effect, Intervenor-Defendants shall abide by all of the mitigation measures described in Section V above when conducting any Deep Penetration Seismic Surveys pursuant to a permit issued by BOEM during the Stay, even if the mitigation measures described in Section V are not included as conditions of the permit itself.

VII. AVAILABILITY OF PERMIT INFORMATION AND BIWEEKLY REPORTS, AND PROVISION OF THE AGREEMENT AND ORDER

A. During the Stay, BOEM shall make non-proprietary information regarding Deep Penetration Seismic Survey permits issued during the Stay available to the public on its website (https://www.data.boem.gov/homepg/data_center/other/WebStore/pimaster.asp?appid=5) including all applications, permits, associated NEPA documents, and any biweekly reports referenced in paragraph V.F above. BOEM will promptly notify all other parties of any changes in the website address provided in the preceding sentence. BOEM will redact or otherwise maintain the confidentiality of proprietary information as defined by BOEM's permit application form (BOEM Form 0327).

B. During the Stay, should BOEM require as a condition for a permit for a Deep Penetration Seismic survey the minimum separation distance mitigation measure described in paragraph V.C and the biweekly reports described in paragraph V.F, BOEM will also compare the biweekly reports to confirm that the minimum separation distances were maintained, and will post notice on its website during the Stay of any exceptions or violations of the requirement.

C. At the time of issuing each Deep Penetration Seismic Survey permit during the Stay period, Federal Defendants will provide to each permittee a copy of this Agreement and the Order approving the Agreement and Staying the litigation in accordance with the terms of the Agreement. Such copy will be accompanied by a written notice to the permittee of the obligations undertaken by Intervenor-Defendants in Section VI above.

VIII. EVALUATION OF POTENTIAL STANDARDS

A. During the Stay, and except as provided in paragraph VIII.B below, BOEM will convene an internal panel or panels with sufficient geophysical and environmental expertise to determine whether it would be feasible to develop standards for determining (A) whether a Deep Penetration Seismic Survey is unnecessarily duplicative and (B) the lowest practicable source level for a Deep Penetration Seismic Survey. If the panel or panels determine that it would be feasible to develop one or both of these standards, and a Draft EIS or EA for BOEM's MMPA Application has not already been released, BOEM will include and evaluate such standards in any draft EIS or EA for BOEM's MMPA Application. If the panel or panels determine that it is not feasible to develop one or both standards, and the Draft EIS or EA for BOEM's MMPA Application has not already been released, BOEM will include its rationale for this determination for review and comment in any Draft EIS or EA. The Parties acknowledge that in making these determinations, the panel or panels may need to solicit outside expertise. BOEM will provide the parties with updates, during the meetings referenced in paragraph XII.A, on progress made under this paragraph.

B. BOEM's obligations under paragraph VIII.A shall cease if the Stay is terminated under paragraph II.D, II.E or II.H, or as a result of either (1) a final decision by NMFS denying BOEM's MMPA Application; or (2) BOEM's withdrawal of the Application without timely submission of a revised application pursuant to paragraph I.C.

C. Plaintiffs reserve the right to challenge any determination by BOEM that it is not feasible to develop one or both standards, or to challenge any such standards should one or more of the Federal Defendants develop and implement them. Any such challenge must be brought in a separate action, and Federal Defendants and Intervenor-Defendants reserve any and all defenses they may have to such a challenge.

D. Intervenor-Defendants do not agree that developing the standards described in paragraph VIII.A is feasible or appropriate. Intervenor-Defendants shall be free to challenge any such standards should one or more of the Federal Defendants develop and implement them. Any such challenge must be brought in a separate action, and Federal Defendants reserve any and all defenses they may have to such a challenge.

IX. ITEMS TO BE EVALUATED IN ANY PROGRAMMATIC NEPA ANALYSIS FOR BOEM'S MMPA APPLICATION

A. Federal Defendants agree to analyze alternatives and/or mitigation measures in any EIS or EA for BOEM's MMPA Application that are substantially similar to the following:

1. The mitigation measures described in Part V.

2. Mechanisms to reduce cumulative or chronic exposure of marine mammal populations to noise (*e.g.*, limiting concurrent surveying, limiting the total amount of survey activity in portions of the Gulf of Mexico).

3. Requirements or incentives to develop and use emergent alternative technologies for Deep Penetration Seismic surveying.

B. Federal Defendants agree to analyze in any EIS or EA for BOEM's MMPA Application the development of a long-term adaptive monitoring plan that addresses potential cumulative and chronic impacts from seismic surveys on marine mammal populations in the Gulf of Mexico.

C. BOEM's obligations under paragraphs IX.A and IX.B shall cease if the Stay is terminated under paragraph II.D, II.E or II.H, or as a result of either (1) a final decision by

NMFS denying BOEM's MMPA Application; or (2) BOEM's withdrawal of the Application without timely submission of a revised application pursuant to paragraph I.C.

D. Intervenor-Defendants do not agree that all of the measures described in paragraph IX.A and IX.B are feasible or appropriate. Intervenor-Defendants shall be free to challenge any such measures should one or more of the Federal Defendants develop and implement them. Any such challenge shall be brought in a separate action, and Federal Defendants reserve any and all defenses they may have to such a challenge.

X. VIBROSEIS STUDY

A. A subset of American Petroleum Institute ("API") members will decide within 60 days of the final execution of this Agreement whether to conduct a study of Vibroseis technology that will include the construction of Vibroseis prototypes for use in the marine environment, and testing to determine whether they are technologically and operationally capable of producing in an efficient and reliable manner geophysical data comparable to that produced by existing seismic surveying technology (hereinafter referred to as the "marine Vibroseis study").

B. The commitments with respect to the marine Vibroseis study shall consist of the following terms, and no others:

1. The marine Vibroseis study shall involve the construction of at least three prototypes, which will be built within 2.5 years of the final execution of this Agreement. At least one prototype shall thereafter be field tested.
2. During the first 2.5 years following the final execution of this Agreement, Intervenor-Defendants will update the Parties to this Agreement orally, through counsel, during the meetings referenced in paragraph XII.A, on the general progress made on each prototype(s) involved in the marine Vibroseis study.

3. Intervenor-Defendants will provide a basic written summary to the Parties to this Agreement regarding the development and testing (if any) of the marine Vibroseis prototype(s), by the close of 2.5 years after the final execution of this Agreement.
4. Intervenor-Defendants will provide a basic written summary to the Parties to this Agreement regarding the further development and field-testing (if any) of the marine Vibroseis prototype(s) by the close of 3.5 years after the final execution of this Agreement. All field testing (if any) will be concluded by the close of 3.5 years after the final execution of this Agreement.
5. A final written report regarding the marine Vibroseis study (the "4-year study report" or "Report") will be submitted for publication in a peer-reviewed scientific journal by the close of 4 years after the final execution of this Agreement. The study participants will act in good faith to secure the timely publication of the study, but that obligation will be subject and subordinate to the scientific journal maintaining control over the publication decision and timing.
6. Dissemination of the 4-year study report.
    a. At the time the 4-year study report is submitted for publication in a peer-reviewed scientific journal, a copy of the unpublished 4-year study report, any acoustical, non-engineering data recorded during testing of the Vibroseis prototypes regarding vertical and horizontal sound propagation from the Vibroseis source(s) (the "Data"), and the results of any environmental research or monitoring imposed by a governmental body as a condition of permitting field testing conducted as part of the marine Vibroseis study (the "Results"), will be made available for review by Plaintiffs and Federal Defendants upon the Court's entry of a protective

order limiting dissemination of the unpublished 4-year study report, Data, and Results as follows:

i. Prior to making the unpublished 4-year study report available for review by Plaintiffs and Federal Defendants, Intervenor-Defendants will stamp the unpublished 4-year study report, Data, and the Results "Proprietary Business—Confidential" and "Exempt from Disclosure." The Parties agree that the unpublished Report, Data, and Results are information not customarily disclosed to the public and, notwithstanding any requirements of this Agreement, will be voluntarily made available by the research proponents for review by Plaintiffs and Federal Defendants in accordance with the restrictions below.

ii. Representatives of the Plaintiffs may review the Report, Data, and Results in Washington, D.C., and one other location to be designated by the Plaintiffs. Plaintiffs and their representatives may not copy or otherwise duplicate the unpublished 4-year study report.

iii. One copy of the 4-year study report, Data, and Results will be made available to BOEM. BOEM may provide a copy of the 4-year study report (stamped as described in the paragraph X.B.6.a.i) to NMFS. However, BOEM shall have the "primary interest" in the document within the meaning of 15 C.F.R. § 4.5(b) and shall be responsible for responding to any Freedom of Information Act ("FOIA") request submitted to either BOEM or NMFS to the extent the FOIA request seeks a copy the Report, Data, or Results. Until the Report has been published or otherwise publicly released, BOEM will be required to keep the copy of the Report, Data and Results confidential, including by withholding the confidential, unpublished Report, Data and Results from FOIA requests. Additionally, should BOEM become aware of any court action in which disclosure of the unpublished 4-year study report, Data and Results may be required, either in response to a discovery request or as part of an administrative record, BOEM shall promptly notify Intervenor-Defendants of the pendency of the action and seek a protective order to prevent the public dissemination of the report, Data and Results. Nothing in this paragraph, however, shall preclude BOEM from producing the 4-year study report, Data or Results to the extent required by any court order.

7. If the Report is rejected for publication in a peer-reviewed scientific journal, Intervenor-Defendants will publicly release the Report and provide a copy of the Data and the Results to Plaintiffs, which may publicly disseminate them. If the Report is published in a peer-reviewed scientific journal, Intervenor-Defendants will provide a copy of the Data and the Results to Plaintiffs, which may publicly disseminate them. Intervenor-Defendants will update the Parties monthly, orally or in writing, on the status of their submission.

8. In the event that the marine Vibroseis study is canceled before completion (with the decision whether to cancel to be determined solely by the API participants in that study), Intervenor-Defendants will provide a written, publicly releasable report to the Parties on the research undertaken before the cancelation, the results obtained from that research, and the reasons for cancelation, as well as a copy of the Data and the Results (if they

exist at the time of cancellation). Intervenor-Defendants agree that, in the event of cancelation, they will not exercise any right they may have, except as patent-holders, to bar, limit, or impede further development or testing by other parties of the prototypes involved in the study. Nothing in this subparagraph shall be construed to require the release of the proprietary information, or otherwise infringe upon the property or intellectual property rights, of the developers of any of the Vibroseis prototypes.

9. In the event that: (i) a decision is not made within 60 days of the final execution of this Agreement to proceed with the marine Vibroseis study, or (ii) the marine Vibroseis study is canceled before completion (with the decision whether to cancel to be determined solely by the API participants in that study), or (iii) the marine Vibroseis study does not meet any of the deadlines set forth in subparagraphs X.B.1 through X.B.5, API will make a contribution of $2 million to a near-coastal bottlenose dolphin-related study, the nature of such study to be mutually agreed upon by API, the International Association of Geophysical Contractors and the Plaintiffs, or if such mutual agreement cannot be reached, to be determined by Dr. Tim Ragen, the present Executive Director of the U.S. Marine Mammal Commission. Payment of this $2 million shall relieve Intervenor-Defendants of all obligations under this Section X, other than the obligations set forth in subparagraph X.B.8. All obligations of all Parties under all other Sections of this Agreement shall remain in full force and effect.

10. The obligations under this Section X shall survive any dismissal of the case pursuant to paragraph III.A, any termination of the Stay by the Intervenor-Defendants pursuant to paragraph II.H, and any termination of the Stay caused by the expiry of 30 months

following the Effective Date of the Agreement, as set forth in paragraph II.I; but shall not come into effect except as provided in paragraph I.E.

XI. DISPUTE RESOLUTION, ENFORCEABILITY, AND MODIFICATION

A. In the event of a dispute arising out of or relating to this Agreement, including a dispute over any asserted violation of any term of the Agreement or an asserted need to modify the Agreement or to terminate or extend the Stay, the Party raising the dispute shall provide the other Parties with notice of the dispute. The Parties agree that they will meet and confer (telephonically or in person) within seven calendar days after notice is provided in a good-faith effort to resolve the claim before seeking relief from the Court. If the Parties are unable to resolve the dispute themselves, the Party raising the dispute may move for appropriate relief from the Court consistent with the terms of this Agreement. Briefing on any such motion shall proceed in accordance with the Local Rules of the United States District Court for the Eastern District of Louisiana.

B. This Agreement may be modified, and the Stay may be terminated or extended, by written stipulation of all Parties filed with and approved by the Court.

C. The Parties agree that contempt of court is not an available remedy for any violation of this Agreement, and the Parties therefore knowingly waive any right that they might have to seek an order of contempt for any such violation.

D. The sole relief available for an asserted violation of this Agreement by Federal Defendants shall be termination of the Agreement, lifting of the Stay, and recommencement of the litigation as set forth in paragraph II.E above.

E. Except to the extent provided by paragraphs II.C, II.G, and III.C above, this Agreement shall be enforceable against Intervenor-Defendants and Plaintiffs solely in this Court through an action for breach of contract under federal contract law, and remedies shall be limited to injunctive relief, including but not limited to specific performance.

XII. ADDITIONAL PROVISIONS

A. During the pendency of the Stay, the Parties agree to meet (in person or by telephone) every four months to discuss the status of BOEM's MMPA Application and the associated NEPA and ESA processes.

B. The Parties agree that the Agreement does not represent an admission by any Party to any fact, claim, or defense concerning any issue in this case; has no precedential value; shall not be used as evidence in any litigation or administrative proceeding except as necessary to enforce its terms; and does not constitute an admission as to the validity or sufficiency of any of the proposed mitigation measures in a court of law or in any future settlement negotiations.

C. No Party concedes by entering into this Agreement that any of the application, permit, or reporting requirements described above are legally required or would yield measurable biological benefits over the long term, or that such requirements are sufficient to achieve legal compliance or reduce biological risk over the long term.

D. By entering into this Agreement, Federal Defendants do not concede or imply that any of the application, permit, or reporting requirements described above will or should ultimately be selected as the preferred alternative in any NEPA analysis or that any of the measures should be incorporated by NMFS into any MMPA authorization or ESA biological opinion or concurrence letter.

E. The Agreement does not modify or limit the discretion afforded to Federal Defendants under any statute or principles of administrative law, or constitute a commitment or requirement that the United States is obligated to pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. § 1341, or any other provision of law.

F. No provision of this Agreement shall be interpreted as, or constitute, a commitment or requirement that Federal Defendants take action in contravention of the NEPA, the MMPA, the ESA, the Administrative Procedure Act, or any other law or regulation, either substantive or procedural.

G. In the event Plaintiffs file a notice of dismissal pursuant to Section III.A above, Plaintiffs shall be entitled to an award of attorney fees and costs against Federal Defendants in the amount of $160,000. Plaintiffs will furnish Federal Defendants with the information necessary to effectuate this payment within seven days of the filing of the notice of dismissal. Federal Defendants agree to process the fee payment within 10 days of the receipt of the necessary information from Plaintiffs or the filing of the notice of dismissal, whichever is later. Plaintiffs agree to accept payment of $160,000 in full satisfaction of any and all claims for attorneys' fees and costs of litigation to which Plaintiffs may be entitled under any statute or on any common law basis with respect to the above-captioned litigation, through and including the date of the filing of the notice of dismissal. By agreeing to pay fees in the circumstances set forth in this paragraph, Federal Defendants do not waive any right to contest fees claimed by Plaintiffs, or its counsel, including the hourly rate, in any future litigation or continuation of the present action as set forth in paragraph H below. Furthermore, the agreement in this paragraph regarding attorneys' fees and costs has no precedential value and shall not be used as evidence in any other attorneys' fees litigation or in any continuation of the present action as set forth in paragraph H below.

H. Should the Stay terminate for any reason other than as a result of Final Action in the form of NMFS's issuance of MMPA take authorization in response to BOEM's Application, Plaintiffs reserve the right to seek attorneys' fees and costs pursuant to the Equal Access to Justice Act ("EAJA"), 28 U. S. C. § 2412(d). Federal Defendants reserve any and all defenses they may have to any such request or petition for fees pursuant to the EAJA or any other statute or common law.

I. It is expressly understood and agreed that this Agreement has been freely and voluntarily entered into by the Parties. Each Party represents and acknowledges that, in executing this Agreement, it is not relying on, nor has it relied on, any representation or statement made by any of the other Parties, their agents, or attorneys with regard to the subject matter, basis, or effect of this Agreement. Each Party represents and acknowledges that no agreements or understandings exist among them relating to the subject matter of this Agreement, other than those set forth in this Agreement.

J. It is hereby expressly understood and agreed that this Agreement was jointly drafted by the Parties. Accordingly, the Parties hereby agree that any and all rules of construction to the effect that ambiguity is construed against the drafting party shall be inapplicable in any dispute concerning the terms, meaning, or interpretation of this Agreement.

K. The undersigned representatives of each party certify that they are fully authorized by the party or parties they represent to consent to enter into this Agreement

Signed this 18th day of June, 2013.

Natural Resources Defense Council, Inc.

by: ______________________

Center for Biological Diversity, Inc.

by: ______________________

Gulf Restoration Network, Inc.

by: ______________________

Sierra Club, Inc.

by: ______________________

Federal Defendants S.M.R. Jewell, Secretary of the U.S. Department of the Interior; the Bureau of Ocean Energy Management; and Tommy Beaudreau, Director, Bureau of Ocean Energy Management BOEM

By: ~~IGNACIA S. MORENO~~ ROBERT G. DREHER
Acting Assistant Attorney General

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by: ______________________

International Association of Geophysical Contractors

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Natural Resources Defense Council, Inc.

by: ______________________

Center for Biological Diversity, Inc.

by: ______________________

Gulf Restoration Network, Inc.

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Sierra Club, Inc.

by: ______________________

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by: ____________________

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Center for Biological Diversity, Inc.

by: ______________________

Gulf Restoration Network, Inc.

by: ______________________

Sierra Club, Inc.

by: ______________________

Federal Defendants S.M.R. Jewell, Secretary of the U.S. Department of the Interior; the Bureau of Ocean Energy Management; and Tommy Beaudreau, Director, Bureau of Ocean Energy Management BOEM

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Attorneys for Federal Defendants

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by: ______________________

International Association of Geophysical Contractors

by: ______________________

Independent Petroleum Association of America

by: ________________________

U.S. Oil & Gas Association

by: ________________________

Chevron U.S.A., Inc.

by: ________________________

Independent Petroleum Association of America

by: ___________________________

U.S. Oil & Gas Association

by: Albert Modiano

Chevron U.S.A., Inc.

by: ___________________________

Independent Petroleum Association of America

by: ___________________________

U.S. Oil & Gas Association

by: ___________________________

Chevron U.S.A. Inc.

by: ___________________________
Frank G. Soler, Assistant Secretary

Exhibit 1

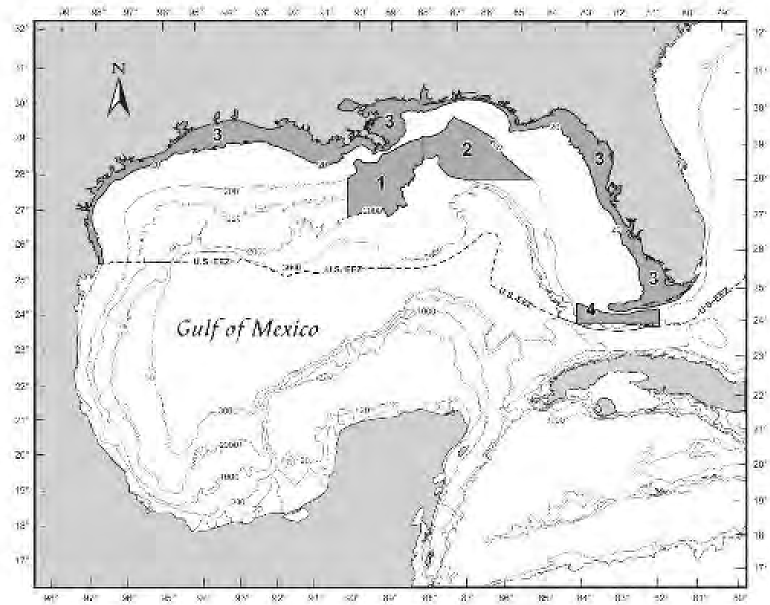

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Exhibit 2

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF LOUISIANA

NATURAL RESOURCES DEFENSE COUNCIL INC., *et al.*, **Plaintiffs,** **v.** **S.M.R. JEWELL, Secretary of the Department of the Interior, *et al.*,,** **Defendants.** **and** **AMERICAN PETROLEUM INSTITUTE, *et al.*,** **Intervenor-Defendants.**	**CIVIL ACTION NO. 2:10-cv-01882** **SECTION "A"** **JUDGE JAY C. ZAINEY** **MAGISTRATE JOSEPH C. WILKINSON**

ORDER GRANTING JOINT MOTION FOR APPROVAL OF SETTLEMENT AGREEMENT AND STAY OF PROCEEDINGS

This matter is before the Court on the Joint Motion for Approval of the Settlement Agreement and Stay of Proceedings ("Joint Motion").

For good cause shown, it is hereby ORDERED that the Joint Motion is GRANTED. It is further ORDERED that the Settlement Agreement is APPROVED and all proceedings in this matter are STAYED in accordance with the terms of the Settlement Agreement.

Dated: ___________________, 2013

____
Judge of the United States District Court

Exhibit 3

A. Form Letter to Individual Alleged to Have Caused Breach of Paragraph II.C

To Whom It May Concern:

As you may be aware, [Plaintiff Organization] has entered into a settlement, dated [insert date], with the Department of the Interior, American Petroleum Institute, International Association of Geophysical Contractors, Independent Petroleum Association of America, U.S. Oil and Gas Association, and Chevron U.S.A., Inc., related to the approval of seismic exploration and development surveys used to develop petroleum resources in the Gulf of Mexico.

As a part of the settlement, [Plaintiff Organization] has agreed that, during a period of approximately 30 months during which the Department of the Interior will take certain actions related to these seismic surveys, [Plaintiff Organization] will not "encourage or assist any other person or entity to file any lawsuit or formal administrative action" asserting the following claims: (1) a claim against the National Marine Fisheries Service alleging unreasonable delay in processing, or failure to act upon, the Bureau of Ocean Energy Management's Pending Marine Mammal Protection Act Application described in 76 Fed. Reg. 34656 (June 14, 2011); (2) a claim challenging the 2004 Programmatic Environmental Assessment referenced in the Complaint filed on June 30, 2010 by Natural Resources Defense Council, Center for Biological Diversity, Gulf Restoration Network, and Sierra Club; the June 29, 2007 Biological Opinion on the Five-Year (2007-2012) Outer Continental Shelf Oil and Gas Leasing Plan for the Western and Central Planning Areas of the Gulf of Mexico (Ref. F/SER/2006/02611); or any other existing programmatic document related to approval of Deep Penetration Seismic Surveys; (3) a claim challenging a decision by the Interior Department to issue a permit for conducting a seismic survey in the Gulf of Mexico, including but not limited to Deep Penetration Seismic Surveys; or (4) a claim challenging an action by any permittee implementing a permit to conduct a seismic survey, including but not limited to Deep Penetration Seismic Surveys, in the Gulf of Mexico.

We have been advised that you have recently engaged in activities that are alleged to breach this commitment, including [describe offending activities]. We ask that you immediately cease engaging in these activities and that you refrain from engaging in these or similar activities in the future. To the extent you continue to engage in these or similar activities, your actions are not approved or endorsed by [Plaintiff Organization], which fully supports the above-described settlement.

Thank you very much for your attention to this important matter.

Yours sincerely,

[Plaintiff Organization Representative]

B. Form Letter to Individual Alleged to Have Caused Breach of Paragraph II.G

To Whom It May Concern:

As you may be aware, [Intervenor Company or Association] has entered into a settlement, dated [insert date], with the Department of the Interior, Natural Resources Defense Council, Center for Biological Diversity, Gulf Restoration Network, and Sierra Club, related to the approval of seismic exploration and development surveys used to develop petroleum resources in the Gulf of Mexico.

As a part of the settlement, [Intervenor Company or Association] has agreed that, during a period of approximately 30 months during which the Department of the Interior will take certain actions related to these seismic surveys, [Intervenor Company or Association] will not "encourage or assist any other person or entity to file any lawsuit or formal administrative action" asserting the following claims: (1) any claim against the National Marine Fisheries Service ("NMFS") alleging unreasonable delay in processing, or failure to act upon, the Bureau of Ocean Energy Management's ("BOEM's") application for an incidental take permit under the Marine Mammal Protection Act, as described in 76 Fed. Reg. 34656 (June 14, 2011), or any revised application submitted by BOEM to NMFS that is substantively the same in scope as the aforementioned application; or (2) any claim challenging a decision by the Federal Defendants in that litigation to issue a permit for conducting a Deep Penetration Seismic Survey based upon the inclusion of the mitigation measures identified in Section V of the settlement agreement.

We have been advised that you have recently engaged in activities that are alleged to breach this commitment, including [describe offending activities]. We ask that you immediately cease engaging in these activities and that you refrain from engaging in these or similar activities in the future. To the extent you continue to engage in these or similar activities, your actions are not approved or endorsed by [Intervenor Company or Association], which fully supports the above-described settlement.

Thank you very much for your attention to this important matter.

Yours sincerely,

[Intervenor Company or Association Representative]

C. Form Letter to Individual Alleged to Have Caused Breach of Paragraph III.C

To Whom It May Concern:

As you may be aware, [Plaintiff Organization] has entered into a settlement, dated [insert date], with the Department of the Interior, American Petroleum Institute, International Association of Geophysical Contractors, Independent Petroleum Association of America, U.S. Oil and Gas Association, and Chevron U.S.A., Inc., related to the approval of seismic exploration and development surveys used to develop petroleum resources in the Gulf of Mexico.

As a part of the settlement, [Plaintiff Organization] has agreed that, following dismissal of the lawsuit, [Plaintiff Organization] will not "encourage or assist any other person or entity to file any lawsuit or formal administrative action" challenging: (1) any permit for conducting a seismic survey in the Gulf of Mexico, including but not limited to Deep Penetration Seismic Surveys, issued by the Bureau of Ocean Energy Management prior to the filing of the dismissal; or (2) any action by any permittee, taken prior or subsequent to the filing of the dismissal, implementing a permit, issued prior to the filing of the dismissal, to conduct a seismic survey, including but not limited to Deep Penetration Seismic Surveys, in the Gulf of Mexico.

We have been advised that you have recently engaged in activities that are alleged to breach this commitment, including [describe offending activities]. We ask that you immediately cease engaging in these activities and that you refrain from engaging in these or similar activities in the future. To the extent you continue to engage in these or similar activities, your actions are not approved or endorsed by [Plaintiff Organization], which fully supports the above-described settlement.

Thank you very much for your attention to this important matter.

Yours sincerely,

[Plaintiff Organization Representative]

Exhibit 4

Eastern Gulf of Mexico (EGM) NAD 27

From the intersection of the SLA boundary with X=1,488,960.000 (UTM zone 16), OPD NH16-05 (Pensacola) south along the west boundary of blocks 843 and 887 to the southwest corner of block 931;

thence east along the south boundary of block 931 to the southwest corner of block 932;

thence south along the west boundary of block 976, continuing south along the west boundary of block 8 of OPD NH16-08 (Destin Dome) to the southwest corner of block 52;

thence east along the south boundary of block 52 to the southwest corner of block 53;

thence south along the west boundary of blocks 97, 141, and 185 to southwest corner of block 229;

thence east along the south boundary of block 229 to the southwest corner of block 230;

thence south along the west boundary of blocks 274, 318, and 362 to the southwest corner of block 406;

thence east along the south boundary of block 406 to the southwest corner of block 407;

thence south along the west boundary of blocks 451, 495, and 539 to the southwest corner of block 583;

thence east along the south boundary of block 583 to the southwest corner of block 584;

thence south along the west boundary of blocks 628, 672, and 716 to the southwest corner of block 760;

thence east along the south boundary of block 760 to the southwest corner of block 761;

thence south along the west boundary of blocks 805, 849, and 893 to the southwest corner of block 937;

thence east along the south boundary of block 937 to the southwest corner of block 938;

thence south along the west boundary of block 982 to the southwest corner of block 982 and the northeast corner of block 16 of OPD NH16-11 (De Soto Canyon);

thence west along the north boundary of block 16 to a point (X=1,594,862.443 Y=10,517,760.000 UTM Zone 16;

thence southeasterly along the planning area limit to a point (X=1,625,229.663 and Y=10,348,337.882 UTM zone 16) within block 458;

thence southeasterly along the planning area limit to a point (X=1,643,612.717 and Y=10,324,041.599 UTM zone 16) within block 547;

thence southeasterly along the planning area limit through OPDs NH16-11 and NG16-02 (Lloyd Ridge), to a point (X=1,792,297.045 Y=9,504,000.000 UTM zone 16) within NG16-05 (Henderson) on the south boundary of block 777 and the north boundary of block 821;

thence southwesterly along the planning area limit through OPD NG16-05 to a point (X=1,731,335.654 Y=9,424,800.000 UTM zone 16) on the south boundary of block 993 and the north boundary of block 25 of OPD NG16-08 (Florida Plain);

thence west along the north boundary of block 25 to the northwest corner of block 25;

thence south along the west boundary of block 25 to the southwest corner of block 25;

thence west along the north boundary of block 68 to the northwest corner of block 68;

thence south to the southwest corner of block 68; thence west along the north boundary of block 111 to the northwest corner of block 111;

thence south along the west boundary of block 111 to the southwest corner of block 155;

thence west along the north boundary of block 198 to the northwest corner of block 198;

thence south along the west boundary of block 198 to the southwest corner of block 198;

thence west along the north boundary of block 241 to the northwest corner of block 241;

thence south along the west boundary of block 241 to the southwest corner of block 241;

thence west along the north boundary of block 284;

thence south along the west boundary of block 284 to the southwest corner of block 328;

thence west along the north boundary of block 371 to the northwest corner of block 371;

thence south along the west boundary of block 371 to the southwest corner of block 371;

thence west along the north boundary of block 414 to the intersection with the Limit of Protraction line;

thence southeasterly along the Limit of Protraction line to 25°12'25" N latitude, 86°33'12" W longitude (point 27 of the U.S.-Cuba Provisional Maritime Boundary);

thence southeasterly along the U.S.-Cuba Provisional Maritime Boundary through OPDs NG16-11 (Campeche Escarpment), NG16-12 (Rankin), NG17-10 (Dry Tortugas), and NF17-01 (Tortugas Valley) to 23°49'22" N. latitude, 83° 00' 00" W longitude (point 12 of the U.S.-Cuba Provisional Maritime Boundary);

thence north through OPDs NF17-01 and NG17-10 to the SLA boundary south of the Dry Tortugas;

thence northwesterly, easterly, and southerly along the SLA boundary as shown on Official Protraction Diagram ("OPD") NG17-10 (Dry Tortugas) dated 9/20/1989 to 24°35' N latitude (all OPDs referenced herein are available at http://www.boem.gov/Oil-and-Gas-Energy-Program/Mapping-and-Data/Atlantic.aspx);

thence east to the SLA boundary west of the Marquesas Keys at 24°35' N latitude;

thence easterly along the SLA boundary as shown on OPD NG17-10 (Dry Tortugas) dated 9/20/1989;

thence easterly along the SLA boundary as shown on OPD NG17-11 (Key West) dated 12/16/1985;

thence easterly and northwesterly along the SLA boundary as shown on OPD NH17-08 (Miami) dated 10/24/1978;

thence northwesterly along the SLA boundary as shown on OPD NG17-07 (Pulley Ridge) dated 10/24/1978;

thence northwesterly along the SLA boundary as shown on OPD NG17-04 (Charlotte Harbor) dated 6/2/1983;

thence northwesterly along the SLA boundary as shown on OPD NG17-01 (Saint Petersburg) dated 6/2/1983;

thence northerly along the SLA boundary as shown on OPD NH17-10 (Tarpon Springs) dated 6/2/1983;

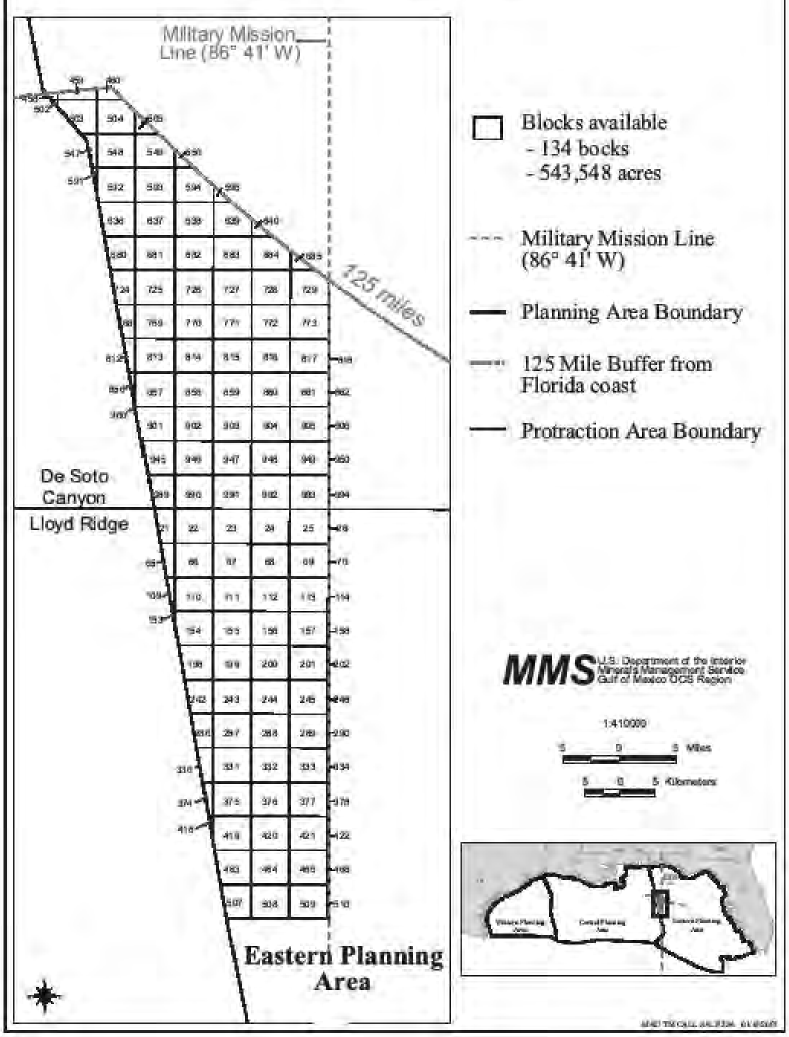
thence northwesterly along the SLA boundary as shown on OPD NH17-07 (Gainesville) dated 6/2/1983;

thence southwesterly and northwesterly along the SLA boundary as shown on OPD NH16-09 (Apalachicola) dated 6/2/1983;

thence northwesterly and southwesterly along the SLA boundary as shown on OPD NH16-05 (Pensacola) dated 1/1/2009 to the point of origin.

Exhibit 5

CALL FOR INFORMATION AND NOMINATIONS MAP
Eastern GOM Planning Area
Lease Sale 224 for 2008



IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF LOUISIANA

NATURAL RESOURCES DEFENSE COUNCIL INC., *et. al*, **Plaintiffs,** **v.** **S.M.R. JEWELL, Secretary of the Department of the Interior, *et. al*,** **Defendants,** **and** **AMERICAN PETROLEUM INSTITUTE, *et al.*,** **Intervenor-Defendants.**	**CIVIL ACTION NO. 2:10-cv-01882** **SECTION "A"** **JUDGE JAY C. ZAINEY** **MAGISTRATE JOSEPH C. WILKINSON**

STIPULATION TO AMEND SETTLEMENT AGREEMENT

Pursuant to paragraph XI.B of the Settlement Agreement ("Agreement") (ECF No. 118-2) approved by Order of the Court, dated June 25, 2013 (ECF No. 119), Plaintiffs (Natural Resources Defense Council, Center for Biological Diversity, Gulf Restoration Network, and Sierra Club), Federal Defendants (S.M.R. Jewell, Secretary of the Department of the Interior; the Bureau of Ocean Energy Management ("BOEM"); Abigail Ross Hopper, Director, BOEM; and their successors), and Intervenor-Defendants (American Petroleum Institute, International Association of Geophysical Contractors, Independent Petroleum Association of America, U.S. Oil and Gas Association, and Chevron U.S.A., Inc.), collectively the "Parties," by and through undersigned counsel, hereby stipulate to amend the Agreement as follows.

1. This Stipulation shall take effect when: (a) the Stipulation is executed by an authorized representative of each party; and (b) the Court enters an Order, substantively identical

to the proposed order attached as Exhibit 1, approving the Stipulation and extending the stay of proceedings in this matter in accordance with the terms of this Stipulation.

2. Except to the extent modified by this Stipulation, the definitions contained in Section I of the Agreement apply equally to this Stipulation. In addition, the terms of Section XI and Paragraphs XII.B-F and XII.I-K of the Agreement apply equally to this Stipulation.

3. The Stay described in Paragraph II.A of the Agreement is extended until September 25, 2017, or until Final Action occurs, whichever occurs first, except as provided in paragraphs II.D, II.E, and II.H of the Agreement. Federal Defendants shall make their best effort to facilitate completion of Final Action on BOEM's MMPA Application within the extended Stay period.

4. All terms of the Agreement shall remain operative during the extended Stay period, except to the extent those terms differ from the terms of this Stipulation, in which case the Stipulation controls. Except where noted, paragraphs 5 through 9 of this Stipulation do not apply to permits for Deep Penetration Seismic Surveys issued by BOEM prior to the effective date of this Stipulation.

5. Paragraph I.D of the Agreement is amended to provide as follows:

"Plaintiffs' Areas of Concern" refers to the following four areas:

(1) The Mississippi Canyon, defined as limited to the area bounded by the 200 meter isobath to the north, the 2000 meter isobath to the south, the 90 degree longitude line to the west, and the 88 degree longitude line to the east.

(2) The De Soto Canyon, defined as follows: (a) the area bounded by the 200 meter isobath to the north, the 28 degree latitude line to the south, the 2000 meter isobath to the west, and the 85 degree longitude line to the east; and (b) a 5 kilometer buffer

established around the portion of the area described in (a) falling within the Eastern Planning Area (defined in Exhibit 4 to the Agreement), except that the buffer shall not apply to the west of the boundary line between the Eastern and Central Planning Areas.

(3) Coastal waters shoreward of the 20 meter isobath, and a 5 kilometer buffer extending seaward from the 20 meter isobath.

(4) An area west of the Florida Keys and Tortugas, defined as follows: (a) the area bounded by the 200 meter isobath to the north, the 24 degree latitude line to the south, the 83 degree 30 minute longitude line to the west, and the 81 degree 30 minute longitude line to the east; and (b) a 5 kilometer buffer established around the area described in (a).

A map indicating these four areas (exclusive of buffers) is attached as Exhibit 1 to the Agreement; however, in the event of any conflict between the map and the boundaries defined in this paragraph, the defined boundaries control.

6. Paragraph V of the Agreement is amended to provide as follows:

After the effective date of the Stipulation and so long as the Stay is in effect, and without limiting (1) BOEM's discretion or authority to consider whatever additional measures not described in this section that BOEM may deem necessary or appropriate, or (2) Intervenor-Defendants' ability to challenge such additional measures, BOEM shall analyze in EAs specific to permitting decisions for individual Deep Penetration Seismic Surveys the mitigation measures described in subparagraphs A through G as conditions of approval of any permits for Deep Penetration Seismic Surveys. Federal Defendants' commitment to analyze the following mitigation measures in no way obligates Federal Defendants to require the measures in any resulting permit:

7. Paragraph V.A of the Agreement is amended to provide as follows:

With respect to Deep Penetration Seismic Surveys as defined herein, the permittee shall not: (a) between March 1 and April 30, operate any airguns or any airgun arrays within the area defined in Paragraph I.D(3); and (b) between January 1 and April 30, operate any airguns or any airgun arrays within the portion of the area defined in Paragraph I.D(3) falling within the boundaries of the Unusual Mortality Event in the Northern Gulf of Mexico, as defined by the National Oceanic and Atmospheric Administration, pursuant to section 404 of the Marine Mammal Protection Act, on December 13, 2010 (*i.e.*, the portion of the area defined in Paragraph I.D(3) falling between a line extending seaward from the Texas/Louisiana border to a line extending seaward from the eastern border of Franklin County, Florida). These seasonal limitations shall not apply to Deep Penetration Seismic Survey preparations, including but not limited to the laying of receiver cables, that do not involve the use of airguns or airgun arrays, or sub-bottom profilers (such as in archeological resources surveys that may be required precedent to some Deep Penetration Seismic Surveys). BOEM shall extend the term of any permit affected by the seasonal limitations by a period of time equal to the time period the permit is affected by the seasonal limitations, but shall not extend the term of any affected permit because of the seasonal limitations for a period of time longer than four months.

8. The following new subparagraph G is added to Paragraph V of the Agreement:

G. Incentives for the use of Noise Reduction Technology

For any permittee that proposes and employs Noise Reduction Technology ("NRT") for reducing or attenuating the sound produced by seismic arrays while conducting Deep Penetration Seismic Surveys, BOEM shall: (a) waive permitting fees; (b) exempt the permittee from the requirements of Paragraphs V.C and V.F; and (c) reduce the buffers referenced in Paragraph I.D.

from 5 kilometers to 1 kilometer. For purposes of this provision, what constitutes NRT shall lie within BOEM's sole discretion. BOEM will notify all other parties of any applications received or permitted pursuant to this provision during the parties' regular status conferences, described at Paragraph XII.A.

9. Paragraph VI of the Agreement is amended to provide as follows:

So long as the Stay is in effect, and consistent with the exemptions and other terms specified in Section V.G for permittees employing NRT, Intervenor-Defendants shall abide by all of the applicable mitigation measures described in Section V.A-F when conducting any Deep Penetration Seismic Surveys pursuant to a permit issued by BOEM during the Stay and after the effective date of the Stipulation, even if the applicable mitigation measures described in Section V.A-F are not included as conditions of the permit itself. When conducting any Deep Penetration Seismic Surveys pursuant to a permit issued by BOEM during the Stay and prior to the effective date of the Stipulation, Intervenor-Defendants shall continue to comply with the terms of the Agreement as approved by the Court on June 24, 2013.

10. Paragraph XII.G of the Agreement is amended to substitute "$172,000" for both references to"$160,000."

11. The terms of this Stipulation have been agreed to for purposes of compromise. No party concedes by entering into this Stipulation that any of the permit requirements described above are warranted by scientific evidence or should be imposed after the Stay expires, or that these requirements are sufficient to achieve legal compliance or reduce biological risk over the long term.

Respectfully submitted this 8th day of February, 2016.

For Plaintiffs Natural Resources Defense Council, Center for Biological Diversity, Gulf Restoration Network, and Sierra Club:

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For Federal Defendants S.M.R. Jewell, Secretary of the Department of the Interior; the Bureau of Ocean Energy Management ("BOEM"); and Tommy Beaudreau, Director, BOEM:

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Assistant Attorney General

/s/ Kevin W. McArdle
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Exhibit 1

IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF LOUISIANA

NATURAL RESOURCES DEFENSE COUNCIL INC., *et al.*,	)	
Plaintiffs,	)	
v.	)	**CIVIL ACTION NO. 2:10-cv-01882**
S.M.R. JEWELL, Secretary of the Department of the Interior, *et al.*,,	)	**SECTION "A"**
Defendants.	)	**JUDGE JAY C. ZAINEY**
and	)	**MAGISTRATE JOSEPH C. WILKINSON**
AMERICAN PETROLEUM INSTITUTE, *et al.*,	)	
Intervenor-Defendants.	)	

ORDER APPROVING STIPULATION TO AMEND SETTLEMENT AGREEMENT

This matter is before the Court on the parties' Joint Motion for Approval of Stipulation to Amend Settlement Agreement ("Stipulation").

For good cause shown, it is hereby ORDERED that the parties' Joint Motion is GRANTED. It is further ORDERED that the Stipulation is APPROVED and ADOPTED, and that the stay of all proceedings in this matter is extended in accordance with the terms of the Stipulation.

Dated: __________________, 2016

____
Judge of the United States District Court

APPENDIX D

ACOUSTIC PROPAGATION AND MARINE MAMMAL EXPOSURE MODELING

ACOUSTIC PROPAGATION AND MARINE MAMMAL EXPOSURE MODELING OF GEOLOGICAL AND GEOPHYSICAL SOURCES IN THE GULF OF MEXICO

2016–2025 Annual Acoustic Exposure Estimates for Marine Mammals

Submitted to:

Kimberly Skrupky Warshaw
Bureau of Ocean Energy Management (BOEM)

Authors:
David Zeddies
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6 Nov 2015
P001253-001
Document 00976
Version 3.0

Statement of Disclaimer

This draft report was reviewed by the BOEM. Approval does not signify that the contents necessarily reflect the views and policies of the Bureau, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Acknowledgement of Sponsorship

Study concept, oversight, and funding were provided by the US Department of the Interior, Bureau of Ocean Energy Management, Environmental Studies Program, Washington, DC under Contract Number M14PC00004.

Suggested citation:

Zeddies, D.G., M. Zykov, H. Yurk, T. Deveau, L. Bailey, I. Gaboury, R. Racca, D. Hannay, and S. Carr. 2015. *Acoustic Propagation and Marine Mammal Exposure Modeling of Geological and Geophysical Sources in the Gulf of Mexico: 2016–2025 Annual Acoustic Exposure Estimates for Marine Mammals*. JASCO Document 00976, Version 3.0. Technical report by JASCO Applied Sciences for Bureau of Ocean Energy Management (BOEM).

Contents

Figures

Tables

1. Executive Summary

1.1. Overview

This report provides estimates of the annual marine mammal acoustic exposure caused by sounds from geological and geophysical exploration activity in the Gulf of Mexico for years 2016 to 2025. Exposure estimates were computed from modeled sound levels as received by simulated animals (animats) in the area for several exploration survey types performed at multiple locations. Because animals and noise sources move relative to the environment and each other, and the sound fields generated by the sound sources are shaped by various physical parameters, the sound levels received by an animal are a complex function of location and time. We used acoustic modeling to compute three-dimensional (3-D) sound fields that varied with time, and we simulated realistic movements of animats within these fields to sample the sound levels in a manner representing how real animals would experience this sound. From the time history of the received sound levels, the number of animats exposed to levels exceeding threshold criteria were determined and then adjusted by the number of animals in the area to estimate the potential number of animals impacted.

The project was divided into two phases. In Phase I, a typical wide azimuth geophysical survey using an airgun array source was simulated at two locations within the Mississippi Canyon. This was done to establish the basic methodological approach and to evaluate the sensitivities of results to uncertainties in input parameters. Results from the Test Scenarios were then used to guide the main modeling effort of Phase II. In Phase II, we divided the Gulf into seven modeling zones and simulated six survey types within each zone to estimate the potential effects of each survey. The results from each zone were summed to provide Gulf-wide estimates of effects on each marine mammal species for each survey type for each year based on specific assumed levels of survey activities.

1.2. Sounds and Marine Mammals

The Marine Mammal Protection Act defines harassment as activities that can potentially injure marine mammals or disrupt their behavioral patterns (MMPA 2007); loud sounds produced by geophysical survey equipment are possible sources of such harassment. National Marine Fisheries Service (NMFS) adopted threshold criteria thought to represent cautionary lower limits for pulsed sound levels that could injure marine mammals or disrupt their activities. The thresholds for cetaceans exposed to impulsive noise were set at 180 dB re 1 µPa rms sound pressure level (rms SPL) for potential injury (Level A harassment) and 160 dB re 1 µPa rms SPL for potential behavioral disruption (Level B harassment; NFMS 1995, NMFS 2000). Animals exceeding these thresholds were considered exposed at their respective harassment level. As further knowledge on injury from sound became available, an expert group reviewed the available evidence and published suggestions for marine mammal sound exposure criteria (Southall et al. 2007). The present study has considered, in the exposure estimates, the NMFS criteria and adaptations of the Southall et al. (2007) criteria based on additional studies.

Injury to marine mammals' anatomical, morphological, and physiological hearing structures (hereafter called hearing structures) can be caused by the fatiguing effect of accumulated sound energy. This energy, measured in terms of the sound exposure level (SEL) [1], depends on the position of the animal in the sound

[1] Sound Exposure Level (SEL) is numerically proportional to acoustic energy flux density only when the acoustic impedance is constant and purely resistive. That is not the case when surface or seabed reflections are present or in refractive environments. SEL is not expressed in energy density units.

field. It changes as the animal and the sound source move, and continues to accumulate as long as the animal is exposed to the sound. Because intense sounds of short duration can also damage an animal's hearing structures, an additional metric of peak sound pressure level (peak SPL) is also used to assess acoustic exposure risk. The exposure duration is not a factor in determining potential injury due to peak SPL; only the proximity of an animal to a source is relevant for estimating this metric.

Defining sound levels that disrupt behavioral patterns is difficult because responses depend on the context in which the animal receives the sound. The environmental context and responses depend on many factors, including an animal's behavioral mode when it hears sounds (e.g., feeding, resting, or migrating), and on biological factors (e.g., age and sex). Available data are consistent with the notion that louder sounds evoke greater responses, but the levels at which responses occur are not necessarily consistent. To predict the probability of behavioral response, we used a step function based on the received rms SPL. Some species, beaked whales in particular, are known to be more behaviorally sensitive to sounds than other species, so the function was adjusted as warranted for such species. To evaluate the potential for behavioral disruption, the maximum sound pressure level each simulated animal received was identified and the step function used to determine the number of simulated animals with the potential to respond.

In developing the exposure effects criteria, a 24 h reset period was chosen. A 24 h reset period is commonly used and means that acoustic energy accumulation and the maximum values of the other metrics were reset after 24 h. Individual animats were eligible to be re-exposed in subsequent 24 h periods.

The NMFS exposure criteria for injury (180 dB re 1 μPa rms SPL) and behavioral disruption (160 dB re 1 μPa rms SPL) uses unfiltered (unweighted) sound fields when determining the number of animals exposed to levels exceeding threshold. The Southall et al. (2007) criteria attempt to account for the hearing ability of the animals. Southall et al. (2007) propose weighting functions for species groups based on their hearing range. These M-weighting filters, based on known and assumed species hearing ranges (audiograms) divide the cetaceans into three hearing groups low-, mid-, and high- frequency specialists (Southall et al. 2007) . Later, Finneran and Jenkins (2012) developed a weighting function based on perceptual measure of subjective loudness. Equal-loudness contours better match the onset of hearing impairment (temporary threshold shift) than the original M-weighting functions. Data for the equal-loudness contours do not, however, cover the full frequency range of the M-weighting filters. Finneran and Jenkins (2012) propose a hybrid filter based on the equal-loudness contours in their measured frequency band and, outside of this range, the original M-weighting function was discounted to match the end points of the equal-loudness functions. Finneran and Jenkins (2012) term the hybrid filters Type II M-weighting to distinguish them from the original M-weighting, which they term Type I M-weighting.

Because Type II filtering was designed to better-predict the onset of injury, it is used in the current report to evaluate exposure for potential injury when using the SEL metric for mid- and high-frequency species. For low-frequency species, Type I filtering is used. No filtering is used when evaluating potential injury with the peak SPL metric. Although the Type II filtering is based on perceptual measures and, therefore, could be an appropriate indicator of behavioral response, as a conservative measure, Type I filtering is used to evaluate potential behavioral disruption using rms SPL criteria with a step function. The current report uses the step function from Wood et al. (2012), which sets out a graded step of increasing probability of behavioral response with increasing received level. Additionally, following Wood et al. (2012), the step function is modified for behaviorally sensitive species (beaked whales).

1.3. Acoustic Modeling

Acoustic source emission levels of a single airgun and an airgun array are calculated using the Airgun Array Source Model (AASM; JASCO Applied Sciences). Source levels of high-resolution survey sources are obtained from manufacturer's specifications for representative sources. Acoustic transmission loss as a function of range from each source is calculated using the Marine Operations Noise Model (MONM; JASCO Applied Sciences) for multiple propagation radials centered at the source to yield 3-D transmission loss fields in the surrounding area. The primary seasonal influence on transmission loss is the presence of a sound channel, or duct, near the surface in winter. To account for seasonal variability in propagation, winter (most conservative) and summer (least conservative) were modeled. The modeled sound fields were also filtered for the hearing ability of the animals as described above.

To account for both the geospatial dependence of acoustic fields and the geographic variations of animal distributions, the project area of the Gulf was divided into seven zones. The selected zone boundaries, patterned to conform to BOEM's planning areas where possible, also considered sound propagation conditions and species distribution to create regions of optimized uniformity in both acoustic environment and animal density. This approach allows the calculation of generalized sound exposure estimates for each species for a representative survey type, season, and zone in which the survey occurs. Modeling was performed for each of the six different acoustic survey types that are assessed in this study: 2-D, 3-D narrow azimuth (NAZ), 3-D wide-azimuth (WAZ), Coil, Shallow Hazard (using a single airgun or boomer), and high resolution surveys (using side-scan sonar, sub-bottom profiler, and multibeam echosounder). The 2-D, 3-D NAZ, 3-D WAZ, and Coil represent large seismic exploration surveys using 8000 in^3 towed airgun array(s) as the sound source(s).

1.4. Marine Mammals in the Gulf of Mexico

Twenty-one cetacean species have been sighted in surveys since 1991 (Waring et al. 2013). Eighteen are mid-frequency hearing specialists—Atlantic spotted dolphins (*Stenella frontalis*), beaked whales spp. (Cuvier's (*Ziphius cavirostris*), Blainville's (*Mesoplodon densirostris*), Gervais' (*Mesoplodon europaeus*)), common bottlenose dolphins (*Tursiops truncatus*), clymene dolphins (*Stenella clymene*), false killer whales (*Pseudorca crassidens*), Fraser's dolphins (*Lagenodelphis hosei*), killer whales (*Orcinus orca*), melon-headed whales (*Peponocephala electra*), pantropical spotted dolphins (*Stenella attenuata*), pygmy killer whales (*Feresa attenuata*), Risso's dolphins (*Grampus griseus*), rough-toothed dolphins (*Steno bredanesis*), short-finned pilot whales (*Globicephala melas*), sperm whales (*Physeter macrocephalus*), spinner dolphins (*Stenella longirostris*), and striped dolphins (*Stenella coeruleoalba*). Bryde's whales (*Balaenoptera brydei/edeni*) are the only low-frequency species, and dwarf and pygmy sperm whales (*Kogia sima, Kogia breviceps*) comprise the only high-frequency hearing specialist group.

In Phase I, the Navy's U.S. Navy OPAREA Density Estimate (NODE; DoN 2007) model was used to obtain animal density estimates (animals/km^2). In Phase II, more current density estimates were obtained from the Marine Geospatial Ecology Laboratory at Duke University preliminary results (Roberts et al., in preparation). In part, distribution information was used to inform boundary choices when establishing modeling zones. Density information was obtained for each of the zones and used when determining exposure estimates.

1.5. Animal Movement Modeling

This analysis uses the Marine Mammal Movement and Behavior (3MB) model developed by Houser (2006). Parameter values to control animat movement are determined using behavioral observations of the species members and reviewing behavior reported by tagging studies. The amount and quality of data varies by species, but often provides a detailed description of the proximate behavior expected for real individual animals. Because there are few or no data available for some species included in this study, surrogate species with more available information are used: Pantropical spotted dolphins are used as a surrogate for Clymene, spinner, and striped dolphins; short-finned pilot whales are surrogates for Fraser's dolphins, the *Kogia* species, and melon-headed whales; and rough-toothed dolphins are surrogates for false killer whales and pygmy killer whales. Observational data for all remaining species in the study were sufficient to determine animat movement. The use of surrogate species is a reasonable assumption for the simulation of proximate or observable behavior, and it is unlikely that this choice adds more uncertainty about location preference.

1.6. Phase I

A Test Case simulating a typical WAZ survey at two locations was performed as a demonstration of the basic modeling approach and as an investigation tool to establish methods used in the full modeling approach of Phase II. Test Scenarios were undertaken using, primarily, the results of the Test Case to investigate the effects of methodological choices on exposure estimates. Surveys vary in duration and some can be months long. In Test Scenario 1, a method for scaling up simulation results to account for long-duration surveys was suggested. In Test Scenario 2, sources of uncertainty and their effects on exposures estimates were investigated. In general, the finding of Test Scenario 2 was that uncertainty affects the distribution of the number of animals projected to exceed threshold levels, but the mean number remains the same. Test Scenario 3 found that mitigation procedures involving shut-downs for animals observed within an exclusion zone may reduce the number of animals exposed, but the effectiveness depends on the probability of detecting animals near the source. Detection probability varies with species and weather. Similarly, in Test Scenario 4, it was shown that animals avoiding high sound levels (aversion) potentially reduces the number of animals exposed to levels exceeding a threshold, but there is little information available upon which to define such behavior. Mitigation and aversion were not suggested for use in the Phase II modeling. Test Scenarios 5 and 6 investigated the effects of overlapping surveys and the impact of simultaneous firing. In neither case were these occurrences found to have a practical impact on exposure estimates. In other words, the exposure estimates from closely-spaced surveys analyzed separately and summed were as high as or higher than if the two surveys were evaluated as a single, combined survey.

1.7. Phase II: Annual Acoustic Exposure Estimates

The top-level results of the Phase II analysis are estimates of the number of exposures for each species and each year from 2016 to 2025 for the entire Gulf of Mexico. To get these annual aggregate exposure estimates, 24 h average exposure estimates from each survey type were scaled by the number of expected survey days from BOEM's regulatory planning projections. Because these projections are not season-specific, surveys are assumed to be equally likely to occur at any time of the year and at any location within a given zone. The exposure estimates from the zones are summed to provide an annual exposure estimate for each species for the entire Gulf.

2. Project Overview

The overall goal of this project is to estimate the yearly acoustic exposures received by marine mammals due to geological and geophysical survey activities in the Gulf of Mexico for the coming decade. This information will be used in developing a Programmatic Environmental Impact Statement, pursuant to the Marine Mammal Protection Act petition for rule making and the consultation under Section 7 of the Endangered Species Act. Six different seismic survey types will be assessed: 2-D, 3-D narrow azimuth (NAZ), 3-D wide azimuth (WAZ), Coil, Shallow Hazard (using single airgun or boomer), and high resolution (using side-scan sonar, sub-bottom profiler, and multibeam echosounder). The exact number, type, and location of future surveys are not known, but yearly level-of-effort projections are available.

The project was divided into two phases. In Phase I, a typical WAZ survey was simulated at two locations. This was done to establish the basic methodological approach and the results used to evaluate scenarios that may influence exposure estimates. Results from the Test Scenarios were then used to guide the main modeling effort of Phase II. In Phase II, we divided the Gulf into modeling zones and simulated each survey type in each zone to estimate the potential effects of each survey. The results from each zone were summed to provide Gulf-wide estimates of effects on each marine mammal species for each survey type for each year.

A modeling workshop was held in January 2014 (in Silver Spring, MD) as a collaborative effort between the American Petroleum Institute (API) and the International Association of Geophysical Contractors (IAGC), the National Marine Fisheries Service (NMFS), and Bureau of Ocean Energy Management (BOEM). The objectives of the workshop were to identify 1) gaps in modeling sound fields from airgun arrays and other active acoustic sources, including data requirements and performance in various contexts, 2) gaps in approaches to integration of modeled sound fields with biological data to estimate marine mammal exposures, and 3) assumptions and uncertainties in approaches and resultant effects on exposure estimates. This workshop aided BOEM and NOAA’s development of the Request for Proposals, Statement of Work, and by extension the methodologies undertaken in this modeling project.

3. Introduction

3.1. The Ocean Soundscape

Human-generated (anthropogenic) contributions to the ocean's soundscape have steadily increased in the past several decades largely driven by a worldwide increase in oil and gas exploration and in shipping (Hildebrand 2009). Some anthropogenic sources, such as vessel noise, are a chronic contribution to local and global soundscapes. Other anthropogenic sources affect marine life on a more restricted temporal and spatial scale, but often produce high sound energies and may pose immediate health risks to marine wildlife. Many anthropogenic sounds are produced intentionally as part of active data gathering effort using sonar, depth sounding, and seismic surveys. When seismic surveys expanded into deep water, their sound footprints increased markedly and these signals are detectable across ocean basins (Nieukirk et al. 2004).

3.1.1. Seismic Sources

3.1.1.1. Airguns

Seismic airguns generate pulsed acoustic energy by releasing into the water highly compressed air, which forms air bubbles that undergo a damped volume oscillation and emit an acoustic pressure wave that follows the bubble's oscillating internal pressure. Seismic airguns produce sounds primarily at frequencies from a few hertz to a few kilohertz, but also produce lower level sounds at higher frequencies. Larger airguns, with larger internal air volume, produce higher broadband sound levels with sound energy spectrum shifted toward the lower frequencies. Single airguns or multiple airguns arranged in a spatial pattern (referred to as an airgun array) are typically towed by a survey vessel, with shots or impulses typically generated every 5 to 30 s along survey track lines.

A single airgun produces an approximately omnidirectional sound field—the acoustic energy is initially emitted equally in all directions. The sound signal that reflects from the water's surface, however, interacts with sounds that travel directly from the airgun. The result of this interaction is that, on average, more sound energy is focused downwardly than horizontally, an effect that is more prominent for lower frequencies. Larger 2-D and 3-D seismic surveys usually use multiple airguns arranged in arrays; this configuration emits higher overall sound levels, specifically more highly downward directed. The arrays are configured with most of the airguns in a horizontal plane. This configuration, combined with the effect of the surface reflection, focuses more sound energy downwardly, while emitting lower levels of sound horizontally. Airgun arrays generally show significant horizontal directionality patterns due to the phase delay between pulses from horizontally separated lines of airguns.

3.1.2. High-resolution Sources

3.1.2.1. Side-scan Sonar Systems

Side-scan sonar systems produce shaded relief images of the ocean bottom by recording the intensity and timing of signals reflected off the seafloor. Side-scan sonars consist of two transducers on the sides of the sonar body that are oriented orthogonally to the towing direction. The projected acoustic beams are usually wide in the vertical plane (50°−70°) and very narrow in the horizontal plane (less than a few degrees). The declination of the beam axis is small: 10°−20° below the horizon. Side-scan sonars can be mounted on a survey vessel, towed behind it, or be part of a survey complex installed on an autonomous underwater vehicle (AUV).

3.1.2.2. Multibeam Echosounders Sonar Systems

Multibeam echosounder sonar systems use an array of transducers that project a fan-shaped beam under the hull of a survey ship and orthogonal to the direction of motion. The system measures the time for the acoustic signal to travel to the ocean floor and back to the receiver. The multibeam echosounder produces a swath of depth measurements to ensure full coverage of an area. The coverage area on the seafloor is typically two to four times the water depth. Many multibeam echosounder systems can record acoustic backscatter data. Multibeam backscatter is intensity data that, when processed, creates a low-resolution image which often helps interpret and post-process the bathymetric data. Instead of deploying the multibeam echosounder under the hull of the survey ship, it can alternatively be deployed on an AUV.

3.1.2.3. Sub-bottom Profiler Sonar Systems

Sub-bottom profiler sonar systems are used to generate vertical cross-section plots of the layers of sediment under the ocean floor. To make measurements, the sub-bottom profiler is towed behind a survey vessel or deployed on an AUV. The towed body of the sub-bottom profiles system contains the acoustic source and receiver elements. The source transducer projects a chirp pulse that spans an operator-selectable frequency band. The lower and upper limits of the sonar's frequency band are usually between ~ 1 to 20 kHz. The system projects a single beam directed vertically down. The projected beamwidth depends on the operating frequency, but is approximately 10°−30°.

3.1.2.4. Boomer Sources

Some sub-bottom profiler systems use a boomer source, which consists of an insulated metal plate paired with an adjacent electromagnetic Coil. A powerful electrical discharge pulse generated by a shipboard power supply and capacitor bank is applied to the Coil, generating an abrupt and strong magnetic field that repels the metal plate. The resulting mechanical impulse generates a high-amplitude broadband acoustic pulse in the water, with high downward directivity (Verbeek and McGee 1995). The boomer source functions as a circular piston surrounded by a rigid baffle; it is not a point-like source (Verbeek and McGee 1995) because the beam pattern of a boomer plate shows some directivity for frequencies above 1 kHz, where acoustic wavelength is on the same order of magnitude as the baffle size.

3.1.3. Pulsed Versus Non-Pulsed Sounds

Anthropogenic sounds can affect marine life in a variety of ways. Numerous scientific reviews and workshops over the past 40 years have investigated these effects (Payne and Webb 1971, Fletcher and Busnel 1978, Richardson et al. 1995, MMC 2007, Nowacek et al. 2007, Southall et al. 2007, Weilgart 2007, Tyack 2008). Anthropogenic sounds that could affect marine life are generally divided into two main categories when they are investigated—pulsed divided into single and multiple, and non-pulsed sounds (Southall et al. 2007). Pulsed or impulsive sounds include pile driving and airgun shots as well as some sonar; non-pulsed, continuous-types of sounds include certain sonar and vessel propulsion sounds and machinery sounds. Numerous definitions and mathematical distinctions distinguish pulsed from non-pulsed sounds (Burdic 2003). Southall et al. (2007) adopted a measurement-based distinction originally proposed by Harris (1998) that if measurements between the continuous and impulse sound level meter settings differ by ≥ 3 dB, a sound is pulsed, whereas if the difference is < 3 dB the sound is non-pulsed. The distinction between these two sound types, however, is not always obvious. Certain signals, for example those from acoustic deterrent or harassment devices, share properties of both pulsed and non-pulsed sounds. A signal near a source could be categorized as a pulse, but due to propagation effects as it moves farther from the source, it could be categorized as non-pulsed (e.g., Greene and Richardson 1988).

3.2. Acoustic Metrics

Underwater sound pressure amplitude is commonly measured in decibels (dB) relative to a fixed reference pressure of p_o = 1 μPa. Because the loudness and other exposureeffects of impulsive (pulsed) noise, e.g., shots from seismic airguns, are not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate impulsive sound effects on marine life.

The zero-to-peak sound pressure level (SPL), or peak SPL (L_{pk}, dB re 1 μPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an impulse, $p(t)$:

$$L_{\mathrm{pk}} = 10\log_{10}\left[\frac{\max\left(\left|p^2(t)\right|\right)}{p_{\mathrm{o}}^2}\right] \tag{1}$$

The peak-to-peak SPL ($L_{pk\text{-}pk}$, dB re 1 μPa) is the difference between the maximum and minimum instantaneous sound pressure level in a stated frequency band attained by an impulse, $p(t)$:

$$L_{\mathrm{pk-pk}} = 10\log_{10}\left\{\frac{\left[\max\left(p(t)\right) - \min\left(p(t)\right)\right]^2}{p_{\mathrm{o}}^2}\right\} \tag{2}$$

The root-mean square (rms) SPL (L_p, dB re 1 μPa) is the rms pressure level in a stated frequency band over a time window (T, s) containing the pulse:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_{\mathrm{o}}^2\right) \tag{3}$$

The rms SPL can be thought of as a measure related to the average sound intensity or as the effective pressure intensity over the duration of an acoustic event, such as the emission of one acoustic pulse. Because the time window length, T, is a divisor, pulses having the same total acoustic energy, but more spread out in time, will have a lower rms SPL. The value of T for the purpose of the rms SPL calculation can be selected using different approaches. According to one, T is defined as the 90% energy pulse duration, containing the central 90% (from 5% to 95% of the total) of the cumulative square pressure (or sound exposure level) of the pulse, rather than over a fixed time window (Malme et al. 1986, Greene 1997, McCauley et al. 1998). The 90% rms SPL (L_{p90}, dB re 1 μPa) in a stated frequency band is calculated over this 90% energy time window, T_{90}:

$$L_{p90} = 10\log_{10}\left(\frac{1}{T_{90}}\int_{T_{90}} p^2(t)dt \Big/ p_{\mathrm{o}}^2\right) \tag{4}$$

The other approach for rms SPL calculation of a pulse is to use fixed time window. In this case, a sliding window was used to calculate rms SPL values for a series of fixed window lengths within the pulse. The maximum value of rms SPL over all time window positions is taken to represent the rms SPL of the pulse.

The sound exposure level (SEL) (L_E, dB re 1 µPa^2·s) is the time integral of the squared pressure in a stated frequency band over a stated time interval or event. The per-pulse SEL is calculated over the time window containing the entire pulse (i.e., 100% of the acoustic energy), T_{100}:

$$L_E = 10\log_{10}\left(\int_{T_{100}} p^2(t)dt \Big/ T_o p_o^2 \right) \tag{5}$$

where T_o is a reference time interval of 1 s by convention. The per-pulse SEL, with units of dB re 1 µPa·√s, or equivalently dB re 1 µPa^2·s, is related, at least numerically, to the total acoustic energy flux density delivered over the duration of the acoustic event at a receiver location. SEL, unlike energy flux density, neglects the acoustic impedance of the medium (here water), which depends on density and sound speed and also on proximity to reflective surfaces and position within refractive environments. SEL is a measure of sound exposure through time rather than just sound pressure.

SEL is a cumulative metric; it can be accumulated over a single pulse, or calculated over periods containing multiple pulses. To accumulate multiple pulse cumulative SEL (L_{Ec}), the single pulse SELs are summed. If there are N such pulses having individual SELs of (L_{Ei}), then:

$$L_{Ec} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{Ei}}{10}} \right) \tag{6}$$

The SEL is related to the total acoustic energy flux density delivered over the duration of the set period of time, i.e., 24 h. It is a representation of the accumulated SEL delivered by multiple acoustic events, e.g., multiple pulses of a single acoustic source.

Because the rms SPL and SEL of a single pulse are computed from the same time integral of square pressure, these metrics are related numerically by a simple expression, which depends only on the duration of the 90% energy time window T_{90}:

$$L_E = L_{p90} + 10\log_{10}(T_{90}) + 0.458 \tag{7}$$

where the factor of 0.458 dB accounts for the missing 10% of SEL due to consideration of just 90% of the cumulative square pressure in the L_{p90} calculation. It is important to note that the decibel reference units of L_E and L_{p90} are not the same, so this expression must be interpreted only in a numerical sense. No similar relationship exists when SPL is calculated using fixed time windows shorter than the full pulse duration, T_{100}; however, if the window length T is equal to or greater than T_{100} then the relationship is simply:

$$L_E = L_p + 10\log_{10}(T) \tag{8}$$

3.3. Use of Sounds by Marine Species

Sounds tend to travel farther than light in water. Many marine species use underwater acoustic signals as their principal mode of information transfer. Cetaceans (whales, dolphins, and porpoises) and sirenians (manatees and dugongs) use sounds passively, when listening to the environment, and actively, when communicating or foraging. Cetaceans in particular are heavily dependent on sounds for communicating, avoiding predators, foraging, and likely for navigating. Anthropogenic sounds in the ocean might interfere with basic life functions of marine species, especially marine mammals.

3.3.1. Cetacean Hearing

Marine mammals have broader hearing frequency ranges than terrestrial mammals, an indication of how important sounds are to them. Because marine mammals evolved from terrestrial mammals, their basic hearing anatomy and physiology resembles that of their terrestrial ancestors. Divergence between terrestrial and marine mammals is primarily apparent in their outer ear structures—absent in cetacean species—and in the middle ear—modified in marine mammals (Mooney et al. 2012).

The majority of detailed data on hearing ranges come from a subset of trained small cetaceans housed in captive settings who are amenable to training (see Southall et al. 2007 for review). Direct hearing data are not available for most of the cetacean species, particularly larger whales, but biophysical procedures and mathematical models have been developed to try to derive audiograms (e.g. Tubelli et al. 2012, Cranford and Krysl 2015) for many mysticete species. In addition, measurements of auditory evoked potentials (AEP) to determine hearing ranges have been successful when applied to some stranded animals (reviewed by Mooney et al. 2012).

3.3.1.1. Classification of Cetacean Hearing

Southall et al. (2007) categorized cetaceans into three functional hearing groups: low-, mid-, and high-frequency cetaceans (Table 1). These groups were defined based on similarities in their known or assumed hearing capabilities rather than their taxonomy.

All low-frequency hearing specialists among cetaceans are mysticetes (baleen whales), which consist of seven species in five genera. Wartzok and Ketten (1999) found mysticetes to be most sensitive to sounds with frequencies in the tens of hertz to lower tens of kilohertz. Some findings, however, suggest that humpback whales (*Megaptera novaeangliae*) produce signals with harmonics extending above 24 kHz (Au et al. 2006). Computational models of the minke whale (*Balaenoptera acutorostrata*) middle ear predicted that their hearing frequency range is between 100 Hz and 30 kHz (Tubelli et al. 2012). Modeling based on computer tomography scans of a juvenile fin whale (*Balaenoptera physalus)* ear predicted their best hearing range is between 20 Hz and 20 kHz (Cranford and Krysl 2015). All of these findings suggest mysticete body size and hearing range are related, with larger whales being sensitive to very low frequencies (< 100 Hz) and smaller mysticetes hearing higher frequencies (> 20 kHz) better than their larger counterparts. From a functional perspective, all cetaceans should be able to hear the important frequencies in signals they produce and to hear predators well. For most cetaceans, including all mysticetes, killer whales are their primary predator. Killer whales produce broadband signals (calls and clicks) with a large portion of signal energy between 1 and 25 kHz. This frequency range is detectable by all cetaceans including low frequency specialists.

Mid- and high-frequency cetaceans are all odontocetes (toothed whales) who have a broad (150 Hz to 180 kHz) functional hearing frequency range. They use echolocation (biosonar) at intermediate to high frequencies (tens of hertz to tens of kilohertz), and produce social sounds in the lower frequency range (one kHz to tens of kHz).

Mid-frequency cetacean adults have a large range in size. This group includes dolphins, larger toothed whales, such as sperm whales, and beaked whales and bottlenose whales (*Hyperoodon ampullatus*; Southall et al. 2007). Mid-frequency cetaceans are estimated to have lower and upper frequency limits of nominal hearing at approximately 150 Hz and 160 kHz, respectively (Table 1).

High-frequency cetaceans are typically characterized by a smaller body size and include, notably, porpoises, but also dwarf and pygmy sperm whales (*Kogia* sp.; Southall et al. 2007). High-frequency cetaceans produce echolocation clicks in a wide range of frequencies, which correspond well with the estimated lower and upper frequency limits of nominal hearing at approximately 200 Hz and 180 kHz, respectively (Table 1).

Table 1. Marine mammal functional hearing groups, auditory bandwidth (estimated lower to upper frequency hearing cut-off), and genera represented in each group. Modified from Southall et al. (2007).

Functional hearing group	Estimated auditory bandwidth	Genera represented in the Gulf of Mexico	Number of species/subspecies
Low-frequency cetaceans	7 Hz to 22 kHz	*Balaenoptera*	1
Mid-frequency cetaceans	150 Hz to 160 kHz	*Steno, Tursiops, Stenella, Lagenodelphis, Grampus, Peponocephala, Feresa, Pseudorca, Orcinus, Globicephala, Physeter, Ziphius, Mesoplodon*	18
High-frequency cetaceans	200 Hz to 180 kHz	*Kogia*	2

3.4. Potential Effects of Sounds on Marine Mammals

The sounds that marine mammals hear and generate vary in characteristics such as dominant frequency, bandwidth, energy, temporal pattern, and directivity. The environment often contains multiple co-occurring sounds and, like all animals, marine mammals must be able to discriminate signals (meaningful sounds) from background sounds. Just as terrestrial animals integrate multiple stimuli from their visual landscape, marine mammals tend to discriminate among multiple stimuli in their acoustic seascape.

Responses of marine mammals exposed to underwater anthropogenic sounds are variable and range from no effect to injury. The magnitude of the effect appears to depend on a combination of various factors, such as spatial relationships between a sound source and the animal, hearing sensitivity of the animal, received sound exposure, duration of exposure, duty cycle, and ambient sound level. Among other ecological factors, the animal's activity at time of exposure and its history of exposure and familiarity with the noise signal are important influences.

The potential effects of sounds on individual marine mammals can be broadly categorized as follows (based on Richardson et al. 1995, Southall et al. 2007):

- Trauma and death
- Temporary and permanent hearing loss
- Non-auditory health effects
- Self-stranding
- Auditory signal masking
- Behavioral disturbance
- Reduced availability of prey

All of these effects can lead to potential removal of individuals and subsequent population consequences. Sections 3.4.1–3.4.5 briefly discuss several of these effects.

3.4.1. Auditory Signal Masking

Auditory signal masking is the reduction in an animal's ability to perceive, recognize or decode biologically relevant sounds because of interfering sounds. Masking may lead to altered communications and, potentially, increased metabolic costs (for example, due to increased call amplitude and repetition). The amplitude, timing, and spectral content of the interfering sounds determine the amount of masking an animal experiences. Masking can decrease the range over which an animal communicates, detects predators, or finds food.

The study of masking in the ocean has traditionally focused on interactions between shipping sounds and mysticetes because these whales communicate using low-frequency calls in the same frequency bands as shipping sounds (Payne and Webb 1971). Over the past 50 years commercial shipping, the largest contributor of masking noise (McDonald et al. 2008), has increased the ambient sound levels in the deep ocean at low frequencies by 10–15 dB (Hatch and Wright 2007). Hatch et al. (2012) estimate that calling North Atlantic right whales (*Eubalaena glacialis*) might have lost, on average, 63–67% of their active acoustic or communication space due to shipping noise.

Sounds from seismic surveys contribute to ocean-wide masking (Hildebrand 2009). Impulse sounds produced during pile driving operations in particular in connection with wind farm installations have been found to mask the calls of marine mammals at great distances (Madsen et al. 2006). Gordon et al. (2003) listed a range of possible effects of seismic impulses on cetacean behavior and communication including masking of sounds used during foraging, such as echolocation.

Cumulative effects of seismic operations and other anthropogenic sound on marine mammals is poorly understood, but there is increasing concerns about masking by ship sounds at higher frequency ranges (e.g., up to 30 kHz; Arveson and Vendittis 2000); (up to 44.8 kHz; Aguilar Soto et al. 2006) at distances up to at least 700 m from the source (Aguilar Soto et al. 2006). Aguilar Soto et al. (2006) recorded a passing vessel on a Digital Acoustic Recording Tag (DTAG) attached to a Cuvier's beaked whale. This recording demonstrated that vessel sounds masked the whale's ultrasonic vocalizations and reduced its maximum communication range by 82% when ambient sound levels increased 15 dB in the vocalization frequencies. The study also determined that the effective detection distance of Cuvier's beaked whales' echolocation clicks was reduced by 58%. It is important to note, however, that these calculations are based on observed noise increases at high frequencies from a single passing vessel at close range, and that noise profiles from ships are highly variable, and high-frequency components attenuate more rapidly than do low frequencies (Hatch and Wright 2007). The reduction in communication space Cuvier's beaked whales would experience at greater distance from the source is much lower.

3.4.2. Behavioral Disturbance

The extent by which an animal's behavior changes in response to underwater sounds can vary greatly, even within the same species (Nowacek et al. 2004). The extent of an individual's response to a stimulus is influenced largely by the context in which the stimulus is received and the relevance that an individual attributes to the acoustic stimulus. The perceived relevance depends on a number of biological and environmental factors, such as age, sex, and behavioral state at the time of exposure (e.g., resting, foraging, or socializing), the origin of the sounds, and the proximity of the sound source. An immediate response to anthropogenic sounds is that animals temporarily avoid or move away from an ensonified area; however, they might also respond more conspicuously based on how close the sound sources are. For instance, their vigilance, defined as scanning for the source of the stimulus, could increase. The more time an animal invests in addressing noise means less time they can spend foraging (Purser and Radford 2011), but this is not always easy to detect.

Marine mammals have reduced their vocalization rates in response to anthropogenic sounds, sometimes not calling for weeks or months (IWC 2007). Some cetaceans might compensate for masking, to a limited degree, by increasing the amplitude of their calls (the Lombard effect, a known response of humans to noise) or by changing vocalization properties such as frequency content (Parks et al. 2010, Hotchkin and Parks 2013). As ambient noise levels increase, killer whales have been known to increase the amplitude of their calls (Holt et al. 2009). North Atlantic right whales produced calls with a higher average fundamental frequency and lowered their call rates in high noise conditions (Parks et al. 2007, Parks et al. 2009), whereas blue whales (*Balaenoptera musculus*) increased the frequency of their discrete, audible calls during a seismic survey (Di Iorio and Clark 2010) or when nearby ships made sounds (Melcon et al. 2012). A long signal or one that repeats could reduce an animal's ability to perceive biologically relevant sounds in a noisy environment. Whales seem most reactive at the onset of a sound and when the sound levels are increasing rapidly. All of these responses increase an animal's metabolic costs and, depending on the animal's metabolic state and the duration of its response, can negatively affect its health.

Although limited, some data suggest that stationary industrial activities that produce continuous sounds such as dredging, drilling, and oil-production-related activities, cause cetaceans to react less than sounds produced by moving sources, particularly ships. Some cetaceans might behaviorally habituate to reliably occurring continuous sounds (Richardson et al. 1995), a response that has also been observed in humans where some physiological habituation (lower endocrine stress responses) to prolonged noise exposure can occur. However, the act of responding could indirectly affect health through related physiological responses, such as cardiovascular stress responses (e.g., increased blood pressure; Christal and Whitehead 2001).

Stone and Tasker (2006) reported that airgun sounds elicited strong reactions—moving away from or avoiding an ensonified area—by small odontocetes. Mysticetes and killer whales responded by diverting paths and long-finned pilot whales changed their orientation. Controlled exposure experiments were conducted with eight tagged sperm whales over a series of 30-min intervals during pre-exposure, ramp-up, and full-array airgun firing (Miller et al. 2009). Results showed seven whales did not avoid airgun sounds. They did not change their buzz rates; however, oscillations in pitch were affected. Following the final airgun transmission, only one individual rested at the surface during the sound exposure and dove immediately thereafter. Miller et al. (2009) concluded that sperm whales in the highly exposed Gulf of Mexico habitat do not show any significant avoidance response to airguns, a lack of reaction that Rankin and Evans (1998) also noticed, but exhibited subtle effects on their foraging behavior.

Others suggested some mysticetes might change their habitat usage considerably after they are exposed to seismic sounds. During the first 72 h of a 10-day seismic survey, fin whales appeared to move away from the airgun array; this displacement persisted well beyond the 10 days of seismic airgun activity (Castellote et al. 2012). It was unknown, however, if the whales were avoiding the sound or following another cue such as a prey. McDonald et al. (1995) observed blue whales' responses to airgun firing. They stopped singing within a 10 km radius of the source, although this could have been a direct response to avoid their sounds being masked.

For reactions to pulsed sounds specifically, there is evidence that the behavioral state (traveling/migrating, foraging, resting, or socializing) of baleen whales exposed to seismic sounds (McCauley et al. 1998, Gordon et al. 2003), combined with their proximity to the airguns, affects how the whales react to the sounds. Several species of baleen whales showed avoidance behavior to sounds from seismic surveys (Richardson et al. 1995); bowhead whales (*Balaena mysticetus*) avoided distant seismic airguns at received levels of rms SPL of 120–130 dB re 1 µPa during their fall migration (Richardson et al. 1999). Feeding bowhead whales in the summer were more tolerant to airgun sounds avoiding airguns only when received levels reached 152–178 dB re 1 µPa, which is roughly 10,000 times louder than avoidance levels of the migrating whales (Richardson et al. 1995). Different sexes might also react differently when exposed to seismic signals. Resting female humpback whales avoided seismic surveys by diverting their travel paths to remain 7–12 km away, while males were occasionally attracted to the sounds (McCauley et al. 2000b).

For other pulsed sound sources, Brandt et al. (2011) and (Dähne et al. 2013) reported that harbor porpoises (*Phocoena phocoena*) were displaced from an area by pile driving noises, a repeating impulsive sound, while male humpback whales either moved out of a study area or sang less when exposed to frequency-modulated pulses that were 200 km away (Risch et al. 2012). Humpback whales also lengthened their mating songs when they were exposed to low-frequency active (LFA) sonar (Miller et al. 2000). Long-finned pilot whales whistled more in response to military mid-frequency sonar (Rendell and Gordon 1999). Castellote et al. (2012) noted that in response to shipping and airgun noise, fin whale calls were of shorter duration, lower frequency ranges, and lowered center and peak frequencies.

In their review of the effect of non-pulsed (continuous) sounds on cetaceans, Southall et al. (2007) reported that low-frequency cetaceans exhibited no or limited responses with received levels up to 120 dB re 1 µPa, but an increasing probability of avoidance (and other behavioral responses) beginning at received levels between 120 to 160 dB re 1 µPa. Reports of possible behavioral responses to non-pulsed sounds include harbor porpoises (high-frequency cetaceans) that generally swam away from approaching vessels (Polacheck and Thorpe 1990) or moved rapidly out of the way of an approaching survey vessel when the vessel was 1 km away (Barlow 1988). In both studies, however, it was unclear whether it was the approaching vessel or its sound that elicited the response, although reacting at 1 km suggests the animal was reacting to the sound.

Aguilar Soto et al. (2006) noted a Cuvier's beaked whale responding to ship sounds by decreasing the vocalizations they normally make when trying to catch prey. Blainville's beaked whales changed their foraging after they were exposed to vessel noise (Pirotta et al. 2012). Groups of Pacific humpback dolphins (*Sousa chinensis*) that contained mother-calf pairs increased their whistling rate after a boat had transited the area (Van Parijs and Corkeron 2001). The authors postulated that vessel sounds disrupted group cohesion, especially between mother-calf pairs, requiring the group to re-establish vocal contact after signal masking from boat noise. In responses to high levels of boat traffic, the duration (Foote et al. 2004) or the amplitude (Holt et al. 2009) of killer whale calls increased. Common bottlenose dolphins produced more whistles when boats approached (Buckstaff 2004).

3.4.3. Temporary and Permanent Hearing Loss

Physical impacts to an animal's auditory system can occur from exposure to intense sounds and can result in the animal losing hearing sensitivity. A temporary threshold shift (TTS) is hearing loss that persists only for minutes or hours, whereas a permanent threshold shift (PTS) is indefinite. The severity of TTS is expressed as the duration of hearing impairment (lowered sensitivity in the bandwidths in which the noise was centered) and the magnitude of the shift in hearing sensitivity relative to pre-exposure sensitivity. TTS generally occurs at lower sound levels than PTS. Repeated TTS, especially if the animal is receiving another loud sound exposure before recovering from the previous TTS, is thought to cause PTS (Lin et al. 2011). If the sound is intense enough, however, an animal can succumb to PTS without first experiencing TTS (Weilgart 2007). Though the relationship between the onset of TTS and the onset of PTS is not fully understood, TTS onset is used to predict sound levels that are likely to result in PTS.

Recent studies have modeled the potential impacts (TTS: Kremser et al. 2005; PTS: Lurton and DeRuiter 2011) of echosounders on marine mammals. The results from the studies suggest that TTS and PTS occur generally at distances of 100 m or less and most important, only apply in the cone ensonified by the modeled echosounders, meaning only animals below the ship are exposed to these levels. Animals at the same distances but to the sides of the vessel will be exposed to lower levels.

Experiments with captive common bottlenose dolphins have shown that loud, short (1 s) tonal sounds can cause TTS (Schlundt et al. 2000), as can lower sound level exposures for periods up to 50 min (Finneran et al. 2005, Nachtigall et al 2005, Nachtigall et al. 2004). Impulsive sounds from a watergun (Finneran et al. 2002) or an airgun (Lucke et al. 2009) have also been shown to cause TTS in beluga whales and harbor porpoises, respectively. Cook (2006) found that captive odontocetes typically experienced more hearing loss than similar-aged free-ranging dolphins. Older captive common bottlenose dolphins are known to have reduced hearing sensitivity, especially at higher frequencies, but whether the cause of this hearing loss is related to captivity is unknown (Ridgway and Carder 1997); it could simply be the phenomenon of reduced high frequency sensitivity with age that occurs in humans.

3.4.4. Non-Auditory Health Effects

Scientists have studied the physiological stress response of captive marine mammals to noise. When Thomas et al. (1990) played drilling noise to four captive beluga whales, they measured their stress hormone levels (blood adrenaline/epinephrine and noradrenaline/norepinephrine) immediately after playback and found no changes in them. After exposing a captive common bottlenose dolphin and a captive beluga whale to sounds from a seismic watergun, Romano et al. (2004) found changes in some hormones and blood cell counts—from the common bottlenose dolphin, with aldosterone and monocytes levels; from the beluga, epinephrine, norepinephrine, and dopamine levels. Miksis et al. (2001) found that the heart rate in a captive common bottlenose dolphin increased in response to threat sounds produced by other dolphins. Rolland et al. (2012) demonstrated that exposing right whales to low-frequency ship noise might be associated with chronic stress.

Crum and Mao (1996) hypothesized that when marine mammals are exposed to high-intensity low-frequency sounds, gas bubbles might form in their tissues, a process called rectified diffusion. The physiological state of a diving cetacean when it is exposed to sounds determines its susceptibility to rectified diffusion. Diving speed and depth of diving are the primary determinants of the amount of nitrogen that can accumulate in tissues, with slower rates of ascent/descent and deeper dives increasing gas supersaturation (accumulation of higher levels of nitrogen than would be possible at atmospheric pressure). Acoustic activation or generation of bubble nuclei before the animal surfaces or when it is just at the surface, can theoretically drive bubbles to grow rapidly by the degree of supersaturation and the animal's continued exposure to sounds (Houser et al. 2001). Bubble growth can damage tissue and block blood vessels. In deep-diving marine mammals, such as beaked whales, Fernández et al. (2005) calculated supersaturation at over 300%, and found bubbles in some stranded beaked whales' tissues.

Animals that change their behavior in response to sounds could injure themselves. Although the sound characteristics and behavioral and physiological mechanisms behind strandings are not fully understood, some scientists believe acoustic exposure might be a culprit, noting particularly the association between military mid-frequency sonar and strandings of melon-headed whales (Southall et al. 2006, 2013), beaked whales (D'Amico et al. 2009) and common dolphins (Jepson et al. 2013). Because beaked whales are extreme divers that undergo gas supersaturation, exposure to sounds that induces them to ascend more rapidly might put them at risk of tissue-damaging nitrogen bubbles forming, similar to decompression sickness that human divers experience (Cox et al. 2006). Alternatively, if beaked whales remain submerged longer because of acoustic exposure, hypoxia could damage their tissues (Cox et al. 2006).

3.4.5. Reduction of Prey Availability

Sound might indirectly affect marine mammals by altering prey abundance, behavior, and distribution. Rising sound levels could affect fish populations (McCauley et al. 2003, Popper and Hastings 2009, Slabbekoorn et al. 2010). Marine fish are typically sensitive to the 100–500 Hz range, where most seismic sounds are produced.

Several studies have demonstrated that anthropogenic sounds might affect the behavior of at least some species of fish. For example, field studies by Engås et al. (1996) and Whitlock and Schluter (2009) showed that when seismic airguns were operating the catch rate of haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*Gadus morhua*) significantly declined over the five days following, after which the catch rate returned to normal. Engås et al. (1996) and Whitlock and Schluter (2009) suggested that the catch rate declined because fish were responding to the sounds of the airguns by avoiding the area of ensonification. Slotte et al. (2004) showed parallel results for several other pelagic species. Fish near the airguns appeared to move to greater depths after being exposed to airguns. Moreover, because the number of fish 30–50 km away from the ensonification area increased, it seems likely that migrating fish avoided the seismic activity zone. Other studies found only minor responses by fish to noise created during or following seismic surveys, such as a small decline in lesser sandeel (*Ammodytes marinus*) abundance that quickly returned to pre-seismic levels (Hassel et al. 2004), or no permanent changes in the behavior of marine reef fishes (Wardle et al. 2001). Both Hassel et al. (2004) and Wardle et al. (2001), however, noted that when fish saw the airgun firing they performed a startle response and sometimes fled.

Squid (*Sepioteuthis australis*) are an extremely important food chain component for many higher order predators, including sperm whales. McCauley et al. (2000b) recorded caged squid responding to airgun signals. They exhibited strong startle responses to a nearby airgun starting up: they fired their ink sacs and/or jetted away from the airgun source. Squid also avoided the airgun by staying close to the water surface near the cage end farthest from the airgun.

The effects of sounds on fish and squid are still poorly understand. Although some fish additionally sense pressure, all fish and squid sense particle motion, and particle motion is not always directly related to pressure measurements. While no studies have investigated the indirect effects of seismic airguns on marine mammals' prey availability, it is possible that seismic surveys could change the feeding opportunities available to marine mammals, especially in cases of restricted foraging locations.

4. Marine Mammals in the Gulf of Mexico

Twenty-one cetacean species have been sighted in marine mammal surveys since 1991(Waring et al. 2013). Eighteen are mid-frequency hearing specialists. Bryde's whales are the only low-frequency species. Dwarf and pygmy sperm whales comprise the only high-frequency hearing specialist group.

Table 2 lists these species, their functional hearing group, and preferred habitat. Determining the risk of acoustic exposure to a population of animals requires an estimate of the number of animals in that area. Occurrence and abundance estimates are determined from surveys that identify, count, and log the position of species in various waters. From these data, models have been created to provide estimates of likely densities) along transect lines and between lines. In Phase I, the Navy's U.S. Navy OPAREA Density Estimate (NODE; DoN 2007) model was used to obtain animal density estimates (see Section 6.2.5). In Phase II, density estimates were obtained from the Marine Geospatial Ecology Laboratory at Duke University preliminary results (Roberts et al. In preparation; see Section 7.2.6).

Table 2. Marine mammal species considered in the acoustic exposure analysis.

Common name	Latin binomial	Functional hearing group	Preferred habitat
Atlantic spotted dolphins	*Stenella frontalis*	MFC	Primarily coastal (< 200 m)
Beaked whales spp. (Cuvier's, Blainville's, Gervais')	*Mesoplodon densirostris, Ziphius cavirostris, Mesoplodon europaeus*	MFC	Oceanic
Common bottlenose dolphins	*Tursiops truncatus*	MFC	Primarily coastal (< 200 m), occasionally oceanic
Bryde's whales	*Balaenoptera brydei/edeni*	LFC	Oceanic
Clymene dolphins	*Stenella clymene*	MFC	Oceanic
False killer whales	*Pseudorca crassidens*	MFC	Oceanic
Fraser's dolphins	*Lagenodelphis hosei*	MFC	Oceanic
Killer whales	*Orcinus orca*	MFC	Various
Kogia spp. (Dwarf sperm whales, Pygmy sperm whales)	*Kogia sima, Kogia breviceps*	HFC	Oceanic
Melon-headed whales	*Peponocephala electra*	MFC	Oceanic
Pantropical spotted dolphins	*Stenella attenuata*	MFC	Oceanic
Pygmy killer whales	*Feresa attentuata*	MFC	Oceanic
Risso's dolphins	*Grampus griseus*	MFC	Oceanic
Rough-toothed dolphins	*Steno bredanesis*	MFC	Oceanic
Short-finned pilot whales	*Globicephala macrorhyncus*	MFC	Various
Sperm whales	*Physeter macrocephalus*	MFC	Oceanic
Spinner dolphins	*Stenella longirostris*	MFC	Oceanic
Striped dolphins	*Stenella coeruleoalba*	MFC	Oceanic

LFC=Low-frequency cetacean; MFC=Mid-frequency cetacean; HFC=High-frequency cetacean.

5. Modeling Methodology

5.1. Acoustic Source Model

5.1.1. Airgun and Airgun Array Modeling Methodology

The source levels and directivity of the airgun array were predicted with JASCO's Airgun Array Source Model (AASM; Austin et al. 2010). This model is based on the physics of oscillation and radiation of airgun bubbles described by Ziolkowski (1970). The model solves the set of parallel differential equations that govern bubble oscillations. AASM also accounts for nonlinear pressure interactions between airguns, port throttling, bubble damping, and generator-injector gun behavior that are discussed by Dragoset (1984), Laws et al. (1990), and Landro (1992). AASM includes four empirical parameters that were tuned so that model output matches observed airgun behavior. The model was originally fit to a large library of empirical airgun data using a simulated annealing global optimization algorithm. These airgun data consisted of measured signatures of Bolt 600/B airguns ranging in volume from 5 to 185 in^3 (Racca and Scrimger 1986).

While airgun signatures are highly repeatable at the low frequencies used for seismic imaging, their sound emissions have a random component at higher frequencies that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (560−25,000 Hz) sound emissions of individual airguns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each airgun in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, making AASM capable of predicting airgun source levels at frequencies up to 25,000 Hz.

AASM produces a set of notional signatures for each airgun element based on:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field[2] source signature of the entire array in the horizontal plane. This far-field array signature is filtered into 1/3-octave passbands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered to be an azimuth-dependent directional point source in the far field.

[2] The far field is the zone where, to an observer, sound originating from a spatially-distributed source appears to radiate from a single point. The distance to the acoustic far field increases with frequency.

A seismic array consists of many sources. The point-source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{nf} < \frac{l^2}{4\lambda} \tag{9}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002 Section 5.2.4). For example, an airgun array length of $l \approx 16$ m yields a near-field range of 85 m at 2 kHz and 17 m at 100 Hz. Beyond R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modeling.

The AASM accurately predicts the source level of the complete array as a point source for acoustic propagation modeling in the far field; however, predicted source levels for zero-to-peak SPL and sound exposure level (SEL) metrics might be higher than the possible maximum levels during the array operation even within the array.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and there is less effective directivity.

5.1.2. Electromechanical Source Modeling—Transducer Beam Theory

Mid- and high-frequency underwater acoustic sources for geophysical measurements create an oscillatory overpressure by either electromagnetic forces or the piezoelectric effect rapidly vibrating the surface of the source. A vibratory source based on the piezoelectric effect is commonly referred to as a transducer, and piezo transducers are often able to receive and emit signals. Transducers are usually designed to produce 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 directivity is beamwidth, defined as the angle subtended by diametrically opposite half power (−3 dB) points of the main lobe (Massa 2003). Depending on the frequency and size of the transducer, the beamwidth can vary from 180° (almost omnidirectional) to less than 1 degree.

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

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 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 1 presents a 3-dimensional (3-D) visualization of a generic beam pattern of a circular transducer.

The true beam pattern of a transducer can be obtained only by measuring the emitted energy around the device when it is in place. Such data, however, are not always available. For propagation modeling, estimating the beam pattern of the source based on transducer beam theory often suffices. An example of a measured beam pattern is shown in Figure 2.

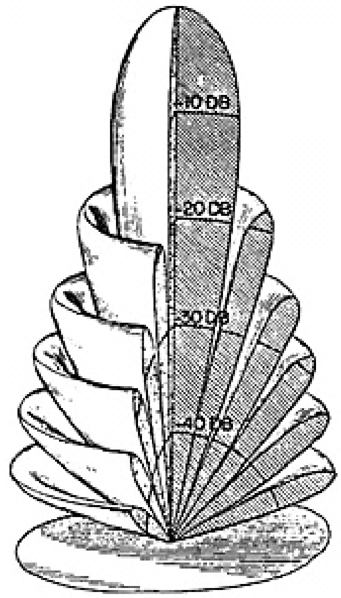


Figure 1. Typical 3-D beam pattern for a circular transducer (Massa 2003).

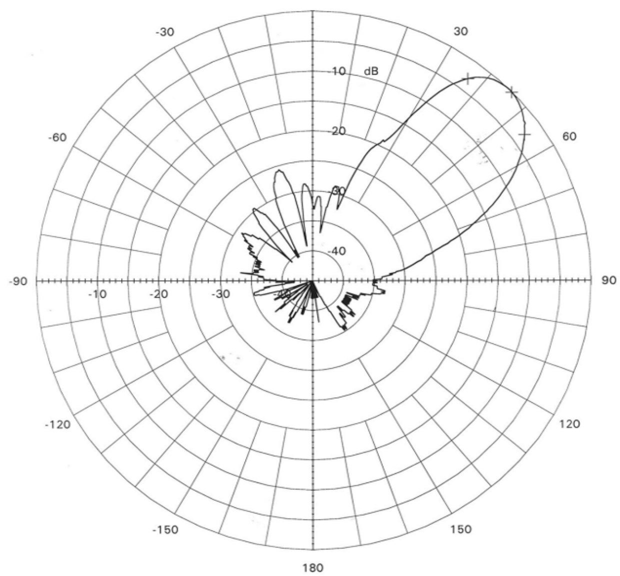


Figure 2. Vertical cross section of a beam pattern measured in situ from a transducer used by Kongsberg (pers. comm. with the manufacturer).

5.1.2.1. Circular Transducers

The beam of an ideal circular transducer is symmetric about the main axis; the radiated level depends only on the depression angle. In this study, beam directivities were calculated from the standard formula for the beam pattern of a circular transducer (ITC 1993, Kinsler et al. 2000). The directivity function of a conical beam relative to the on-axis pressure amplitude is:

$$R(\phi) = \frac{2 \cdot J_1\left(\pi\, D_\lambda \sin(\phi)\right)}{\pi\, D_\lambda \sin(\phi)} \text{ and } D_\lambda = \frac{60}{\theta_{bw}}, \tag{10}$$

where $J_1(\phi)$ is the first-order Bessel function, D_λ is the transducer dimension in wavelengths of sound in the medium, θ_{bw} is the beamwidth 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 beamwidth or from the diameter of the active surface and the operating frequency. The calculated beam pattern for a circular transducer with a beamwidth of 20° is shown in Figure 3. The grayscale represents the source level (dB re 1 µPa @ 1 m) and the declination angle is relative to a central vector (0°, 0°) pointing down.

Although some acoustic energy is emitted at the back of the transducer, the theory accounts for the beam power in only the front half-space ($\phi < 90°$) 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 decibels per angular degree, which gives a beam power at $\phi = 90°$ of 30 dB less than that at $\phi = 0°$. This is a conservative estimate of the beam power in the back half-space.

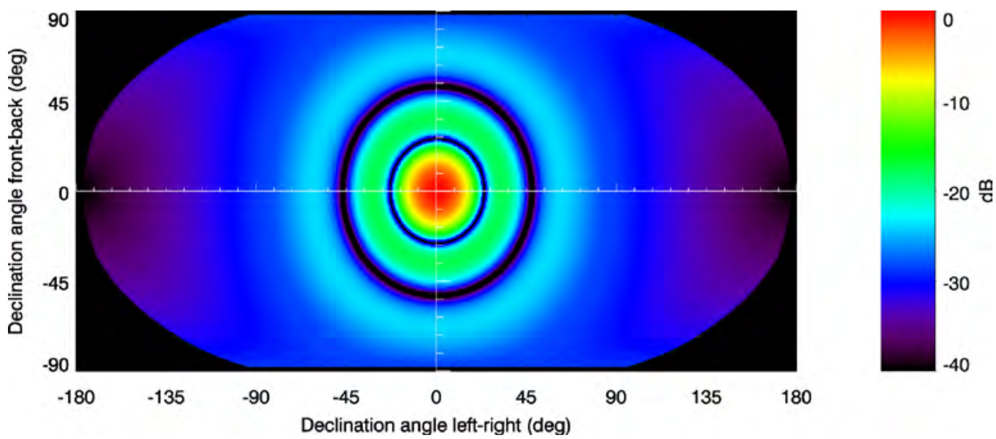


Figure 3. Calculated beam pattern for a circular transducer with a beamwidth of 20°. The beam power function is shown relative to the on-axis level.

5.1.2.2. Rectangular Transducers

Rectangular transducer beam directivities were calculated from the standard formula for the beam pattern of a rectangular acoustic array (ITC 1993, Kinsler et al. 2000). The directivity function 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 beamwidths. The directivity function of a toroidal beam relative to the on-axis pressure amplitude is:

$$R(\phi) = \frac{\sin\left(\pi\, L_\lambda \sin(\phi)\right)}{\pi\, L_\lambda \sin(\phi)} \text{ and } L_\lambda = \frac{50}{\theta_{bw}}, \tag{11}$$

where L_λ is the transducer dimension in wavelengths, θ_{bw} is the beamwidth in degrees, and ϕ is the angle from the transducer axis. The beam pattern of a transducer can be calculated using either the specified beamwidth 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 beamwidths of 4° and 10°, respectively, is shown in Figure 4.

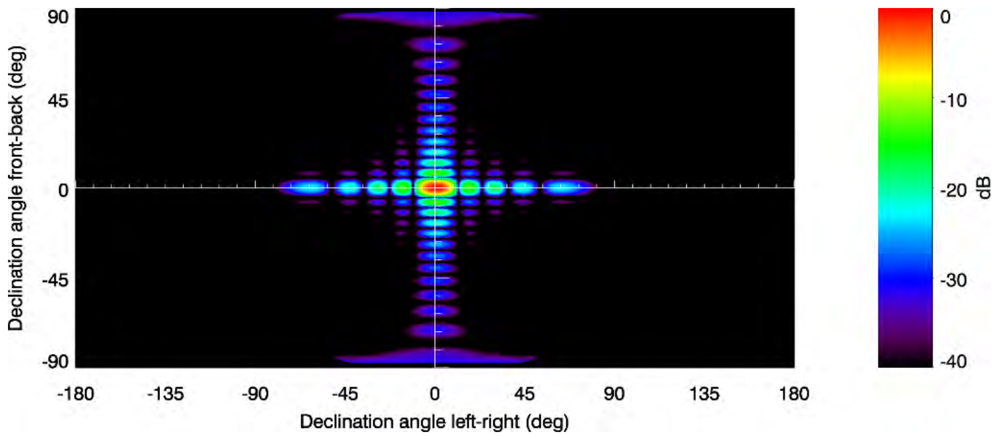


Figure 4. Calculated beam pattern for a rectangular transducer with a 4° × 10° beamwidth. The beam power function is shown relative to the on-axis level using the Robinson projection.

5.1.2.3. Multibeam Systems

High-frequency systems often have two or more transducers, e.g., side-scan and multibeam sonar. Typical side-scan sonar use two transducers, with the central axes directed perpendicular to the survey track and at some depression angle below the horizontal. In contrast, multibeam bathymetry systems can have upward of 100 transducers. Such systems generally consist of rectangular transducers and have a narrow beamwidth in the horizontal (along-track) plane (0.2–3°) and a wide beamwidth in the vertical (across-track) plane.

For multibeam systems, the beam patterns of individual transducers are calculated separately and then combined into the overall pattern of the system based on beam engagement types, which can be broadcast simultaneously or successively. If the beams are engaged successively, the source level of the system in a given direction is assumed to be the maximum source level realized from the individual transducers; if the beams are engaged simultaneously, the system beam pattern is the sum of all beam patterns. Figure 5 shows the predicted beam pattern for two rectangular transducers engaged simultaneously. These transducers have along- and across-track beamwidths of 1.5° and 50°, respectively.

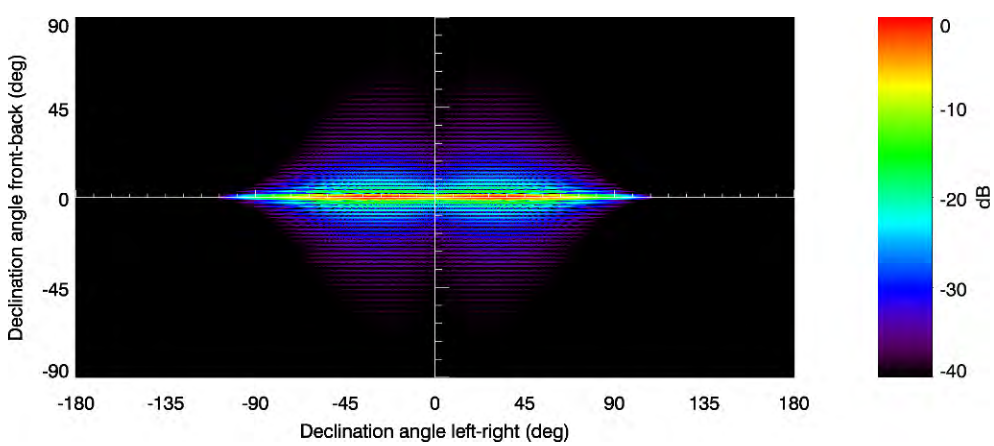


Figure 5. Calculated beam pattern for two rectangular transducers engaged simultaneously, with individual beamwidths of 1.5° × 50°, and a declination angle of 25°. The beam power function is shown relative to the on-axis level using the Robinson projection.

5.2. Acoustic Propagation Modeling

The underwater sound propagation (i.e., transmission loss) was predicted with JASCO's Marine Operations Noise Model (MONM). This model computes received per-pulse SEL for directional sources at a specified depth.

5.2.1. Two Frequency Regimes: RAM vs. BELLHOP

In order to achieve the greatest accuracy and computational efficiency, MONM uses two separate models to estimate transmission loss. At frequencies ≤ 2 kHz, MONM computes acoustic propagation via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for an elastic seabed (Zhang and Tindle 1995). The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). The RAM-based component of MONM (MONM-RAM) accounts for the additional reflection loss at the seabed due to partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM-RAM's predictions have been validated against experimental data in several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010). MONM-RAM incorporates the following site-specific environmental properties: a modeled area bathymetric grid, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor. MONM-RAM accounts for source horizontal directivity.

At frequencies ≥ 2 kHz, MONM employs the widely-used BELLHOP Gaussian beam ray-trace propagation model (Porter and Liu 1994), which accounts for increased sound attenuation due to volume absorption at these higher frequencies following Fisher and Simmons (1977). This type of attenuation is significant for frequencies higher than 5 kHz and cannot be neglected or model results far from the source will noticeably suffer. The BELLHOP component of MONM (MONM-BELLHOP) accounts for the source directivity, specified as a function of both azimuthal angle and depression angle. MONM-BELLHOP incorporates the following site-specific environmental properties: a bathymetric grid of the modeled area and underwater sound speed as a function of depth. In addition to horizontal directivity of the source, MONM-BELLHOP accounts for the vertical variation of the source beam pattern.

In contrast to MONM-RAM, the geoacoustic input for MONM-BELLHOP consists of only one interface: the sea bottom. This is an acceptable limitation because the influence of the sub-bottom layers on the propagation of acoustic waves with frequencies above 1 kHz is negligible. Both propagation models account for full exposure from a direct acoustic wave, as well as exposure from acoustic wave reflections and refractions (i.e., multi-path arrivals at the receiver).

These propagation models effectively assume a continuous wave source. That is an acceptable approximation for a pulse in the case of the SEL metric because the energy in the various multi-path arrivals will be summed. When significant multi-path arrivals cause broadening of the pulse, the continuous wave assumption breaks down for pressure metrics such as rms SPL. For this reason, a subset of the modeling sites were selected to have acoustic propagation from the airgun array modeled using a full-wave RAM PE model (FWRAM), with which broadband SEL to SPL conversion factors could be calculated using a sliding 100 ms integration window. The modeling time required to perform these calculations (often several days for each site) made it prohibitive to perform them at any more than a representative subset of the modeling sites. These azimuth-, range- and depth-dependent conversion factors were then used to calculate the broadband rms SPL from the broadband SEL prediction at all the modeling sites. Conversion factors were calculated for each modeling location.

For geotechnical source propagation modeling, a fixed +10 dB factor was used to convert SEL to rms SPL. A fixed correction factor was used for simplicity because there was little variability over the range of propagation for the geotechnical sources. It is noted that 10 dB assumes the pulse length is 100 ms. Pulse lengths less than 100 ms would have greater than 10 dB conversion factors, but the minimal integration time for the mammalian ear is ~100 ms. Additional details about source directivity and propagation modeling are provided in Sections 5.1.1, 5.1.2, 5.2.2, 5.2.3, and 5.2.4.

5.2.2. *N*×2-D Volume Approximation

MONM computes acoustic fields in three dimensions by modeling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as *N*×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding $N = 360°/\Delta\theta$ number of planes (Figure 6).

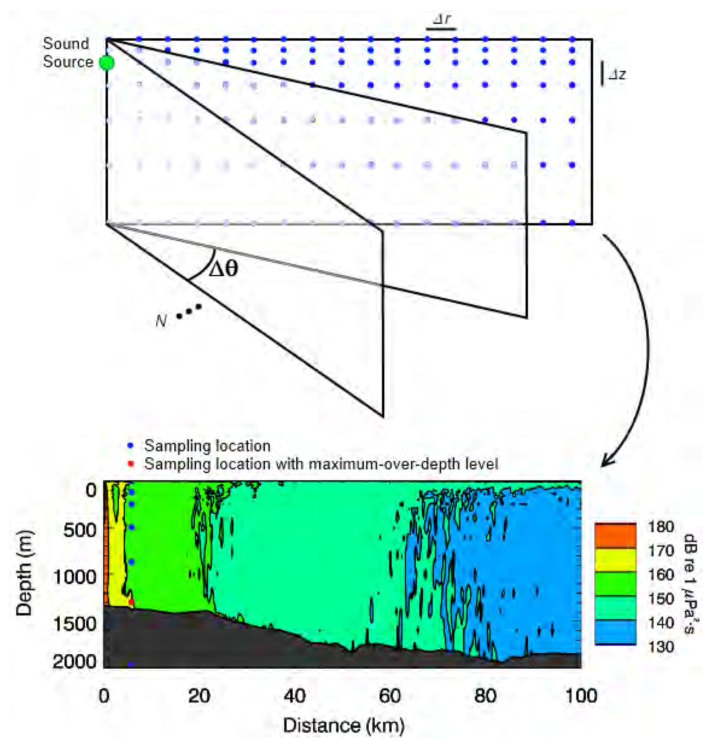


Figure 6. The *N*×2-D and maximum-over-depth modeling approach.

5.2.3. Frequency Dependence: Summing Over 1/3-Octave-Bands

MONM treats frequency dependence by computing acoustic transmission loss at the center frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modeled to include the majority of acoustic energy emitted by the source. At each center frequency, the transmission loss is modeled within each of the *N* vertical planes as a function of depth and range from the source. The 1/3-octave-band received per-pulse SELs are computed by subtracting the band transmission loss values from the SL in that frequency band.

Composite broadband received SELs are computed by combining the transmission loss (TL) values obtained from propagation modeling with MONM and source levels (SL) obtained from source modeling (see Section 5.1) in each 1/3-octave-band and summing the band levels:

$$\mathrm{RL} = 10 \cdot \log_{10} \sum_{i=1}^{n} 10^{(\mathrm{SL}_i - \mathrm{TL}_i)/10} \tag{12}$$

where n is the number of modeled 1/3-octave-bands, SL_i and TL_i are the source level and transmission loss in the respective 1/3-octave-band.

The frequency weighted received levels ($\mathrm{RL}_{\mathrm{MW}}$) were obtained by adding the relative levels (MW) (see Section 5.4.1) to the above equation:

$$\mathrm{RL}_{\mathrm{MW}} = 10 \cdot \log_{10} \sum_{i=1}^{N} 10^{(\mathrm{SL}_i - \mathrm{TL}_i + \mathrm{MW}_i)/10} \ . \tag{13}$$

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b).

5.2.4. Converting Modeled SEL to rms SPL

5.2.4.1. Background

Current National Marine Fisheries Service (NMFS) exposure criteria for impulsive sound sources are based largely on the rms SPL metric. As shown in Equations 7 and 8 in Section 3.2, the rms SPL metric is numerically related to the single pulse SEL and the integration time window for the cases of the commonly-used 90% window, T_{90}, and for fixed integration windows greater than T_{100}. These relationships are important because models are more efficient at estimating SEL than rms SPL. Therefore, in some cases models can be used to calculate the SEL of impulsive acoustic events, after which the aforementioned equations can be used to derive the corresponding rms SPL.

Unfortunately, T_{90} is sensitive to the specific acoustic multipath arrival time of signals. Multipath arrival time varies greatly with source and receiver depths, distance of the receiver from the source, and the water depth profile between source and receiver. Water column refractive effects in deep waters, such as those within deeper regions of the study area, can strongly influence the multipath arrival structure and consequently affect T_{90}. Another problem arises when considering fixed time windows of duration shorter than T_{100}; in these cases Equations 7 and 8 are not valid and cannot be used directly.

Two methods are available to deal with the problems identified above: if field measurements in a similar environment are available, they can be analyzed to directly calculate differences between SEL and rms SPL. Those differences can then be applied to modeled SEL values to derive the corresponding rms SPL. The approach is limited to applications where measurements are available in a suitably similar environment and where the actual measurement source-receiver geometry spans the ranges and depths of interest. The second approach is to apply full-waveform models to calculate synthetic data from which the numeric differences between SEL and corresponding rms SPL can be predicted. This approach can address a much larger variety of ocean environments and source-receiver geometries.

Various empirical measurements of airgun pulses have shown that differences between rms SPL and SEL typically range from +15 to −5 dB (Greene 1997, McCauley et al. 1998, Blackwell et al. 2007, MacGillivray et al. 2007). The difference is highly sensitive to multipath arrival timing and reverberation, but it is generally larger at closer distances, where the airgun pulse duration is short ($\ll$ 1 s), and smaller at farther distances, where pulse duration tends to increase due to increased reverberation and larger differences in the arrival times of different propagation paths.

5.2.4.2. Fixed Integration Time Window

For individual acoustic pulses, we used a fixed integration time window of 100 ms, the shortest expected temporal integration time for the mammalian ear (Plomp and Bouman 1959, MacGillivray et al. 2014). At this window length, the maximum numerical difference between SEL and rms SPL for an impulsive acoustic event is 10 dB. This maximum difference occurs when all of the pulse's acoustic energy is received in less than 100 ms. As the pulse length increases beyond 100 ms, the difference decreases. A difference value of 0 dB (SEL = rms SPL), occurs when the acoustic energy is received evenly distributed over 1 s.

We applied a nominal conversion difference of +10 dB from SEL to rms SPL at all receiver positions for all single airgun and geotechnical source types. The +10 dB results from the assumption that the shortest temporal integration time of the mammalian ear is 100 ms (as mentioned above). This approach is accurate at distances where the pulse duration is less than 100 ms, and conservative for longer distances. Most of the effects of these smaller sources occur at relatively short distances where the pulse durations are short so this approach is not expected to be overly conservative even for lower-level effects.

Conversion values for the larger airgun array source were determined with the Full-Waveform Range-dependent Acoustic Model (FWRAM) (JASCO Applied Sciences). This model was applied at a representative shallow (Shelf), mid-depth (Slope), and deep-water location along each of the three acoustic modeling transects (see Section 7.2.3.2). At each of these locations, the model was run along 16 evenly spaced azimuths to examine the effect of source directivity and direction-dependent bathymetric variation. The synthetic data from the model were processed to compute SEL and rms SPL using 100 ms time windows. These results were computed as a function of distance, receiver depth, and receiver direction from each full-waveform modeling site. Conversion tables were then used to extract representative SEL to rms SPL conversions at all 30 sites modeled using MONM. The optimal conversion values were selected from the tables based on the closest full-waveform model source location and the nearest azimuthal direction, using bilinear interpolation over receiver range and depth.

5.3. Animal Movement Modeling for Impact Assessment

The sounds animals receive when near one or more sound sources are a function of where the animal is at any given time relative to the source(s), which may themselves be moving (Figure 7). To a reasonable approximation, the location of the sound source(s) is known and acoustic modeling can be used to predict the three dimensional (3-D) sound field (Section 5.1 and 5.2). The location of animals within the sound field, however, is unknown. Realistic animal movement within the sound field can be simulated, and repeated random sampling (Monte Carlo)—achieved by simulating many animals within the operations area—used to estimate the sound exposure history of animals during the operation. Monte Carlo methods provide a heuristic approach to determine the probability distribution function (PDF) of complex situations, such as animals moving in a sound field. A greater number of random samples, in this case more simulated animals (animats), better approximates the PDF. Animats are randomly placed, or seeded, within the simulation boundary at a specified density (animats/km^2), and to maintain constant modeling density any animat exiting across a border is replaced with a new animat at the opposite border. Higher densities provide a finer PDF estimate resolution, but require greater computational resources. To ensure good representation of the PDF, the animat density is set as high as practical allowing for computation time. The resulting PDF is then scaled using the real-world animal density to obtain the real-world number of individuals affected. The probability of an event's occurrence is determined by the frequency with which it occurs in the simulation. The Monte Carlo method works well for assessing the probability of common events, its weakness is in accurately determining the probability of rare events.

Several models for marine mammal movement have been developed (Ellison et al. 1987, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behavior. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of an animal foraging, playing, resting, or traveling. This analysis uses the Marine Mammal Movement and Behavior (3MB) model developed by (Houser 2006). The parameters used for forecasting realistic movement are detailed in Appendix C.

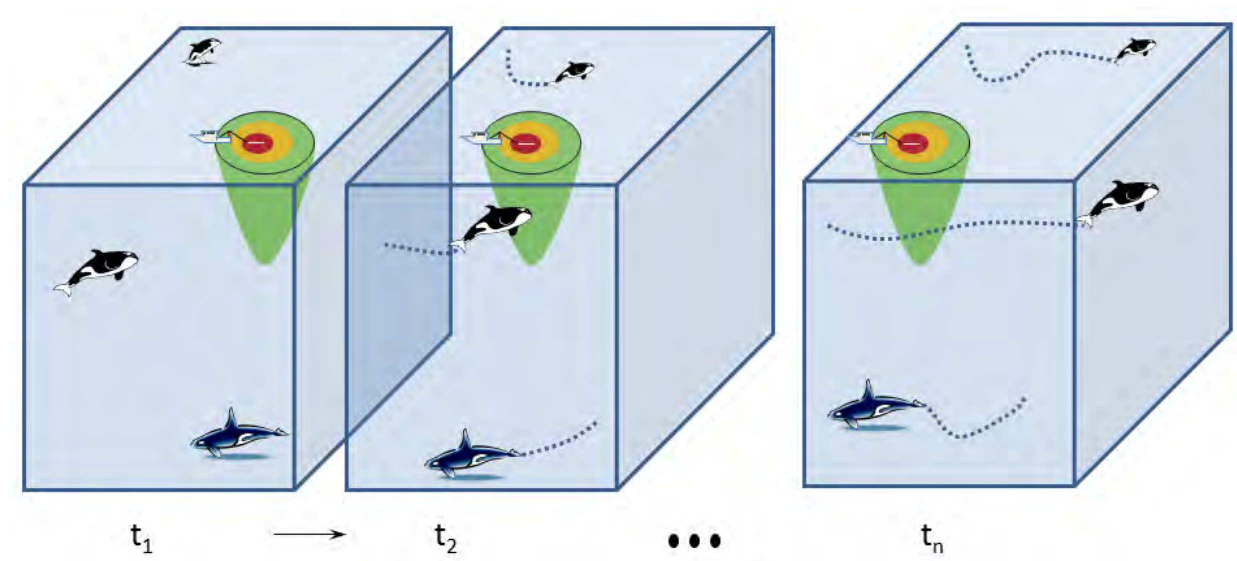


Figure 7. Cartoon animats in a moving sound field. The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation progresses. In this cartoon, the vessel and sound source are moving right to left, as is the lowest animat. The two upper animats move from left to right. Because the upper and lower animats are far from the source, low levels of sound exposure are expected. The middle animat is nearer the sound source so its acoustic exposure would be expected to be higher than the other two animats, and its highest exposure occurs when it is closest to the sound sources at the second time step (t_2).

5.4. Acoustic Exposure Criteria

The Marine Mammal Protection Act (MMPA 2007) defines harassment as any act of pursuit, torment, or annoyance that (i) has the potential to injure a marine mammal, or (ii) has the potential to disturb a marine mammal by disrupting its behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Harassment with the potential for injury is termed Level A harassment, and harassment with the potential to disrupt behavior is termed Level B harassment. Loud sounds can potentially damage the hearing of marine mammals or disrupt their behavior. In the 1990s, NMFS adopted received levels for pulsed sounds that should not be exceeded for marine mammals. The rms SPL thresholds for marine mammals exposed to impulsive sound are 180 dB re 1 µPa for Level A and 160 dB re 1 µPa for Level B (NMFS 1995, NMFS 2000).

These criteria were set before there was adequate data about the received levels that could injure marine mammals. Since then, more data have become available. In 1998, a group of experts was convened to update and establish methods for determining acoustic exposure criteria (Gentry et al. 2004). The results of the expert group were published as Southall et al. (2007) and are commonly referred to as the Southall criteria. In this report, the Southall criteria were used as the basis for developing additional exposure criteria to evaluate potential impacts of the modeling results described in this study.

5.4.1. Marine Mammal Frequency Weighting Functions

The potential for anthropogenic sounds to impact marine animals depends on how well the animal detects the sounds. Sounds are less likely to injure or disturb animals if it occurs at frequencies that an animal cannot hear well, except when the sound pressure level is so high that it could physically injure tissue. Based on a review of marine mammal hearing and on physiological and behavioral responses to anthropogenic sounds, Southall et al. (2007) proposed standard frequency weighting functions—referred to as M-weighting functions—for three functional hearing groups of cetaceans (Table 1):

- Low-frequency cetaceans (LFCs)—mysticetes (baleen whales)
- Mid-frequency cetaceans (MFCs)—some odontocetes (toothed whales)
- High-frequency cetaceans (HFCs)—odontocetes specialized for using high-frequencies

The discount applied by the M-weighting functions for less-audible frequencies is less than that indicated by the corresponding audiograms (where available) for member species of these hearing groups. The rationale for applying a smaller discount than suggested by the audiograms measured at low sound levels is due in part to an observed characteristic of mammalian hearing that, as sound levels increase, perceived equal loudness curves increasingly have less rapid roll-off outside of the most sensitive hearing frequency range. This is why, for example, C-weighting curves for humans, used for assessing loud sounds such as blasts, are flatter than A-weighting curves, used for quiet to mid-level sounds. The M-weighting functions are, therefore, usually applied at high sound levels where impacts such as temporary or permanent hearing threshold shifts might occur. The use of M-weighting is considered precautionary (in the sense of overestimating the potential for impact) when applied to lower level impacts such as the onset of behavioral response. Figure 8 shows the decibel frequency weighting of the cetacean underwater M-weighting functions.

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

$$G(f) = K - 20\log_{10}\left[\left(1 + \frac{f_{low}{}^{2}}{f^{2}}\right)\left(1 + \frac{f^{2}}{f_{hi}}\right)\right] \tag{14}$$

where K is a constant used to normalize the function at a reference frequency, and the roll-off and passband of these functions are controlled by the parameters f_{lo} and f_{hi}, the estimated upper and lower hearing limits specific to each functional hearing group (Table 3).

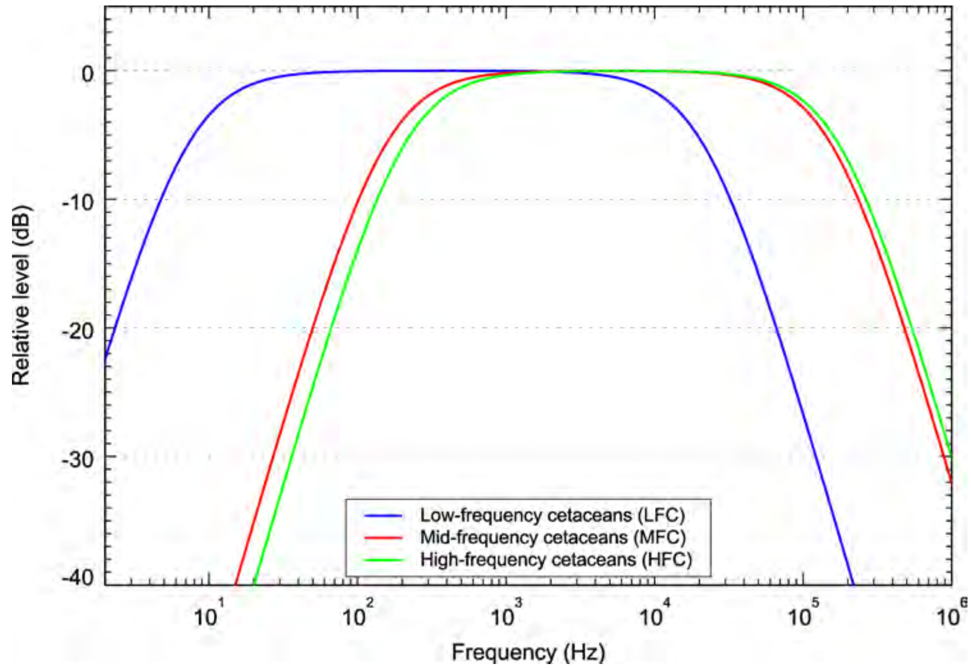


Figure 8. Standard M-weighting functions for the four underwater functional marine mammal hearing groups (Southall et al. 2007).

Table 3. Low and high frequency cut-off parameters of M-weighting functions for the cetacean functional hearing groups (Southall et al. 2007).

Functional hearing group	K	f_{low} (Hz)	f_{hi} (Hz)
Low-frequency cetaceans	0	7	22,000
Mid-frequency cetaceans	0	150	160,000
High-frequency cetaceans	0	200	180,000

Subjective loudness measurements for a common bottlenose dolphins have provided information to help develop equal-loudness contours for this animal (Finneran and Schlundt 2011). Equal loudness contours (also called Fletcher-Munson curves) are the sound levels over the frequency spectrum for which a listener perceives constant loudness. These curves are the basis of the Occupational Safety and Health Administration (OSHA) noise regulation 1910.95. The equal-loudness contours determined by Finneran and Schlundt (2011) better match the frequency dependence of TTS onset data (Schlundt et al. 2000) than audiograms or the M-weighting curves. For this reason, the dolphin equal-loudness contours were used to develop marine mammal frequency weighting functions (Finneran and Jenkins 2012).

The (inverse) equal-loudness contours were fit with equations of the same form as the M-weighting function (Equation 14). The fits suggest steeper roll-off at lower frequencies than the mid-frequency M-weighting curve. Because data for the equal-loudness contours did not cover the entire spectral range of the M-weighting functions, the M-weighting curves were modified. The lowest frequency for which subjective loudness data were obtained was 3 kHz, therefore Finneran and Jenkins (2012) took a conservative approach and set the mid-frequency M-weighting curve and the inverted equal loudness contour equal at 3 kHz. The result is that below 3 kHz the overall function is identical to the M-weighting curves, while above 3 kHz the overall function is equal to the fitted (inverse) equal-loudness contour. A similar procedure was used for low- and high-frequency animals, but the fitting parameters for the inverted equal-loudness contours were adjusted appropriately for each of those groups.

Frequency weighting functions for cetaceans are calculated as:

$$G_1(f) = K_1 - 20\log_{10}\left[\left(1+\frac{f_{low1}^{\,2}}{f^2}\right)\left(1+\frac{f^2}{f_{hi1}^{\,2}}\right)\right] \qquad (15)$$

$$G_2(f) = K_2 - 20\log_{10}\left[\left(1+\frac{f_{low2}^{\,2}}{f^2}\right)\left(1+\frac{f^2}{f_{hi2}^{\,2}}\right)\right] \qquad (16)$$

$$G_2(f) = \max[G_1(f), G_2(f)] \qquad (17)$$

where f_{low1} and f_{hi1} are the same parameter values for M-weighting, and $f_{low\,2}$ and f_{hi2} are the fitted parameters for the inverted equal-loudness contour adjusted for hearing groups. K_2 is used to normalize the G_2 equation to zero at 10 kHz (the reference frequency for the subjective loudness studies) and K_1 is used to set the G_1 equation equal to the G_2 equation at 3 kHz for mid-frequency and high-frequency species. For low-frequency species, K_1 was adjusted so that the flat portion of the G_2 was 16.5 dB below the peak level of G_2 (as it was for the mid-frequency cetaceans). G_1 and G_2 are equal at 267 Hz for low-frequency species. Parameters for each of the cetacean groups are shown in Table 4, and the resulting frequency weight curves are shown in Figure 9.

Finneran and Jenkins (2012) termed their frequency weighting functions Type II M-weighting and referred to the original Southall et al. (2007) M-weighting as Type I M-weighting. We adopt the Finneran and Jenkins (2012) nomenclature in this study.

Table 4. Frequency weighting parameters for the cetacean functional hearing groups. Modified from Finneran and Jenkins (2012).

Functional hearing group	K_1 (dB)	f_{low1} (Hz)	f_{hi1} (Hz)	K_2 (dB)	f_{low2} (Hz)	f_{hi2} (Hz)	Inflection point (Hz)
Low-frequency cetaceans	−16.5	7	22,000	0.9	674	12,130	267
Mid-frequency cetaceans	−16.5	150	160,000	1.4	7,829	95,520	3,000
High-frequency cetaceans	−19.4	200	180,000	1.4	9,480	108,820	3,000

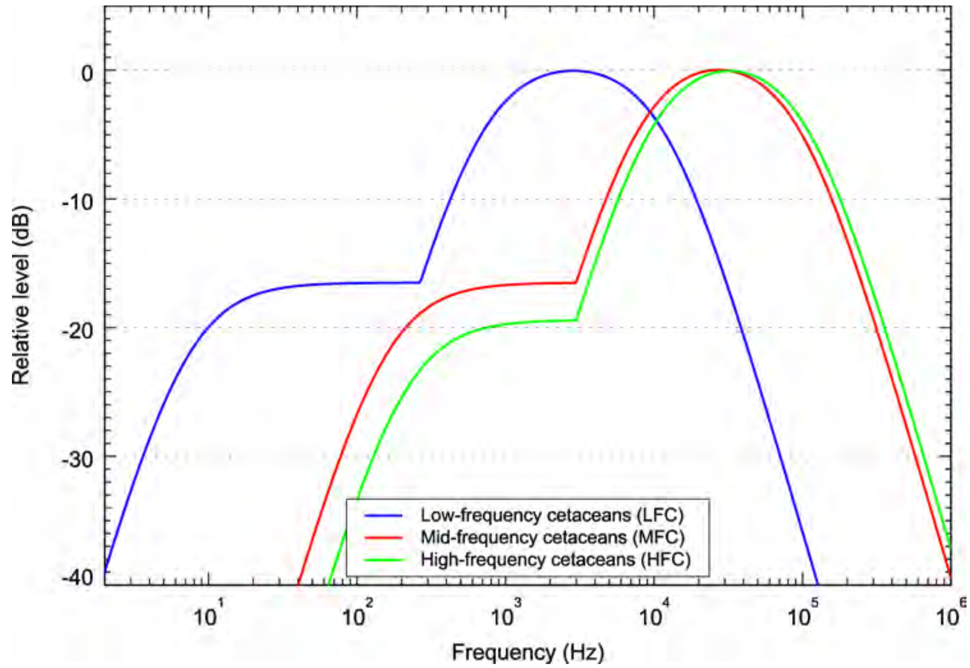


Figure 9. Frequency weighting functions for the cetacean functional hearing groups. Adapted from Finneran and Jenkins (2012).

5.4.2. Injury Exposure Criteria Selection

Loud or sustained sounds can injure an animal's hearing structures, resulting in a permanent shift in hearing thresholds (PTS; see Section 3.4.3). There are no data on the sound levels that cause PTS in marine mammals. There are, however, data that indicate the received sound levels at which temporary threshold shifts (TTS) occur. PTS onset can be hypothetically extrapolated from TTS onset and growth.

Sound level and duration are key determinants in TTS. The SEL metric includes amplitude, duration, and TTS magnitude. TTS is best correlated with SEL (rather than SPL) in dolphins exposed to sounds of < 8 s long (Finneran et al. 2005). Although limited, these findings are consistent with an equal acoustic energy hypothesis for TTS prediction (see Southall et al. 2007). Data from terrestrial mammals indicate that TTS of 40–50 dB could be induced without causing PTS (e.g., Ward et al. 1958, Ward et al. 1959, Ward 1960, Miller 1963, Kryter et al. 1966). Southall et al. (2007) chose 40 dB of TTS as a conservative onset limit of PTS. In humans, Ward et al. (1958) found a linear relationship between TTS and SEL of 1.5–1.6 dB TTS per 1 dB increase in SEL. TTS onset is defined as the sound level that produces 6 dB of TTS. The TTS growth rates from Ward et al. (1958) predict the onset PTS SEL at about 21 dB greater than the onset of TTS SEL ($34/1.6 \approx 21$). This TTS growth rate appears to be conservative for cetaceans, as Finneran and Schlundt (2010) measured a TTS growth rate in a dolphin exposed to 16 s tones from 3 and 20 kHz, to be somewhat less than the values found in humans by Ward et al. (1958). For non-pulsed stimuli, both Southall et al. (2007) and Finneran and Jenkins (2012) rounded down and used a conservative value of 20 dB + TTS SEL onset as the PTS SEL onset level. For pulsed sounds, Henderson and Hamernik (1986) reported that the TTS growth rate for chinchillas was between 0.5 and 3 dB TTS per dB SEL, with higher growth rates at higher SELs. Southall et al. (2007) used 2.3 dB TTS per dB SEL as a conservative growth rate to predict PTS SEL onset for marine mammals, and thus calculated 15 dB + TTS SEL onset as the PTS SEL onset. Because TTS is related to hearing sensitivity, the signal levels for determining TTS and PTS should be filtered using an appropriate auditory frequency weighting function (see Section 5.4.1).

Particularly loud sounds could induce TTS regardless of whether a cumulative sound energy (SEL) threshold has been exceeded or how long they last. Rather than the sensory system fatiguing, tissue damage might occur, which would violate the equal-energy assumption of TTS prediction. In this case, SPL is the appropriate metric and no auditory frequency weighting is applied. In assessing the potential for injury due to these sounds, Southall et al. (2007) began with 40 dB of TTS as the onset of PTS. They used a conservative extrapolation of chinchilla data to argue that sounds 6 dB above the TTS SPL threshold could cause PTS.

Injury exposure criteria for each cetacean functional hearing group is determined from TTS onset data as explained below, and the results are shown in Table 5.

Low-Frequency Cetaceans

There are no TTS data for low-frequency species. As a conservative measure, the Type I M-weighting function described by Southall et al. (2007; Section 5.4.1) was used for low-frequency species. Extrapolating current data from mid-frequency animals, we subtracted 6 dB from the Southall et al. (2007) SEL injury criteria of 198 dB re 1 $\mu Pa^2 \cdot s$ to obtain 192 dB re 1 $\mu Pa^2 \cdot s$ for use in this study (Wood et al. 2012).

Mid-Frequency Cetaceans

For pulsed sounds, TTS data are available for common bottlenose dolphins and beluga whales exposed to single impulse from a seismic watergun (Finneran et al. 2002). The beluga whales were found to have a TTS onset at a SEL of 186 dB re 1 $\mu Pa^2 \cdot s$ or peak SPL of 224 dB re 1 µPa (measured at 0.4 and 30 kHz). The dolphins showed no TTS up to a SEL of 186 dB re 1 $\mu Pa^2 \cdot s$ or peak SPL of 226 dB re 1 µPa. As a precaution, the TTS onset levels for the beluga are taken to represent all mid-frequency cetaceans (Southall et al. 2007, Finneran and Jenkins 2012). Using the auditory frequency weighting, TTS onset occurs at an SEL of 172 dB 1 $\mu Pa^2 \cdot s$. Adding 15 dB results in a PTS SEL threshold of 187 dB 1 $\mu Pa^2 \cdot s$.

We used the unweighted peak SPL of 224 dB re 1 µPa for TTS in beluga to predict PTS onset for particularly loud sounds that violate the equal energy hypothesis for TTS prediction (Southall et al. 2007, Finneran and Jenkins 2012). Adding 6 dB to the TTS onset results in a PTS SPL onset threshold of 230 dB re 1 µPa. We used this hypothetical exposure value as SPL PTS threshold for all mid-frequency cetaceans and for all types of sounds.

High-Frequency Cetaceans

Lucke et al. (2009) found a TTS SEL onset of 164 dB re 1 $\mu Pa^2 \cdot s$ at 4 kHz for a harbor porpoise exposed to a seismic airgun impulse. When auditory frequency weighting is applied to the airgun signal, the SEL TTS exposure threshold is 146 dB re 1 $\mu Pa^2 \cdot s$ (see Finneran and Jenkins 2012); adding 15 dB to the TTS onset results in an SEL threshold of 161 dB re 1 $\mu Pa^2 \cdot s$ as the PTS exposure criteria for pulsed sounds.

Lucke et al. (2009) also found that 194 dB re 1 µPa was the peak SPL that resulted in TTS. Adding 6 dB to the peak SPL results in a peak SPL PTS onset of 200 dB re 1 µPa, which will be used in this report as the peak sound pressure level exposure criteria for high-frequency cetaceans for all types of sounds.

Table 5. Injury exposure criteria for pulsed sounds. Cumulative sound exposure level (SEL) is weighted for hearing sensitivity; peak sound pressure level (peak SPL) is unweighted.

Functional hearing group	SEL (dB re 1 μPa^2·s)	peak SPL (dB re 1 μPa)
Low-frequency cetaceans	192	230
Mid-frequency cetaceans	187	230
High-frequency cetaceans	161	200

5.4.3. Behavioral Exposure Criteria Selection

NMFS currently uses a step function at an unweighted rms SPL of 160 dB re 1 μPa to assess behavioral impacts (NMFS and NOAA1995). This threshold is based on observations of migrating mysticete whales responding to an airgun (Malme et al. 1984, Malme et al. 1988). Although animals' behaviors in response to sounds might happen at lower levels, significant responses were only likely to occur above an rms SPL of 140 dB re 1 μPa; animals began avoiding pulsed sounds when rms SPL neared 160 dB re 1 μPa (Malme et al. 1988).

Southall et al. (2007, Appendix B) extensively reviews behavioral responses to sounds, and finds that most marine mammals exhibited varying responses between rms SPLs of 140 and 180 dB re 1 μPa—consistent with the NMFS threshold—but lack of convergence in the data prevents them from suggesting explicit step functions. Lack of controls, precise measurements, appropriate metrics, and context dependency of responses (including the activity state of the animal) all contribute to variability. Southall et al. (2007) propose a severity scale that increases with increased sound level as a qualitative scaling paradigm.

For pulsed sounds, Wood et al. (2012) proposed a graded probability of response with 10% response likelihood at an rms SPL of 140 dB re 1 μPa, 50% at an rms SPL of 160 dB re 1 μPa, and 90% at an rms SPL of 180 dB re 1 μPa for most marine mammals. Wood et al. (2012) also designated behavioral response categories for migrating mysticetes and sensitive species, such as harbor porpoises and beaked whales. For the sensitive species, the likelihood of a 50% response was set to an rms SPL of 120 dB re 1 μPa; 90% response probability was set at an rms SPL of 140 dB re 1 μPa (Wood et al. 2012). No migrating mysticetes were modeled in our study.

The NMFS step function, (unweighted) rms SPL of 160 dB re 1 μPa, and the Wood et al. (2012) graded functions (Table 6) were used to determine the number of behavioral responses. Following Wood et al. (2012), Type I weighting was used to filter the source signals when behavioral responses were evaluated with the graded functions (see Section 5.4.1).

Table 6. Behavioral exposure criteria. Probability of behavioral response frequency-weighted sound pressure level (rms SPL dB re 1 μPa). Probabilities are not additive. Adapted from Wood et al. (2012).

Marine mammal group	Probability of response to frequency-weighted rms SPL (dB re 1 μPa)			
	120	140	160	180
Beaked whales	50%	90%		
All other species		10%	50%	90%

5.4.4. Exposure Estimation

5.4.4.1. Injury Exposure Estimates—cumulative SEL

To evaluate the likelihood an animal might be injured from accumulated sound energy, the cumulative SEL for each animat in the simulation was calculated. To obtain that animat's cumulative SEL, the SEL an animat received from each source over the integration window was summed. The number of animats whose cumulative SEL exceeded the specified thresholds (Table 5) during the integration window was counted.

5.4.4.2. Injury Exposure Estimates—peak SPL

To evaluate the likelihood an animal might be injured by being exposed to peak SPL, we estimated the range at which the specific peak SPL threshold occurs (Table 5) for each source based on the broadband peak SPL source level. For each integration window, the number of animats that came within this range of the source was counted.

5.4.4.3. Behavior Exposure Estimates—rms SPL

To evaluate the likelihood an animal might have its behavior disrupted based on the step function criteria, we calculated the number of animats that received a maximum rms SPL exposure within the specified step ranges (Table 6). The number of animats with a maximum rms SPL received level categorized into each bin of the step function was scaled by the probability of the behavioral response specific to that range (Table 6). These scaled values were then summed as the estimated number of behavioral exposures. This process was repeated for each integration window.

5.4.4.4. NMFS Criteria for Injury and Behavior Exposure Estimates—rms SPL

To evaluate the likelihood an animal might be injured or its behavior disrupted based on NMFS's criteria (180 and 160 dB rms SPL, respectively), we set the exposure simulation to use un-weighted rms SPL acoustic fields. The number of animats receiving an exposure greater than 180 dB was counted as the number of injurious exposures. The number of animats that received an exposure between 160 dB and 180 dB was counted as the number of behavioral exposures. An animat counted as an injurious exposure is not counted as a behavioral disruption exposure. As with the other criteria, animat received level was reset at the beginning of each integration window.

6. Phase I: Test Case and Test Scenarios

A seismic survey Test Case was defined and evaluated using acoustic and animal movement models as an initial evaluation of potential impacts on marine mammals and to establish the use of various modeling methodologies prior to the Phase II modeling. The Test Case was a typical WAZ seismic survey conducted at two locations near the Mississippi Canyon of the Gulf of Mexico (Figure 10). Survey site A was centered on the slope of the continental shelf break and Survey site B was centered on the deep ocean plain. The WAZ surveys consisted of four vessels sailing in parallel with staggered sail directions. Each vessel towed two 8000 in^3 arrays. Six species (Bryde's whales, Cuvier's beaked whales, common bottlenose dolphins, dwarf sperm whales, short-finned pilot whales, and sperm whales) were evaluated in the Test Case as representative Gulf of Mexico species that may be near the survey sites. Bryde's whales were chosen because they are the only low-frequency species in the Gulf. Dwarf sperm whales were chosen as the representative high-frequency *Kogia* species. The four mid-frequency species were chosen to represent various other aspects of diving and hearing sensitivity. Cuvier's beaked whales are deep-diving and behaviorally sensitive to sounds, sperm whales are also deep-diving and are the only endangered species listed in the Gulf. Short-fin pilot whales and common bottlenose dolphins both represent the swimming behavior of smaller cetaceans with different preferred water depth. Sound exposure estimates were determined by first using computational models to calculate sound fields generated by the airgun arrays, and then by sampling those sound fields using computational models of animal movement during each survey. Risk for each species was evaluated based on the predetermined exposure criteria (see Section 5.4).

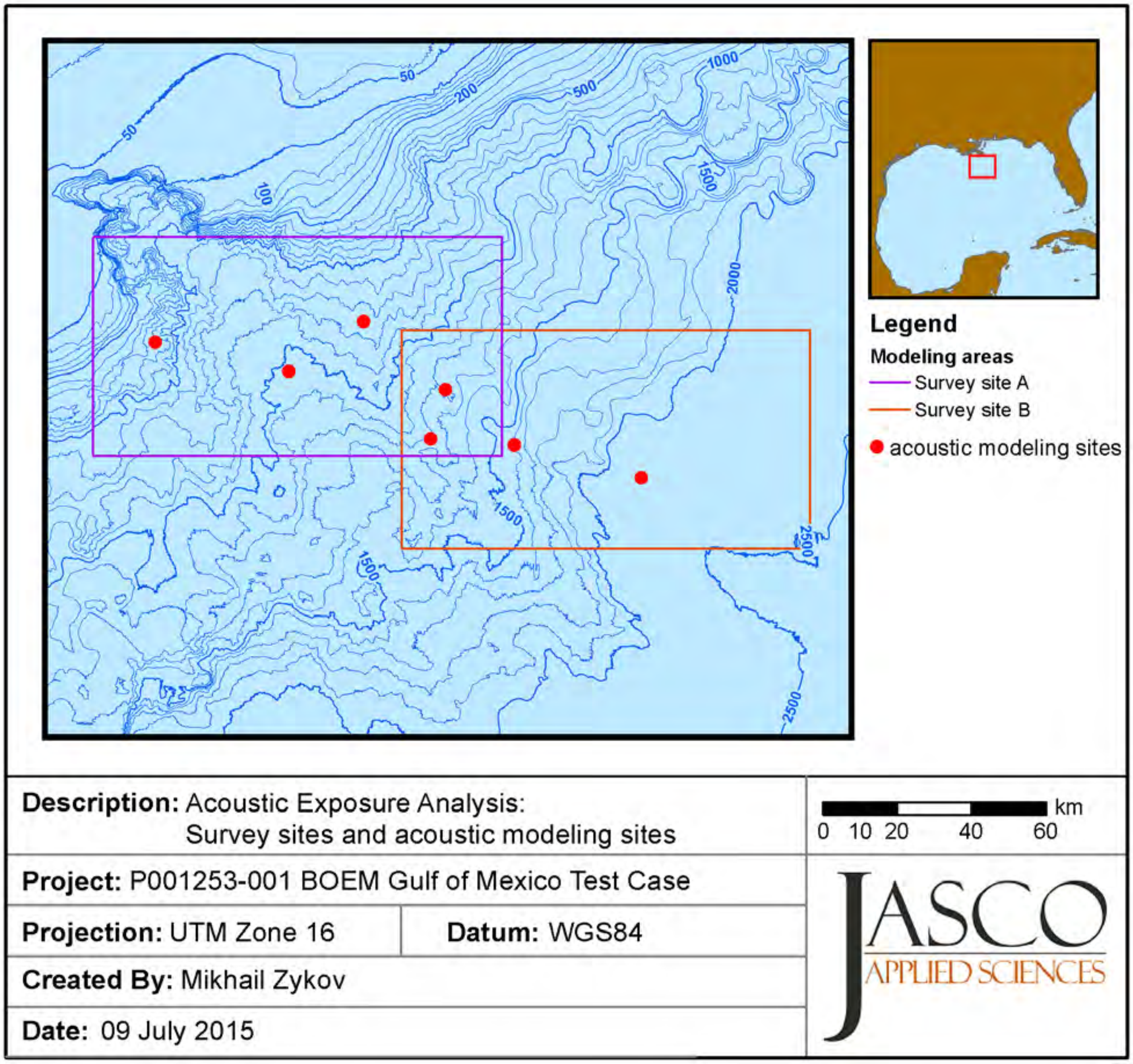


Figure 10. Locations of the Survey site A (purple box) and Survey site B (red box) and acoustic field modeling sites.

6.1. Test Case Acoustic Source Parameters

The WAZ surveys consist of four vessels, each towing two 8000 in^3 airgun arrays fired in flip-flop mode with a shot interval of ~ 14 s.

Acoustic source levels were modeled for the Bolt 1900 LLXT 8000 in^3 airgun array, which was used for the 3-D WAZ survey. The array consisted of six sub-arrays with 9 m in-line separations. The airguns fired simultaneously at 2,000 psi air pressure. The airgun array was modeled at a tow depth of 8 m (the center of the array). Table 7 describes the horizontal layout of each sub-array. Figure 11 presents the airgun distribution in the horizontal plane and gives the volume of each airgun within the sub-array.

Table 7. Relative airgun positions within each of the six sub-arrays. The center of each sub-array is aligned at the same position in x (fore-aft, where the array is towed in the positive x direction), and spaced 9 m apart in y (port-starboard, where port is in the positive y direction). All airguns are at 8 m depth. The volume of the airgun at each position varies among the sub-arrays.

Gun	x (m)	y (m)	Volume (in^3)	
			Strings 1 and 6	Strings 2–5
1	−7.0	0.4	150	150
2	−7.0	−0.4	150	150
3	−4.0	0.4	70	60
4	−4.0	−0.4	70	60
5	−2.0	0	50	40
6	0.0	0	90	70
7	2.0	0.4	70	60
8	2.0	−0.4	70	60
9	4.0	0.4	60	90
10	4.0	−0.4	60	90
11	7.0	0.4	250	250
12	7.0	−0.4	250	250

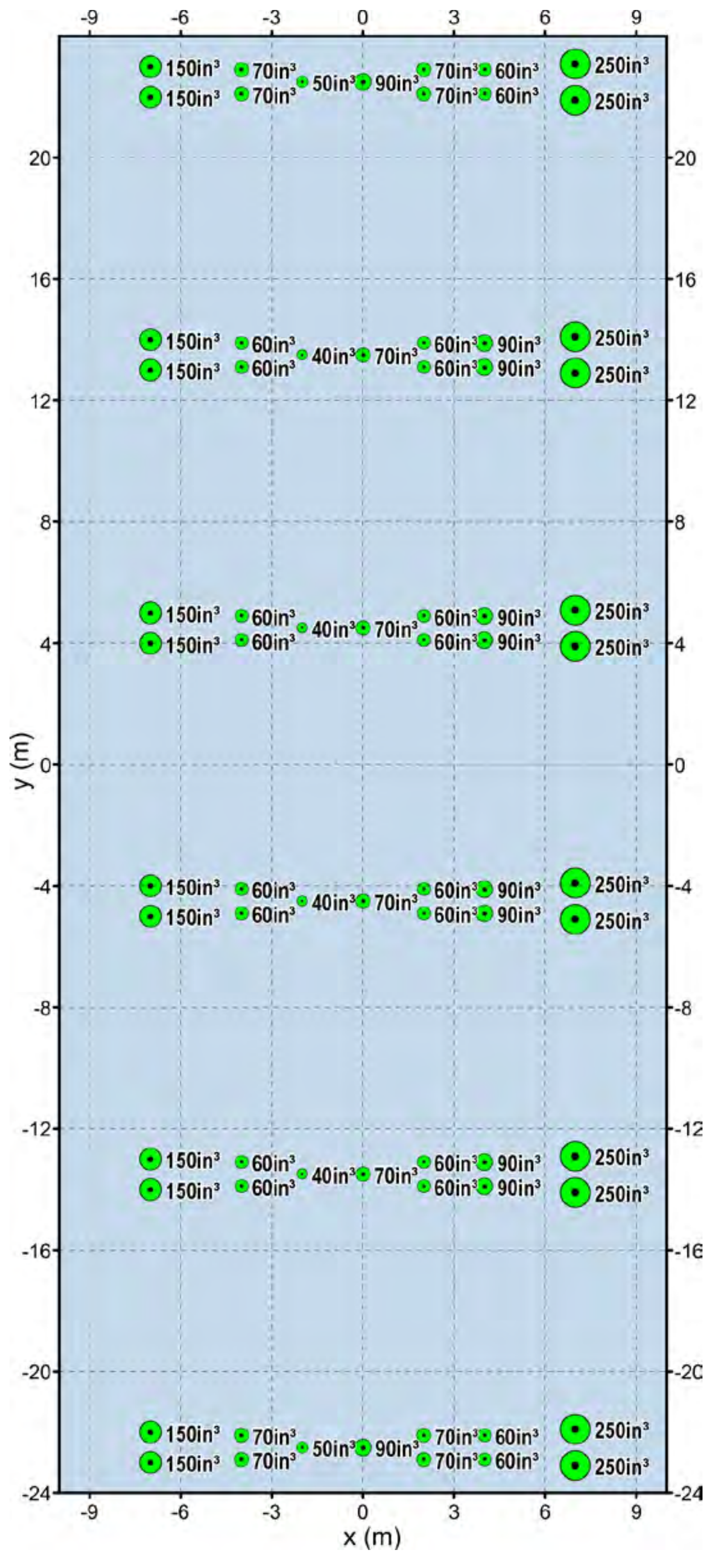


Figure 11. Layout of the modeled airgun array (8000 in³ total firing volume, 8 m depth), which is composed of 6 sub-arrays of 12 airguns each (72 airguns in total). The relative size of green circles and the numbers next to each indicate airgun firing volume.

6.2. Test Case Environmental Parameters

6.2.1. Modeling Sites

Survey site A and Survey site B around Mississippi Canyon (rectangular zones in Figure 10) were selected to be representative of locations for typical shallow (Survey site A) and deep (Survey site B) 3-D wide azimuth surveys conducted in the Gulf. Survey site A was placed so that the shallowest portion would remain at a depth of at least ~ 100 m to ensure that the survey could be safely conducted. The location for Survey site B was chosen to include the deepest water where a seismic survey could reasonably be expected to occur. Acoustic fields were computed at four locations in each survey area (Figure 10), with one location common to both areas. As examples, Appendix A shows per-pulse acoustic fields from a single 8000 in^3 array as field maps and tables of propagation radii for three of the acoustic propagation modeling sites.

6.2.2. Bathymetry

Water depths throughout the modeled area were obtained from the National Geophysical Data Center's U.S. Coastal Relief Model (NGDC 2003) that extends up to about 200 km from the U.S. coast. These bathymetry data have a resolution of 3 arc-seconds (~ 80 × 90 m at the studied latitude). Bathymetry data for an area were extracted and re-gridded, using minimum curvature method, onto a Universal Transverse Mercator (UTM) zone 15 coordinate projection with a horizontal resolution of 50 × 50 m.

6.2.3. Multi-Layer Geoacoustic Profile

MONM assumes a single geoacoustic profile of the seafloor for the entire modeled area. MONM requires these acoustic properties:

- Sediment density
- Compressional-wave (or P-wave) speed
- P-wave attenuation in decibels per wavelength
- Shear-wave (or S-wave) speed
- S-wave attenuation, also in decibels per wavelength

The geoacoustic parameters were estimated based on typical values expected within the Mississippi Canyon, in accordance with our experience in modeling this area. Survey site A was in the vicinity of latitude 28 N and longitude 89 W, and Survey site B was centered approximately 72 km farther southeast (Figure 10). Modeling at Survey site A required two geoacoustic provinces, one consisting of surficial clay, designated S01, and a second consisting of surficial sand, designated S02. Modeling at Survey site B required only one geoacoustic province, designated as D01. The geoacoustic profile assumed for these three modeling provinces is shown in Tables 8 through 10, respectively.

Table 8. Geoacoustic properties of the sub-bottom sediments as a function of depth for the S01 modeling province. Within each depth range, each parameter varies linearly within the stated range.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–10	Clay	1.44–1.61	1480–1522	0.21–0.37	100	0.1
10–50		1.61–1.78	1522–1610	0.37–0.56		
50–100		1.78–1.87	1610–1670	0.56–0.67		
100–300		1.87–2.0	1670–1800	0.67–0.9		
300–1000	Compacted/ consolidated sediments	2.0–2.5	1800–3000	0.9–0.2		
> 1000	Compacted/ consolidated sediments	2.5	3000	0.2		

Table 9. Geoacoustic properties of the sub-bottom sediments as a function of depth for the S02 modeling province. Within each depth range, each parameter varies linearly within the stated range.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–10	Silt	1.44–1.61	1505–1570	0.34–0.55	150	0.2
10–50		1.61–1.78	1570–1695	0.55–0.86		
50–100		1.78–1.87	1695–1775	0.86–1.02		
100–300		1.87–2.0	1775–1950	1.02–1.3		
300–1000	Compacted/ consolidated sediments	2.0–2.5	1950–3000	1.3–0.2		
> 1000	Compacted/ consolidated sediments	2.5	3000	0.2		

Table 10. Geoacoustic properties of the sub-bottom sediments as a function of depth for the D01 modeling province. Within each depth range, each parameter varies linearly within the stated range.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–12	Soft clay	1.35–1.68	1460–1518	0.14–0.55	100	0.1
12–45	Clay	1.68–1.87	1518–1601	0.55–0.86		
45–90	Stiff clay	1.87–1.95	1601–1660	0.86–1.02		
90–200		1.95–2.0	1660–2200	1.02–1.3		
200–1000	Compacted/ consolidated sediments	2.0–2.5	2200–3000	1.3–0.2		
> 1000	Compacted/ consolidated sediments	2.5	3000	0.2		

6.2.4. Sound Speed Profile

The sound speed profiles for the modeled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep), including 55 standard depths between 0 and 2000 m. The GDEM temperature-salinity profiles were converted to sound speed profiles according to the equations of Coppens (1981):

$$\begin{aligned} c(z,T,S,\phi) &= 1449.05 + 45.7t - 5.21t^2 - 0.23t^3 \\ &\quad + \left(1.333 - 0.126t + 0.009t^2\right)\left(S-35\right) + \Delta \\ \Delta &= 16.3Z + 0.18Z^2 \\ Z &= \frac{z}{1000}\left[1 - 0.0026\cos(2\phi)\right] \\ t &= \frac{T}{10} \end{aligned} \tag{18}$$

where z is water depth (m), T is water temperature (°C), S is salinity (psu), and ϕ is latitude (radians).

The sound speed profile for August at Survey site A indicates a strong, downward-refracting environment with a very weak surface sound channel (Figure 12). The surface channel is essentially absent in the Survey site B profile, which is also strongly downward refracting for a sound source near the surface. For a source near the surface, long-range acoustic propagation at both sites is mainly dependent on bottom-interacting pathways (despite a weak surface channel at Survey site A). As discussed in Section 6.2.3, the bottom composition is unfavorable for long-range propagation.

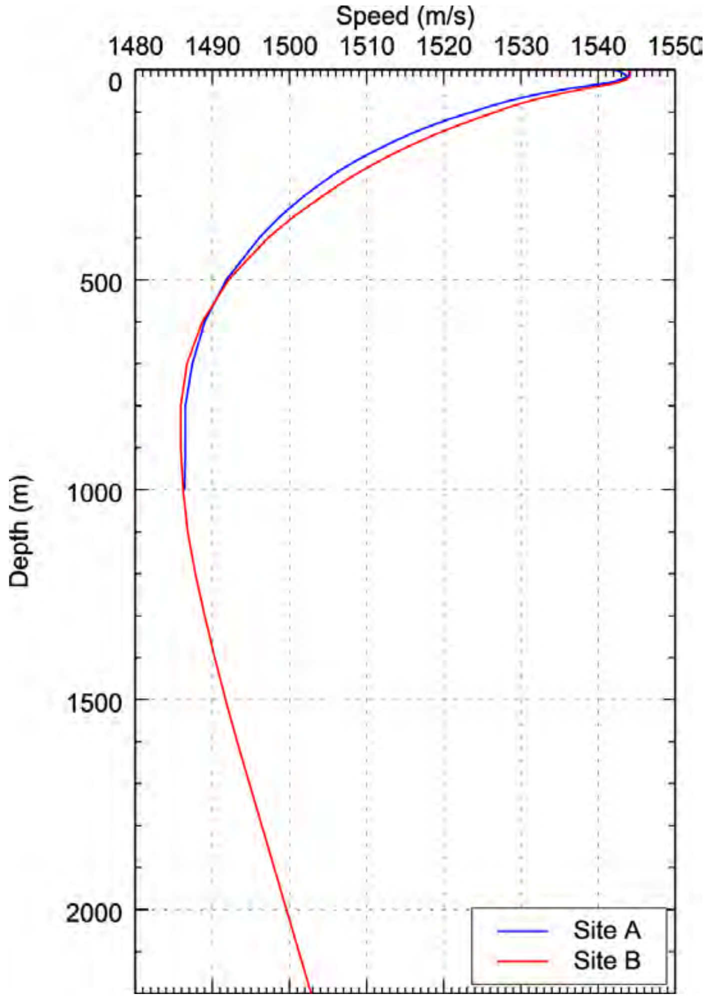


Figure 12. Sound speed profiles for August in the Mississippi Canyon, Gulf of Mexico at Survey sites A and B, derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

6.2.5. Marine Mammals Density Estimates

Density estimates, animals/km^2, for marine mammal species from survey data can be obtained from the online Strategic Environmental Research and Development Program (SERDP) Spatial Decision Support System (SDSS) hosted by Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS SEAMAP) at Duke University. For the Gulf of Mexico, the U.S. Navy OPAREA Density Estimate (NODE; DoN 2007) model is available. The NODE data for the Gulf of Mexico are based on shipboard surveys conducted between 1994 and 2004 by the National Marine Fisheries Service-Southeast Fisheries Science Center (NMFS-SEFSC). Surveys conducted before 2003 were in conjunction with Southeast Area Monitoring and Assessment Program (SEAMAP) as adjuncts to cruises designed as ichthyoplankton sampling surveys. The NODE database generates seasonal density estimates for each species based on a statistical analysis of the survey data. For species with adequate sighting data, the DISTANCE model (Buckland et al. 2001) was used to generate density estimates. For species with too few sightings for the DISTANCE model to create a density, NOAA's stock assessment report (SAR; Waring et al. 2013) data were used to generate density by dividing abundance by the regional area.

Seasons were defined by the mean sea surface temperature (DoN 2007) as:

- Winter: 23 Dec through 2 Apr
- Spring: 3 Apr through 1 Jul
- Summer: 2 Jul through 28 Sep
- Fall: 29 Sep through 22 Dec

The DISTANCE model is a regression model (as opposed to a habitat suitability model), and, as with any model, a number of assumptions and simplifications are required. A notable assumption when generating the NODE database was that the estimating bias—the probability of detecting an object on a transect line, $g(0)$—was set to 1. That is, no correction is made to the density estimates to account for animals missed during the survey. Animals can be missed for a variety of reasons, including deep or long diving times for species including sperm whales and beaked whales. With no correction for the estimation bias, the density estimates should be regarded as floor estimates. Figures 13 and 14 are examples of density estimates for sperm whales obtained at Survey sites A and B, respectively. Tables 11 and 12 list the marine mammal density estimates for the species evaluated. The minimum, maximum, and mean density estimates for the region of interest are shown.

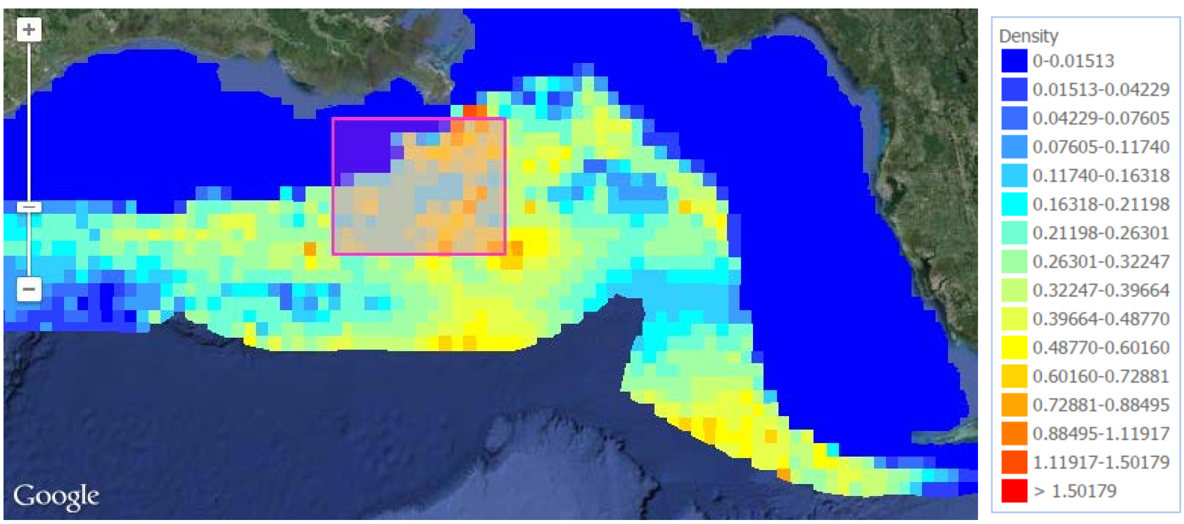


Figure 13. Density estimates for sperm whales near Survey site A in the Gulf of Mexico from NODES model. Density is animals/km^2. The red rectangle represents the area around the survey site for which density estimates were obtained.

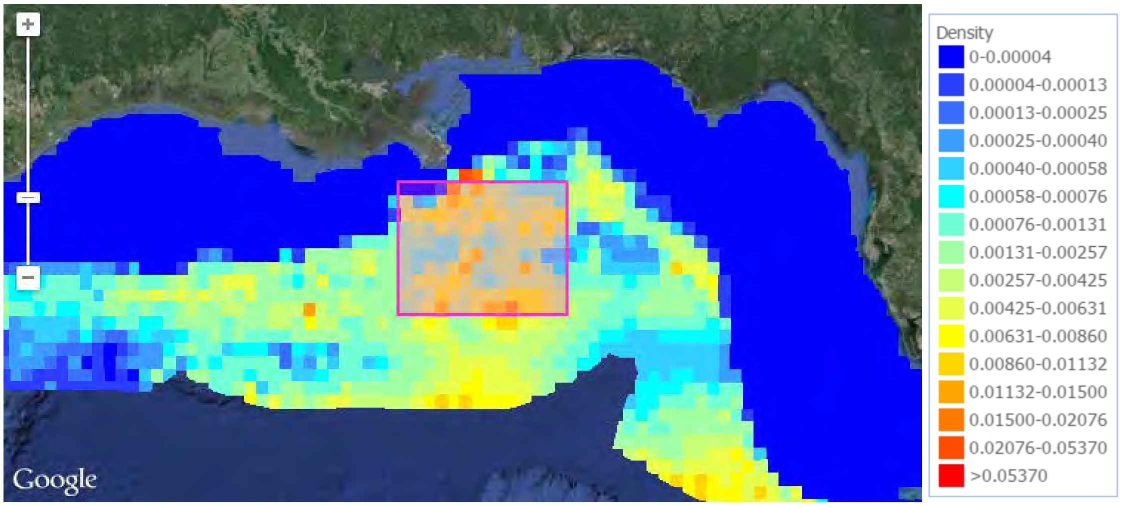


Figure 14. Density estimates for sperm whales near Survey site B in the Gulf of Mexico from NODES model. Density is animals/km^2. The red rectangle represents the area around the survey site for which density estimates were obtained.

Table 11. Summer regional statistics of marine mammal density near Survey site A for the Gulf of Mexico.

Common name	Regional Density (animals/km^2)		
	Minimum	Maximum	Mean
Bryde's whales	0	0.000105	0.000081
Cuvier's beaked whales	0.000003	0.004121	0.000676
Common bottlenose dolphins†	0	0.107	0.01387
Short-finned pilot whales†	0	0.006277	0.004845
Sperm whales†	0.000036	0.008154	0.002761
Dwarf sperm whales	0	0.004605	0.000673

† Density estimates from SERDP-SDSS NODES database derived from NMFS-SEFSC survey data.

Table 12. Summer regional statistics of marine mammal density near Survey site B for the Gulf of Mexico.

Common name	Regional Density (animals/km^2)		
	Minimum	Maximum	Mean
Bryde's whales	0	0.000105	0.000097
Cuvier's beaked whales	0	0.004121	0.000809
Common bottlenose dolphins†	0	0.08429	0.001525
Short-finned pilot whales†	0	0.006277	0.005785
Sperm whales†	0.000365	0.005395	0.002311
Dwarf sperm whales	0.000002	0.01558	0.001589

† Density estimates from SERDP-SDSS NODES database derived from NMFS-SEFSC survey data.

6.2.6. Animal Movement Modeling

In in Phase I analysis, the Marine Mammal Movement and Behavior (3MB) model developed by Houser (2006) was used. 3MB is included in the Effects of Sound on the Marine Environment (ESME) interface developed by the Office of Naval Research (ONR) and Boston University (Gisiner et al. 2006, Shyu and Hillison 2006). ESME is an open-source software program conveniently combines animal movement models and computed sound fields. For the current application, ESME was modified so that it used the sound fields from the study area. 3MB uses a number of parameters to simulate realistic animal movement. It was necessary to determine these parameters from published studies for the simulated species (see Appendix D).

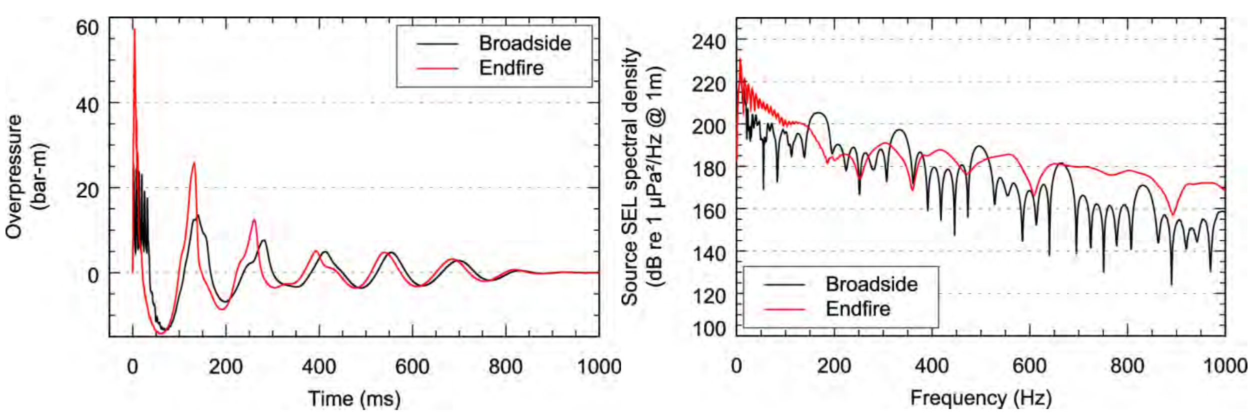
6.3. Test Case Results

6.3.1. Acoustic Sources: Levels and Directivity

The pressure signatures of the individual airguns and the composite 1/3-octave-band source levels of the array, as functions of azimuthal angle (in the horizontal plan), were computed with AASM as described in Section 5.1. While effects of source depth on bubble interactions are accounted for in the AASM source model, the surface-reflected signal (i.e., surface ghost) is not included in the far-field source signatures. The surface reflections, a property of the medium rather than the source, are accounted for by the acoustic propagation models.

6.3.1.1. 8000 in³ Airgun Array

The horizontal overpressure signatures and corresponding power spectrum levels for the 8000 in^3 array, when stationary at a depth of 8 m (to the vertical center of the gun clusters), are shown in Figure 15 and Table 13 for the broadside (perpendicular to the tow direction) and endfire (parallel to the tow direction) directions. The signatures consist of a strong primary peak related to the initial firing of the airguns, followed by a series of pulses associated with bubble oscillations. Most energy is produced at frequencies below 200 Hz (Figure 15b). The spectrum contains peaks and nulls resulting from interference among airguns in the array, where the frequencies at which they occur depend on the volumes of the airguns and their locations within the array. The maximum (horizontal) 1/3-octave-band sound levels over all directions are plotted in Figure 16. The horizontal 1/3-octave-band directivities are shown in Figure 17.



(a) (b)

Figure 15. The 8000 in^3 array: Predicted (a) overpressure signature and (b) power spectrum in the broadside and endfire (horizontal) directions. Surface ghosts (effects of the pulse reflection at

the water surface) are not included in these signatures as they are accounted for by the MONM propagation model.

Table 13. Horizontal source level specifications (10–5000 Hz) for the seismic airgun array (8000 in^3) at 8 m depth, computed with AASM in the broadside and endfire directions. Surface ghost effects are not included as they are accounted for by the MONM propagation model.

Direction	Zero-to-peak SPL (dB re 1 μPa @ 1 m)	SEL (dB re 1 μPa^2 @ 1 m)		
		0.01–2 kHz	0.01–1 kHz	1–2 kHz
Broadside	248.1	225.7	225.7	182.2
Endfire	255.2	231.8	231.8	189.6

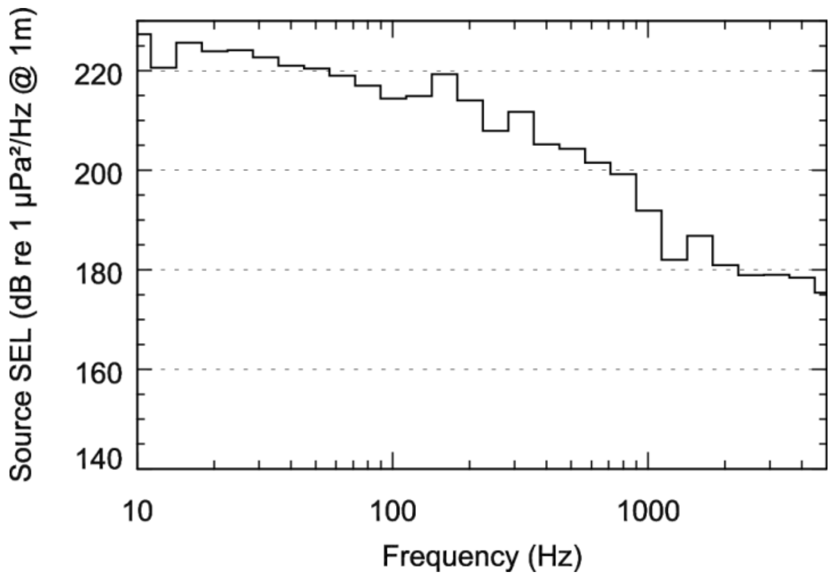


Figure 16. Maximum directional source level (SL) in the horizontal plane, in each 1/3-octave-band, for the 8000 in^3 airgun array (10–5000 Hz).

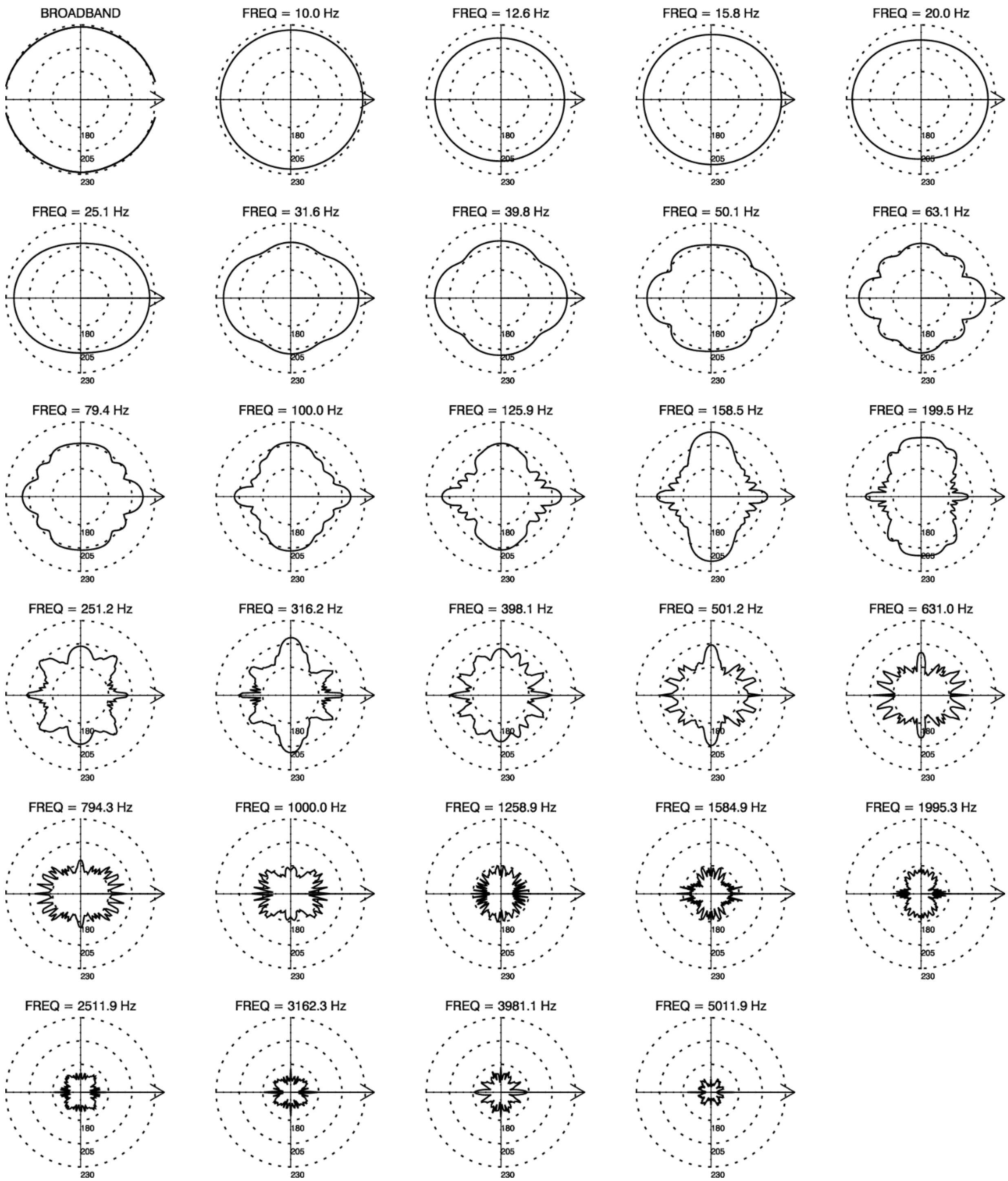


Figure 17. Horizontal directivity of the 8000 in^3 array. Source levels (SLs, dB re 1 $\mu Pa^2 \cdot s$) in 1/3-octave-bands. The 1/3-octave-band center frequencies are indicated above each plot.

6.3.1.2. Per-Pulse Acoustic Field for Input to ESME

The per-pulse acoustic field propagation modeling for input to ESME was computed for the Survey site A and Survey site B modeling locations. Transmission loss for the purpose of exposure simulation was modeled along 16 radial profiles (angular step 22.5°) to the range of up to 50 km from the source location. The horizontal step along the radials was 10 m. At each surface sampling location, the sound field was sampled at multiple depths with equal vertical steps of 10 m down to the maximum water depth along the profile.

The frequencies up to 5 kHz for the airgun array source were considered in the calculations of the broadband received levels. All 1/3-octave-band frequencies from 10 Hz to 5 kHz were used for the airgun array source level modeling (Section 7.3.1). For the transmission loss calculations, frequencies higher than 2 kHz are computationally intensive, so it was assumed that the transmission loss field for higher frequencies (up to 5 kHz) was identical to that at 2 kHz.

The broadband acoustic field passed as input to ESME was in SEL metrics and was both range and depth dependent (Figure 18).

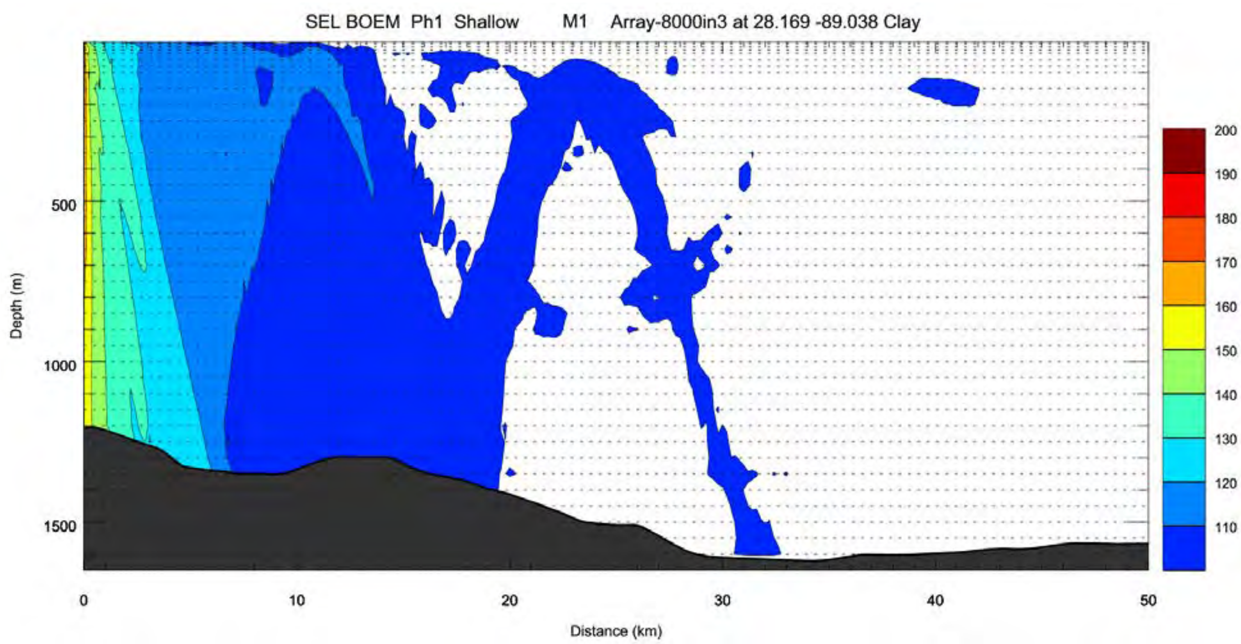


Figure 18. An example of per-pulse received SEL field (with mid-frequency cetacean auditory frequency weighting applied) from the 8000 in³ airgun array at the S01 modeling province.

6.3.1.3. Range to Zero-to-Peak SPL Isopleths

To evaluate the risk of acoustic injury, the range to the unweighted, zero-to-peak SPL (dB re 1µPa) was needed to the 200 dB isopleth (high-frequency cetaceans) and 230 dB isopleth (low- and mid-frequency cetaceans). The ranges were calculated assuming spherical spreading from a point source starting with the maximum source level of the airgun arrays being considered. The maximum zero-to-peak source level for the 8000 in^3 array was 255.2 dB re 1µPa in the endfire direction (Table 13; the broadside source level was lower). The range to 200 dB zero-to-peak SPL re 1µPa was 575.4 m and the range to 230 dB zero-to-peak SPL re 1µPa was 18.2 m. The source level of the array is a theoretical definition assuming a point source and measurement in the far field of the source. The 230 dB isopleth was within the near field of the array where the definition of source level breaks down, so actual locations within the 18.2 m of the array center (or near any one airgun) where the sound level exceeds 230 dB zero-to-peak SPL re 1µPa did not necessarily exist. The 200 dB isopleth, however, was in the far field and sound levels within 575.4 m of the center of the array did experience sound levels exceeding 200 dB zero-to-peak SPL re 1µPa. The number of animals expected to come within the 200 dB and 230 dB isopleths were determined for the high-frequency, and low-frequency and mid-frequency cetaceans, respectively.

6.3.2. Simulation Exposure Estimates

The amount of acoustic energy received depends on where in the sound field, both horizontally and vertically, an animal is when the sound source is active. Animal movement was simulated using the Marine Mammal Movement and Behavior (3MB) model, and ESME was used to sample the sound field produced by the airgun array. Sampling the sound field(s) produced during an operation using a simulated animal (animat) provided a history of acoustic exposure for that animat. The acoustic exposure history of many animats yields the probability, or risk, of exposure due to operations.

Two sites were chosen near the Mississippi Canyon to conduct hypothetical, though typical, WAZ surveys. Survey site A was centered on the slope of the continental shelf break with the survey extending into shallow waters on the continental shelf. Survey site B was centered in deeper water though the survey also included the slope of the continental shelf break. The longitudinal tow direction of the vessels was selected for computational efficiency.

The WAZ survey area was covered in a racetrack fashion using four seismic vessels, each towing a single airgun array. Production segments were 100 km long and the overall survey width was 60 km. Each production segment included 5 km run-in and run-off segments, and the turning segment to the next track line in the opposite direction was 30 km. For the first vessel, the lateral offset to the track in the opposite direction was 30 km. The other vessels had identical track geometries, but laterally shifted by 350 m relative to their neighbors. There was also a 2700 m shift along the track for each vessel, so the vessels were not moving side-by-side (inset Figure 19). Each vessel delivered a seismic pulse every 60 s (15 s for the vessel group), and vessel speed was 4 kts.

To account for variability of sound propagation due to changing water depth, the acoustic field was pre-computed at four locations for each of the survey areas. For each location, the 2-D acoustic field was calculated for 16 radials emanating from the source (airgun array). For each shot during the simulation, an acoustic field was selected from the pre-computed set based on the nearest neighborhood method.

To evaluate potential behavioral response, 30 day simulations of hypothetical WAZ surveys (Survey sites A and B) were run for each of the species evaluated (Figure 19). The boundaries of the simulation were determined from transmission loss calculations by finding the maximum range at which an animat could receive an rms SPL ≥ 120 dB re 1µPa (the lowest exposure levels at which impacts are expected). The maximum range was estimated at 50 km. To evaluate potential behavioral disruption, the simulation area was defined based on the perimeter of the survey tracks with an extension of 50 km on each side with the exception for the north side at Survey site A, where the extension was 35 km due to proximity of the shore. The simulation areas for Survey sites A and B were 214 × 144 km (30,800 km^2) and \212 × 161 km (34,100 km^2), respectively. To evaluate potential injury, the width of the survey was reduced to 11 km (Figure 20), and duration of 5 days. The boundaries of the simulation were extended by 5 km on each side of the survey area for 214 × 21 km (5061 km^2) areas at both Survey site A and Survey site B (Figure 20). The animat density for simulations were 0.1 and 2 animats/km^2 for behavior and injury, respectively.

Exposure levels were determined for the combined effect of the sources. Results for each of the marine mammal species are shown in Table 14 for Survey site A and Table 15 for Survey site B. Appendix A shows the frequency of exposure level for each simulation.

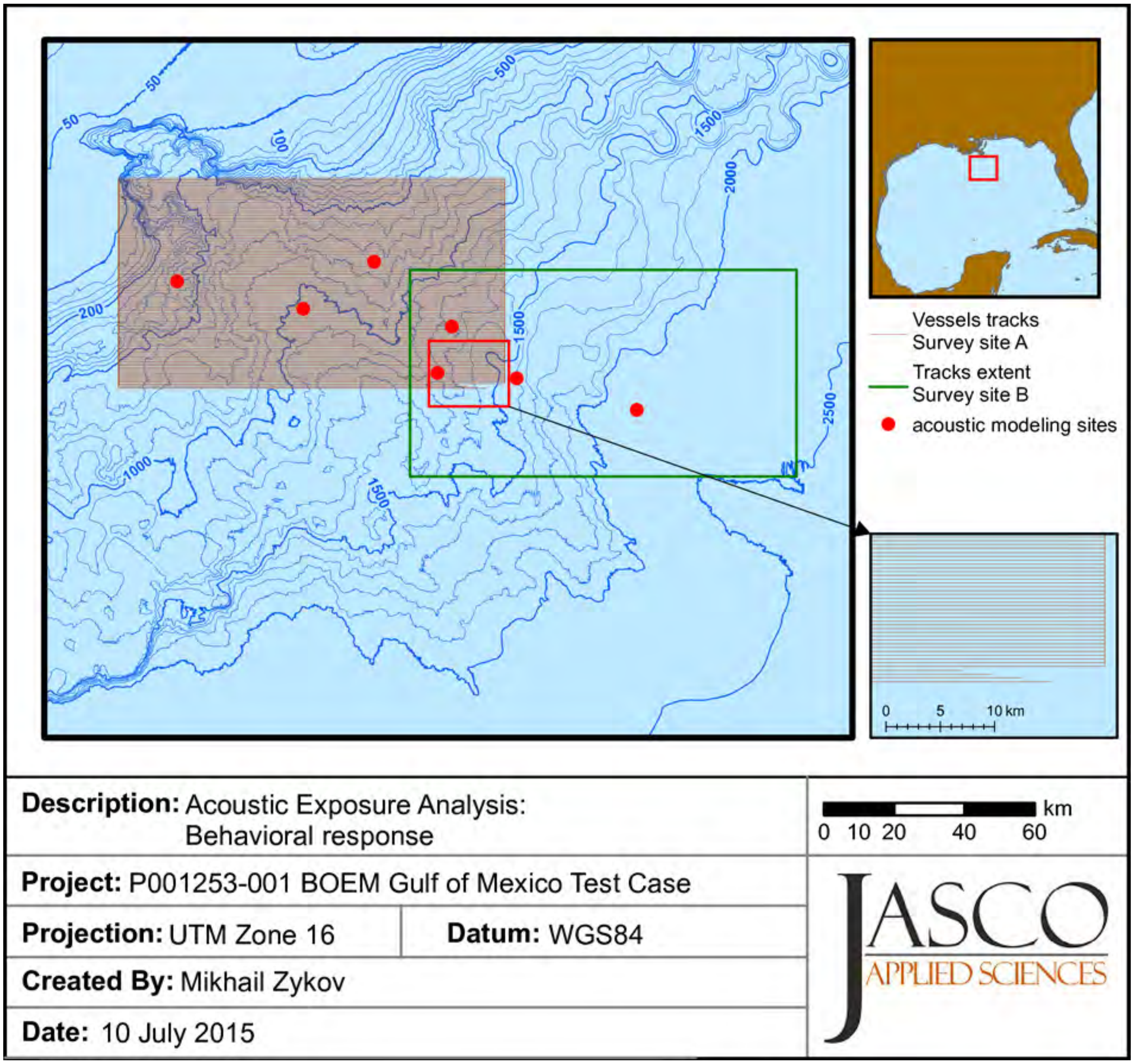


Figure 19. Vessel track locations for behavioral response analysis at Survey sites A and B. Inset shows the starting point in the southeast corner.

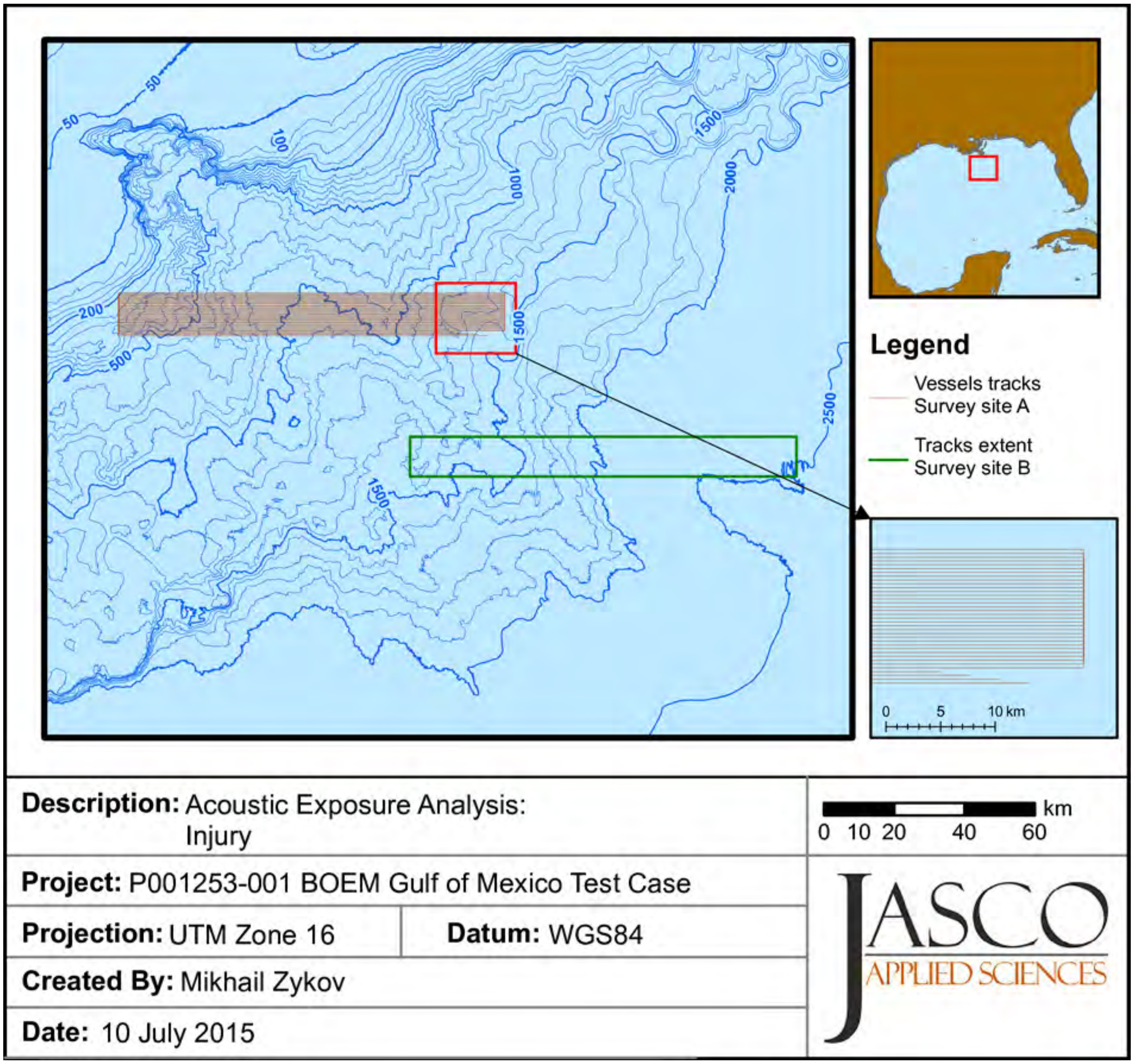


Figure 20. Vessel track locations for injury analysis at Survey sites A and B. Inset shows the starting point in the southeast corner.

Table 14. Number of modeled cetaceans above exposure criteria for Survey site A for entire duration of the simulations. Simulations for zero-to-peak SPL and SEL injury metrics were 5 day duration with animat density of 2.0 animats/km^2. Simulations for rms SPL metrics were 30 day duration with animat density of 0.1 animats/km^2.

Marine mammal species	Injury			Behavior	
	zero-to-peak SPL	SEL	180 dB rms SPL	160 dB rms SPL	Step fxn. rms SPL
Bryde's whales	47	534	348	571	637
Cuvier's beaked whales	45	0	276	577	1941.4
Common bottlenose dolphins	105	0	246	342	439.2
Short-finned pilot whales	106	1	240	330	425
Sperm whales	15	1	166	349	386.5
Dwarf sperm whales	7060	1053	209	343	405

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square.

Table 15. Number of modeled cetaceans above exposure criteria for Survey site B for entire duration of the simulations. Simulations for zero-to-Peak SPL and SEL injury metrics were 5 day duration with animat density of 2.0 animats/km^2. Simulations for rms SPL metrics were 30 day duration with animat density of 0.1 animats/km^2.

Marine mammal species	Injury			Behavior	
	zero-to-peak SPL	SEL	180 dB rms SPL	160 dB rms SPL	Step fxn. rms SPL
Bryde's whales	51	485	313	357	529.8
Cuvier's beaked whales	38	0	300	491	1829.2
Common bottlenose dolphins	99	0	254	285	411
Short-finned pilot whales	102	0	263	315	426.6
Sperm whales	35	0	381	701	789.9
Dwarf sperm whales	7246	893	242	337	417.7

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square

6.3.3. Real-world Individual Exposure Estimates

Simulations were run with animat densities (animats/km^2) greater than are typically found in the real world in order to generate reliable exposure probability density functions for each species. The numbers of exposures, therefore, must be adjusted for the species real-world density. Minimum, maximum, and mean regional real-world densities estimates were obtained from the U.S. Navy OPAREA Density Estimate (NODE) model for the Gulf of Mexico (DoN 2007, as shown in Section 6.2.5 and Table 11). The real-world number of cetacean individuals expected to exceed the injury exposure criteria is shown for Survey sites A and B in Tables 16 and 17, respectively. Likewise, the real-world number of cetacean individuals expected to exceed the behavioral disruption exposure criteria is shown for Survey sites A and B in Tables 18 and21, respectively.

Table 16. Real-world number of cetaceans above injury exposure criteria for summer for Survey site A.

Marine mammal species	peak SPL			SEL			180 dB rms SPL		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bryde's whales	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.02	< 0.01	0.37	0.28
Cuvier's beaked whales	< 0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	59.56	5.43
Common bottlenose dolphins	< 0.01	5.62	0.73	< 0.01	0.05	0.01	< 0.01	714.63	53.65
Short-finned pilot whales	< 0.01	0.14	0.11	< 0.01	< 0.01	< 0.01	< 0.01	15.06	11.63
Sperm whales	< 0.01	0.42	0.14	< 0.01	< 0.01	< 0.01	< 0.01	45.68	4.73
Dwarf sperm whales	< 0.01	16.30	2.38	< 0.01	2.42	0.35	< 0.01	11.59	1.29

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square; min=minimum; max=maximum

Table 17. Real-world number of cetaceans above injury exposure criteria for summer for Survey site B.

Marine mammal species	peak SPL			SEL			180 dB rms SPL		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bryde's whales	< 0.01	< 0.01	< 0.01	< 0.01	0.03	0.02	< 0.01	0.33	0.30
Cuvier's beaked whales	< 0.01	0.07	0.01	< 0.01	< 0.01	< 0.01	< 0.01	52.26	5.49
Common bottlenose dolphins	< 0.01	4.21	0.08	< 0.01	< 0.01	< 0.01	< 0.01	250.42	8.20
Short-finned pilot whales	< 0.01	0.12	0.11	< 0.01	< 0.01	< 0.01	< 0.01	16.51	15.21
Sperm whales	< 0.01	0.27	0.11	< 0.01	< 0.01	< 0.01	< 0.01	104.85	13.57
Dwarf sperm whales	< 0.01	56.45	5.76	< 0.01	6.95	0.71	< 0.01	33.15	3.33

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square; min=minimum; max=maximum

Table 18. Real-world number of cetaceans above behavioral exposure criteria for summer for Survey site A.

Marine mammal species	Step fxn. max. rms SPL			160 dB rms SPL		
	Min	Min	Min	Min	Max	Mean
Bryde's whales	< 0.01	0.76	0.59	< 0.01	0.60	0.46
Cuvier's beaked whales	0.10	140.57	23.06	< 0.01	124.52	11.34
Common bottlenose dolphins	< 0.01	522.16	67.69	< 0.01	993.51	74.59
Short-finned pilot whales	< 0.01	30.18	23.29	< 0.01	20.71	15.99
Sperm whales	0.16	35.96	12.18	< 0.01	96.04	9.95
Dwarf sperm whales	< 0.01	20.75	3.03	< 0.01	19.03	2.12

SPL=sound pressure level; rms=root-mean-square; min=minimum; max=maximum

Table 19. Real-world number of cetaceans above behavioral exposure criteria for summer for Survey site B.

Marine mammal species	Step fxn. max. rms SPL			160 dB rms SPL		
	Min	Min	Min	Min	Max	Mean
Bryde's whales	< 0.01	0.75	0.69	< 0.01	0.37	0.35
Cuvier's beaked whales	< 0.01	99.11	19.46	< 0.01	85.53	8.98
Common bottlenose dolphins	< 0.01	383.18	6.93	< 0.01	280.98	9.20
Short-finned pilot whales	< 0.01	29.41	27.10	< 0.01	19.77	18.22
Sperm whales	3.31	48.99	20.98	< 0.01	192.92	24.97
Dwarf sperm whales	0.01	71.12	7.25	0.01	46.17	4.64

SPL=sound pressure level; rms=root-mean-square; min=minimum; max=maximum

6.4. Test Case Exposure Summary

The estimated number of animals exposed to levels exceeding the acoustic exposure thresholds was determined for the two WAZ survey sites. For injury, it was found that relative to the other species, a large number of dwarf sperm whales may be exposed to levels exceeding both the SEL and zero-to-peak SPL thresholds. It was also found that a relatively high number of Bryde's whales may be exposed to levels exceeding the SEL injury threshold. Dwarf sperm whales are a high-frequency species with greater susceptibility to injury than the other species. For this reason, injury thresholds were lower for dwarf sperm whales and as a result the number of animats exposed to levels exceeding threshold was higher. Bryde's whales are low frequency animals and most of the acoustic energy emanating from an airgun is low frequency. Because less restrictive filtering (Type I M weighting) was used to calculate the sound field for the low-frequency species, the ensonified area above threshold was much greater than for mid-frequency species and therefore the number of animats exposed to levels exceeding threshold is higher. For Bryde's whales, the estimated real-world density is low so the predicted real-world number of animals exposed to levels exceeding injury criteria is less than one animal. The estimated real-world density of dwarf sperm whales is higher and, therefore, the predicted number of real-world animals exposed to levels exceeding injury threshold was up to 56.5 animals (Survey site B and maximum density estimate).

The volume over which behavioral disturbance may occur is greater than the volume over which injury may occur. Animats for all species were found to exceed thresholds for potential behavioral disturbance. Cuvier's beaked whales had the greatest number of exceedances because, as a behaviorally sensitive species, the step function used to assess their potential for behavioral disturbance starts at lower sound levels (120 dB rms SPL versus 140 dB rms SPL for the remaining species). It was also found that Bryde's whales and sperm whales had higher exceedance than the common bottlenose dolphins, short-finned pilot whales, and dwarf sperm whales. Because the majority of acoustic energy from the airguns is in the low frequency band (< 1500 Hz) and the low-frequency weighting function permits more low-frequency energy to propagate, the ensonified volume above threshold was larger for low frequency species and results in more animats exposed to sounds above the thresholds. Sperm whales are deep-diving animals and in the downward-refracting acoustic environment are more consistently exposed to sound levels above threshold when diving. This is apparent at Survey site B where a behavioral response was predicted for approximately twice as many sperm whale animats (908) as common bottlenose dolphin, short-finned pilot whale, and dwarf sperm whale animats (all ~ 450). At Survey site A, the number behavioral responses predicted for sperm whales was about the same as the predictions for common bottlenose dolphin, short-finned pilot whale, and dwarf sperm whale animats (all ~ 450). The reason for the difference in the number of behavioral responses predicted for sperm whales at the two sites is that

Survey site A is shallower than Survey site B. Sperm whales generally do not enter water shallower than 1000 m, so during the simulation the animats changed swimming direction to avoid depths < 1000 m. In addition, because much of the area at Survey site A is < 1000 m, a smaller number of animats were used during the simulation (animats are not seeded in depth-restricted areas) so that the animat density remained consistent for all simulations.

6.5. Test Scenarios

Primarily using the results of the Test Case, several scenarios were investigated to determine their potential effects on exposure estimates and to inform the main modeling effort.

Scenarios investigated were:

- Long-duration surveys (Section 6.5.1),
- Sources and effects of uncertainty (Section 6.5.2),
- Mitigation (Section 6.5.3),
- Aversion (Section 6.5.4),
- Stand-off distance (Section 6.5.5.1), and
- Simultaneous firing of sources (Section 6.5.5.2).

6.5.1. Test Scenario 1: Scaling Modeled Acoustic Exposure Estimates

Some seismic surveys operate (nearly) continuously for several months. Evaluating the potential impacts due to underwater sound exposures from these extended operations is challenging because assumptions about parameters that are valid for short-duration simulations may become less valid, or more varied, as the time period increases. For example, the average sound velocity profile changes as the surface layer temperature changes. Also large-scale animal movement, such as migrations or prey movement, may change the density estimate of animals in the simulation area. Treating such parameters as constant, as is typically done in shorter duration simulations, could lead to errors. Systematic bias in modeling processes may also lead to increasing error as the simulation time is increased. Simulated animals (animats) may settle into unrealistic behaviors such as following an arbitrary boundary, or, if animats are allowed to leave the simulation area without a replacement method, a diffusion process will systematically decrease the density.

This Test Scenario investigates the potential impacts of large-scale animal movement and possible systematic bias in the modeling process. Methods for scaling results from shorter-duration simulations to longer duration operations are suggested.

6.5.1.1. Large-scale Animal Movement

Current agent-based animal movement models, such as the Marine Mammal Movement and Behavior (3MB) model (Houser 2006), estimate movement from the current disposition of a simulated animal. Limited, or no, memory of prior states is considered when generating movement changes, such as change of direction or swim speed. These models generate realistic behavior (using swimming and diving parameters) over short durations (days to weeks). They become increasingly less valid as durations are extended because they may not include the effects of long-term behaviors. The models do not account for animal movements on large temporal or spatial scales, and this also may lead to errors. Large-scale marine mammal movement in the Gulf of Mexico and its potential as a source of error in the acoustic exposure estimates is discussed in the subsections below, and further in section 6.5.1.3.1.

6.5.1.1.1. Scaling Methods

The available literature on cetacean distribution and behavior for the six Gulf of Mexico species studied in the Test Case were examined for information on large-scale movement and seasonality. The majority of the Test Case species prefer deeper water (> 200 m), which makes it difficult to obtain detailed information on their distribution and movements. If no quantitative information could be found, knowledge of behavioral and feeding ecology for the species was used to infer possible movement patterns and large-scale movement behavior.

6.5.1.1.2. Assumptions

Potential movement patterns were based on available information regarding the general behavioral and feeding ecologies of the species in question and observed interactions of the species/populations with the environment. The patterns do not account for evolved programs, such as adaptive predator responses (spatial and temporal movement patterns due to behavioral programming to reduce predation risks) or intra- and interspecies competition for resources, as the available information is insufficient to discuss their relevance.

6.5.1.1.3. Prey Distribution as an Environmental Attractor

The distribution of plankton in the deeper waters of the Gulf of Mexico, especially the northern and eastern parts of the Gulf, is controlled by the loop current (Mullin and Fulling 2004). The temporal movement of all organisms, including marine mammals and their prey, may be effected by upwelling of nutrient rich cold water eddies (Davis et al. 2001); however, habitat use appears to be more directly correlated with static features such as water depth, bottom gradient, and longitude (Mullin and Fulling 2004). Temporal fluctuation near the surface can cause changes in diurnal movement patterns in squid, which prefer colder water, but does not substantially affect cetaceans feeding on squid in deeper waters. As a result, the occurrences of the four Test Case odontocetes that rely on squid as a main food source are only affected by water temperature when deeper layers are affected, which is rarely the case. A more critical consequence of feeding on squid that may cause the whales to leave an area may be that squid may learn to avoid the whales by moving to different areas (Long et al. 1989).

6.5.1.1.4. Distribution and Movement Behavior of Modeled Species

Common Bottlenose Dolphins

Common bottlenose dolphins travel and forage in close association with short-finned pilot whales and other species that feed on squid (NOAA Fisheries 2012a), but since common bottlenose dolphins do not regularly perform deep foraging dives, large-scale movements are likely driven by fish movement in the upper ocean layers. The one offshore common bottlenose dolphin population that feeds primarily on schooling fish, but also on squid, is less driven by the vertical diurnal movements of squid (Barros and Odell 1990, Barros and Wells 1998). Other oceanic delphinids, such as some spotted dolphins travel 55–90 km/day (Mullin and Fulling 2004) possibly following fish schools, such as tuna. Common bottlenose dolphin density in a given area is likely to fluctuate because they travel at high speed and in groups of more than 100 individuals (NOAA Fisheries 2015a).

Sperm Whales

Most sperm whales are found in very deep waters (> 3,000 m), but can be encountered in waters as shallow as 300 m. Male and female sperm whales are not usually encountered together, and females are rarely found in waters less than 1000 m deep (Taylor et al. 2008a).

In the northern Gulf of Mexico, sperm whales occur year round, but at higher densities during the summer. There are no discernable seasonal migrations, but Gulf-wide movements occur primarily along the northern Gulf slope. Tracks show that whales exhibit a range of movement patterns within the Gulf, including movement into the southern Gulf in a few cases (Waring et al. 2013, NOAA Fisheries 2015b).

Kingsley and Stirling (1991) reported movements of groups of female sperm whales from different vocal clans ranging from less than 10 km to over 100 km in 24 h. The movements appeared to be driven by differences in dominance rankings between clans; more dominant groups often displace lower ranking clans. This likely causes rapid displacement movement patterns in areas of high prey concentrations. These rapid movements of groups of females due to displacement may show short-term changes in density, but are not likely considerable in magnitude.

Dwarf Sperm Whales

Dwarf sperm whales prefer warm tropical, subtropical, and temperate waters worldwide. They are most common along the waters of the continental shelf edge and the slope; dwarf sperm whales are thought to be more "coastal" than pygmy sperm whales (NOAA Fisheries 2012b).

There is very little information on dwarf sperm whales feeding habits, other than a preference for squid. Information on movement behaviors is practically absent. The density of dwarf sperm whales in the Gulf is considered very low, and members of the species either travel alone or groups of 6–10 animals (NOAA Fisheries 2012b). Würsig et al. (1998) notes that dwarf sperm whales are difficult to survey because they avoid ships and airplanes. This could mean that their density is generally underestimated.

Short-finned Pilot Whales

These whales occur in tropical to cool temperate waters. Sightings in the northern Gulf of Mexico (i.e., U.S. Gulf of Mexico) occur primarily on the continental slope west of 89˚W. There appears to be a year round aggregation of short-finned pilot whales in nutrient rich waters off the Mississippi River outflow. In other areas, pilot whales travel constantly (Mullin and Fulling 2004).

Short-finned pilot whales often occur in groups of 25–50 animals and often co-occur with common bottlenose dolphins and other delphinids. This species feeds on vertically migrating prey, with deep dives at dusk and dawn following vertically migrating prey and near-surface foraging at night (Baird et al. 2003). When they are swimming and probably looking for food, pilot whales form ranks that can be over a kilometer long (Taylor et al. 2011).

Based on food preference and group size information, it appears that short-finned pilot whales may need to travel over large distances to sustain groups of the reported sizes. This will lead to fluctuating densities in any given area as groups of 25–50 animals are possibly widely dispersed in order to avoid competition for patchy food sources. Squid abundance in any given area will be affected by groups of that size and the fact that pilot whales often occur together with odontocetes feeding on the same prey would underline the need for large-scale movement in this species.

Cuvier's Beaked Whales

Beaked whales were seen in all seasons during GulfCet aerial surveys of the northern Gulf of Mexico (Waring et al. 2013). Like many beaked whales, Cuvier's beaked whales eat mostly deep water squid and octopus near the bottom, but will eat fish and crustaceans in the water column. They prefer deep waters (depths usually greater than 1,000 m) of the continental slope, as well as steep underwater geologic features like banks, seamounts, and submarine canyons. Recent surveys suggest that beaked whales, like this species, may favor oceanographic features such as currents, current boundaries, and core ring features (Taylor et al. 2008b).

Cuvier's beaked whales occur individually or in small groups of 2–12 animals (NOAA Fisheries 2012c). Like most beaked whales, information on behavior is sparse, and movements are not well understood. Given their small group sizes, but highly specialized foraging on squid, these whales probably remain in the same area longer than pilot whales. Information on aggregations is not available, which means density fluctuation in a given area is unknown and cannot be accurately assessed. The reported foraging locations over steep topographical structures may indicate avoidance of competition with other odontocetes foraging on the same prey. This may allow Cuvier's beaked whales to remain longer in a specific area.

Bryde's Whales

Bryde's whales are often characterized as displaying erratic and strange behavior relative to other baleen whales because they surface for irregularly spaced time intervals and can unexpectedly change directions (NOAA Fisheries 2014). These large baleen whales are usually sighted individually or in pairs, but there are reports of loose aggregations of up to twenty animals associated with feeding areas. These whales feed opportunistically on plankton, crustaceans, and schooling fish. They regularly dive for about 5–15 min (maximum of 20 min) after 4–7 blows at the surface. Bryde's whales are capable of reaching depths up to 300 m during dives (NOAA Fisheries 2014).

Given the information about feeding behavior and grouping, it appears unlikely that animals move rapidly between feeding areas. There is no information on large-scale movements, but aggregations could be the result of animals moving synchronously toward a certain area of high primary productivity. Bryde's whale distribution and movements are affected by plankton occurrence, which can be patchy due to the presence of large, warm-water eddies in the Gulf of Mexico.

6.5.1.2. Potential Biases in the Modeling Procedure

Underlying, and perhaps unknown, systematic biases in model procedures may lead to errors that could increase with modeling run duration.

6.5.1.2.1. Methods

Exposure estimates from 30 day (0.1 animats/km^2) and 5 day (2.0 animats/km^2) wide azimuth survey simulations from the Test Case (Section 6.3.2) were determined in subsets using a 'sliding window' to find the number of exposures as a function of time. The length of the sliding window was 24 h, advanced by 4 h, resulting in 174 samples from the 30 day simulation and 25 samples from the 5 day simulation. A sliding window of 7 days advancing by 1 day for the 30 day simulation was also be evaluated. Exposures were calculated using the behavioral threshold criteria indicated in the Test Case (Section 5.4.3). Bias in the model was expected to manifest itself as a trend in the exposure levels as a function of time.

The survey vessel paths in the simulations begin in the south east corner of the survey area, proceed on a westward longitudinal production line, step north at the end of the survey area, and then start on an eastward longitudinal production line (Figures 19 and 20). Simulations with 'reversed' track lines at Survey site A (starting in the northwest corner of the survey area, initially proceeding eastward on a longitudinal production line, and then stepping south) were also analyzed for short-finned pilot whales and sperm whales. To eliminate trends and variance due to changing sound fields (as the vessels move) and depth constraints, simulations were run with a stationary source in deep water (2000 m) and a flat bottom.

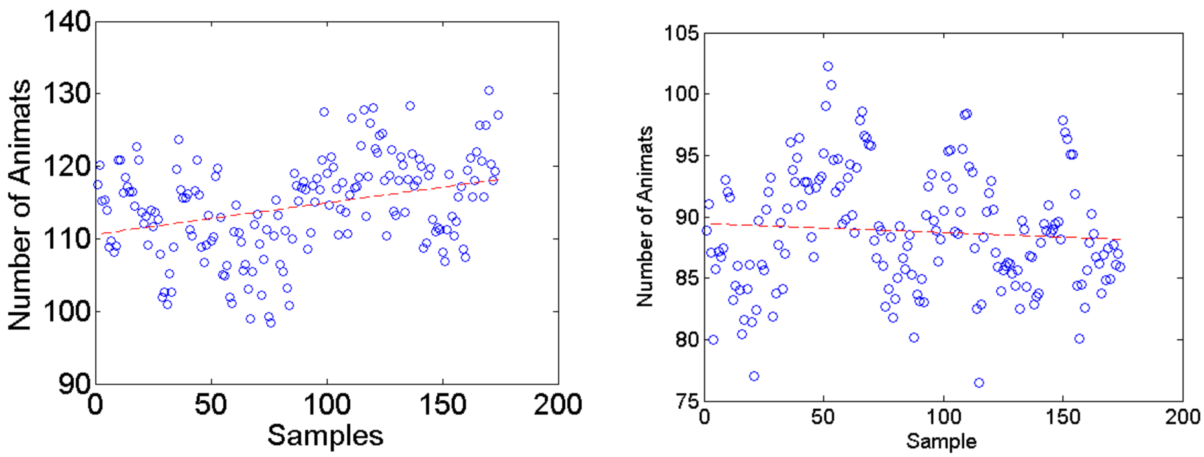
During all simulations in this project, any animat that left the simulation area as it crossed the simulation boundary was replaced by a new animat traveling in the same direction and entering at the opposite boundary. For example, an animat heading north and crossing the northern boundary of the simulation was replaced by a new animat heading north and entering at the southern boundary. By replacing animats in this manner, the animat modeling density remained constant.

Also common to all analysis in this project was that animats were only allowed to be 'taken' once during an evaluation period. That is, an animat whose received level exceeds the peak SPL threshold more than once during an evaluation period (i.e., 24 h, 7 day, or 30 day) was only counted once. Energy accumulation for SEL occurred throughout the evaluation period and was reset at the beginning of each period. Similarly, the maximum received rms SPL was determined for the entirety of the evaluation period and reset at the beginning of each period. The consequences of using a short time-period, such as 24 h, was evaluated.

6.5.1.2.2. Results

The number of animats exposed to levels exceeding the behavioral step function criteria in 30 day simulations evaluated using a 24 h sliding window are shown in Figure 21 for the low-frequency Bryde's whales at Survey sites A and B. In Figure 21, least-squares fitted trend lines show a positive trend at Survey site A indicating increasing exposures as function of simulation time, and a negative trend at Survey site B indicating decreasing exposures as a function of simulation time, but residual analysis did not find either trend to be significant. For the other species, the trend lines at Survey site A, though not necessarily significant, were negative, indicating decreasing exposures as a function of simulation time: common bottlenose dolphins (Figure 22a), Cuvier's beaked whales (Figure 23a), short-finned pilot whales (Figure 24a), sperm whales (Figure 25a), and dwarf sperm whales (Figure 26a). The trend lines at Survey site B for these species (Figure 22b–26b) were less pronounced, positive for common bottlenose dolphins and sperm whales, and negative for Cuvier's beaked whales, short-finned pilot whales, and dwarf sperm whales.

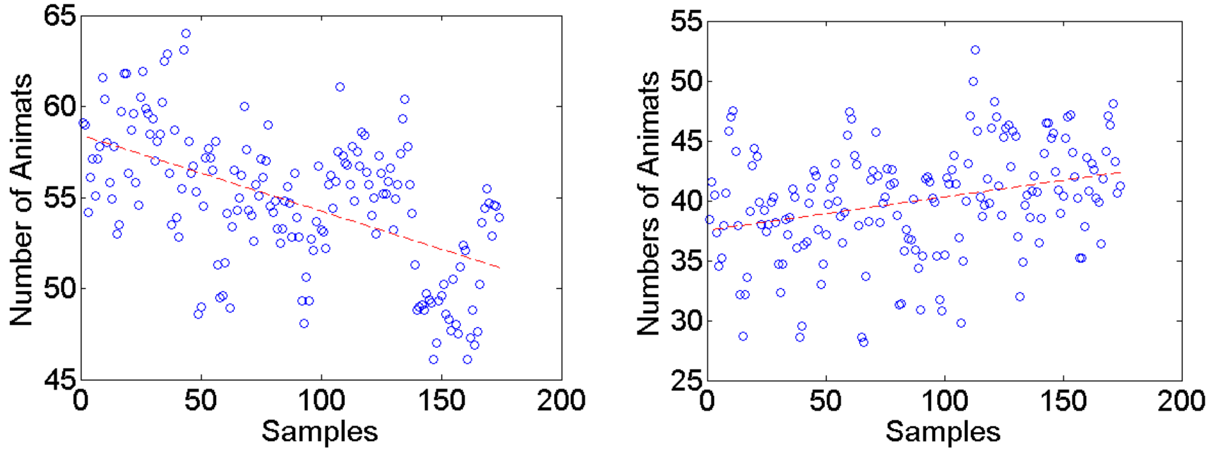
The exposure estimates as a function of simulation time and trend lines for 'reversed' track lines are shown in Figure 27. For short-finned pilot whales and sperm whales, the trend lines were positive. Figure 28 shows that the variability in the exposure estimates decreased, and there was no significant trend as a function of simulation time when the source was stationary and there were no depth constraints on the animats.



(a) (b)

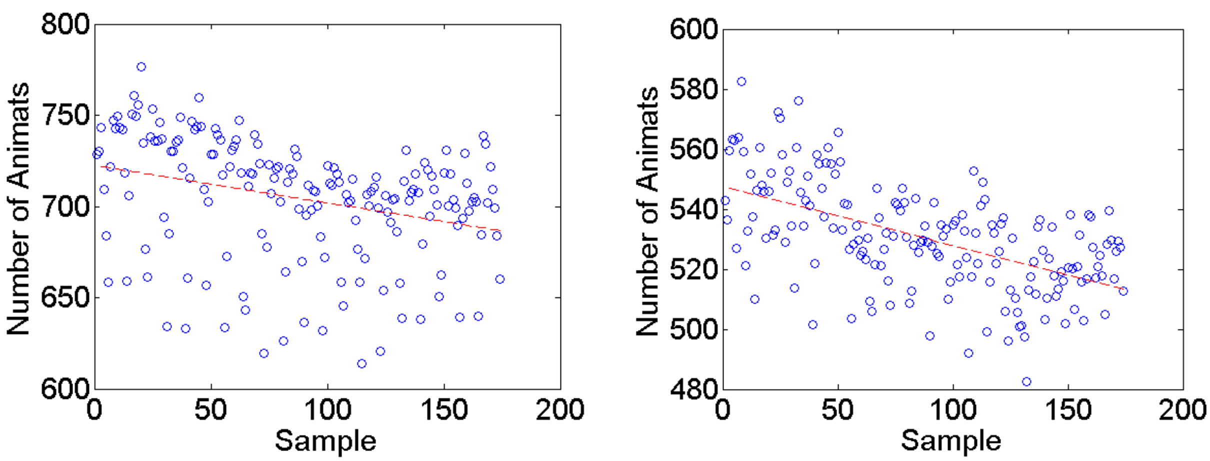
Figure 21. Bryde's whales: Behavioral exposure estimates for (a) Survey sites A and (b) B. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30

day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.



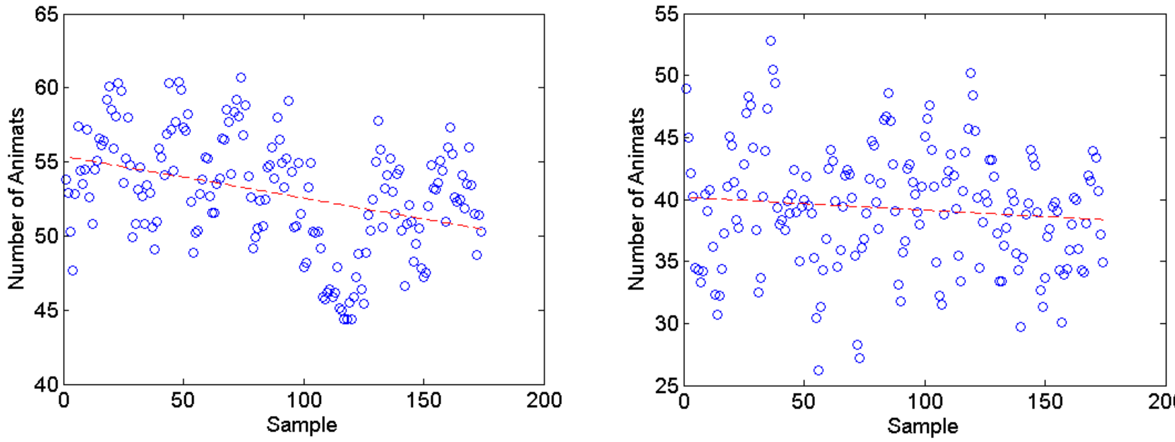
(a) (b)

Figure 22. Common bottlenose dolphins: Behavioral exposure estimates for (a) Survey sites A and (b) B. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30 day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.



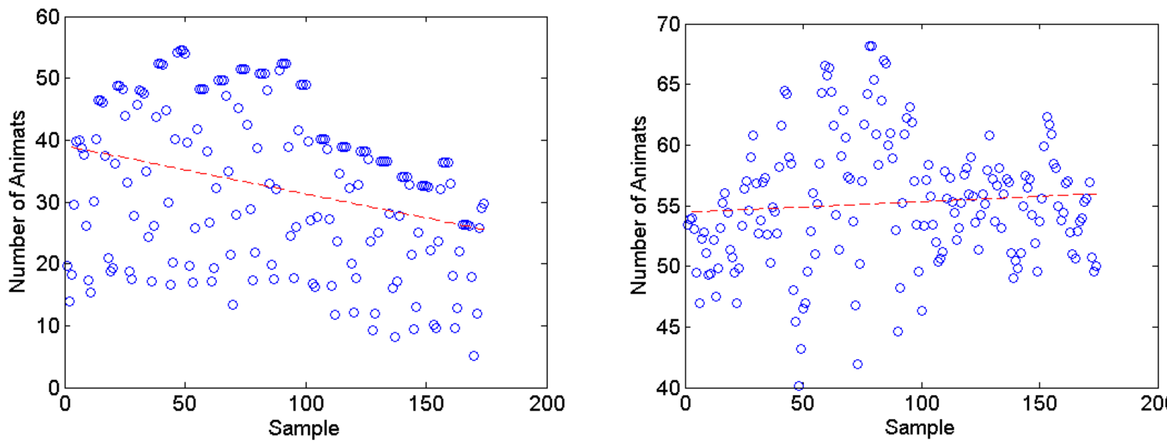
(a) (b)

Figure 23. Cuvier's beaked whales: Behavioral exposure estimates for (a) Survey sites A and (b) B. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30 day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.



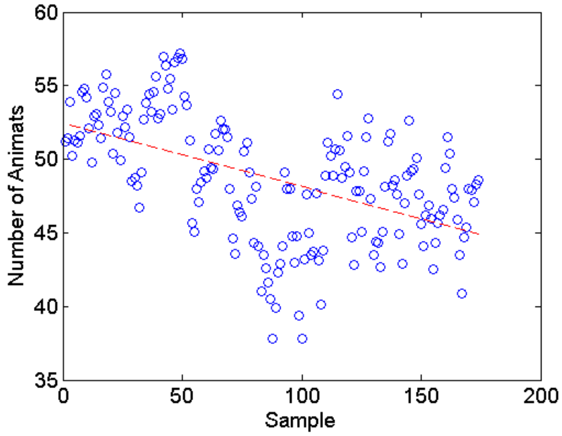
(a) (b)

Figure 24. Short-finned pilot whales: Behavioral exposure estimates for (a) Survey sites A and (b) B. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30 day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.

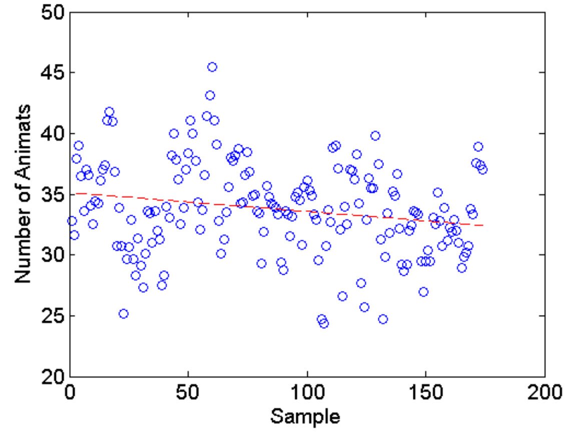


(a) (b)

Figure 25. Sperm whales: Behavioral exposure estimates for (a) Survey sites A and (b) B. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30 day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.

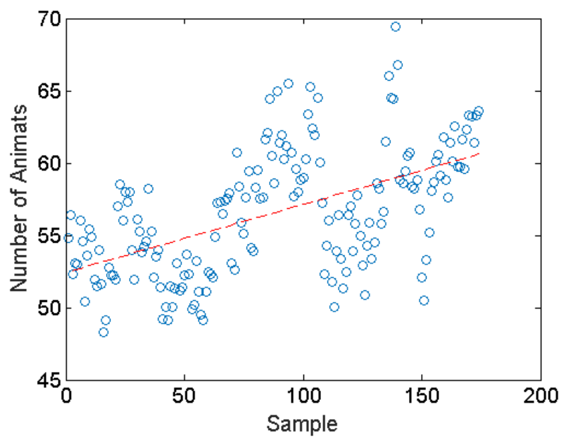


(a)

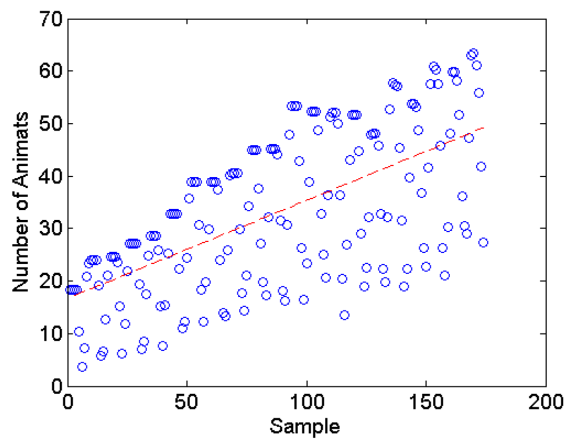


(b)

Figure 26. Dwarf sperm whales: Behavioral exposure estimates for (a) Survey sites A and (b) B. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30 day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.

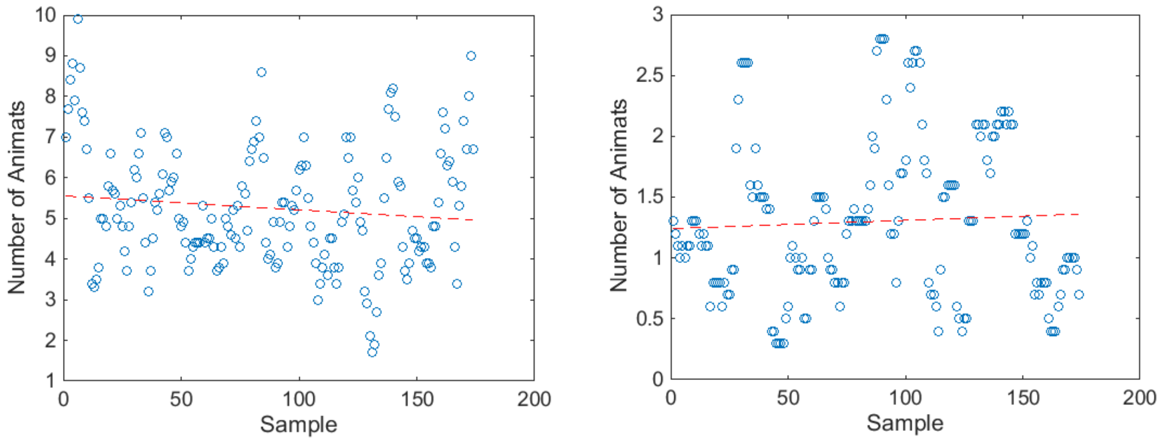


(a)



(b)

Figure 27. Behavioral exposure estimates for (a) short-finned pilot whales and (b) sperm whales, both with reversed vessel tracks at Survey site A. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30-day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.



(a) (b)

Figure 28. Behavioral exposure estimates for (a) short-finned pilot whales and (b) sperm whales, with stationary source in deep water near Survey site B. Exposure estimates are for 24 h sliding windows (samples), which advance in 4 h increments during 30 day simulations. Circle markers indicate exposure estimates during each 24 h sample period, dashed red line is a least-squares fit.

The Test Case preliminary results found the number of animats exposed to levels exceeding threshold criteria for the entire duration of the simulations—5 days for the zero-to-peak SPL and SEL and 30 days for the criteria based on rms SPL (Table 14 and Table 15). It is often impractical or unwarranted to integrate exposures for an entire survey and an integration window is defined. A 24 h time-period for determining potential impacts is commonly used. Table 20 and Table 21 show the average number of animats receiving levels exceeding exposure criteria in the 24 h sliding windows at Survey sites A and B, respectively. To estimate the number of animats receiving levels exceeding threshold for a longer duration survey, the 24 h average was scaled by the survey duration in days. Table 22 and Table 23 show the 24 h averages scaled to the simulation length (5 days for zero-to-peak SPL and SEL, and 30 days for the criteria based on rms SPL) and the percentage of the full-duration estimates that the scaled values represent (shown in parenthesis). It can be seen in Tables 22 and 23 that when scaling the 24 h averages for the rms SPL-based criteria, the percentages were uniformly positive, indicating that scaling resulted in a greater number of animats predicted to received levels exceed these criteria. The increased number of animats estimated to exceed threshold could be quite large, several times the estimate for the full duration (100% is twice the full duration estimate). For the zero-to-peak and SEL metrics the difference between the scaled estimates and the full-duration estimates was smaller and the scaled values may be less than the full duration values (indicated by a negative percentage). Because SEL accumulates throughout the evaluation period, it is possible that some animats' received level SELs would not exceed threshold in 24 h, but would when integrated over the full duration of the simulation. The zero-to-peak SPL criteria does not accumulate and animats were only counted once per evaluation period, so a reduced number of estimated exceedances for the scaled values compared to the full-duration values was not expected. To investigate, the 24 h estimates were scaled (by 4) and compared to a 4 day evaluation period starting 12 h into the 5 day simulation. Tables 26 and 27 shows that the percentage difference between the scaled estimates and the 4 day estimates were positive, except for SEL for short-finned pilot whales and zero-to-peak SPL for sperm whales, which are very rare events, and the negative percentage results from a rounding error (e.g., there was one short-finned pilot whale above the zero-to-peak SPL threshold for the entire simulation, but the 24 h average was ~ 0.23 and rounded to 0.2).

Knowing the amount of time that animals are exposed to levels exceeding the threshold criteria can provide additional information about the potential impacts. Tables 26 and 27 show the mean time that levels exceeded the NMFS criteria of 180 dB rms SPL re 1 μPa (Level A Harassment) and 160 dB rms SPL re 1 μPa (Level B Harassment) for the entire duration of the 30 day simulation and the averaged mean time in the 24 h sliding windows. The times only consider animats exposed to levels that exceed the criteria and the distributions of exceedance times are not normally distributed. The exceedance-time distributions are better fit by a Poisson model (not shown), but it is improper to fit these distributions because the animats whose received levels are below threshold are not considered (i.e., the number of animats with zero time above threshold exposure is indefinable because it changes with the arbitrary choice of simulation boundaries). For this reason, we report the mean value (equivalent to lambda for a Poison distribution) and the maxim time that an animat was exposed leveling exceeding threshold. Other criteria, such as SEL and zero-to-peak SPL injury criteria were not considered. SEL was not considered because it only positively accumulates; once the SEL threshold is reached it does not decrease even though the animal may have moved away from the source. Zero-to-peak SPL is meant for evaluating one-time exposures to very loud sounds that may do mechanical damage to the ear, once damage has occurred it is not expected to regain function.

The amounts of time that animats were exposed to levels exceeding the 160 dB rms SPL re 1 μPa threshold over the 30 day duration were approximately twice as long as the average times in a 24 h window. Whereas, the amounts of time that exposure levels exceeded the 180 dB rms SPL re 1 μPa threshold over the 30 day duration were closer to the average times in a 24 h window. The exceedance times of the 180 dB rms SPL re 1 μPa threshold were similar because threshold exceedance was a relatively rare event and was not usually repeated (an individual animat was not often exposed to levels exceeding this threshold in multiple separated events). There were more opportunities for animats to be exposed to levels exceeding the 160 dB rms SPL re 1 μPa threshold, so there were more instances when this threshold was reached and it was more common for the threshold to be exceeded on multiple separate occasions. Exceedance on multiple occasions accounts for the increased exceedance times for the 30 day duration relative to the 24 h average. The amount of time when either threshold was exceeded was short relative to the evaluation period (24 h or 30 days). Two factors contributed to the total time thresholds were exceeded—the amount of time per occasion (i.e., how long an animat was near the source) and the number of occasions that occur (i.e., how many times an animat was near a source). The number of occasions was, essentially, the same item determined when finding the number of animats with exposures exceeding threshold criteria (the typical use of the threshold criteria). As was investigated above, the number of occasions scales with the duration of the evaluation period, but the time per occasion does not. The time per occasion is specific to how an individual animat interacted with a source. It is, therefore, inappropriate to scale the 24 h exceedance times to estimate the exceedance times for longer durations.

Table 20. Average number of modeled cetaceans above exposure criteria at Survey site A for 24 h sliding windows. Simulations for zero-to-Peak SPL and SEL injury were 5 day duration with animat density of 2.0 animats/km^2. Simulations for rms SPL metrics were 30 day duration with animat density of 0.1 animats/km^2.

Marine mammal species	Injury			Behavior	
	zero-to-peak SPL	SEL	180 dB rms SPL	160 dB rms SPL	Step fxn. rms SPL
Bryde's whales	8.1	105.5	15.6	113	115.4
Cuvier's beaked whales	8.6	0	10.5	38.1	715.3
Common bottlenose dolphins	20.3	0	10.9	32.2	57.3
Short-finned pilot whales	21.1	0.2	10.2	29.5	55.1
Sperm whales	2.9	0.2	6	19.3	32.4
Dwarf sperm whales	1871.7	207.7	8.7	26	49.8

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square

Table 21. Average number of modeled cetaceans above exposure criteria at Survey site B for 24 h sliding windows. Simulations for zero-to-Peak SPL and SEL injury were 5 day duration with animat density of 2.0 animats/km^2. Simulations for rms SPL metrics were 30 day duration with animat density of 0.1 animats/km^2.

Marine mammal species	Injury			Behavior	
	zero-to-peak SPL	SEL	180 dB rms SPL	160 dB rms SPL	Step fxn. rms SPL
Bryde's whales	10.6	93.7	14.3	41.6	90.5
Cuvier's beaked whales	8.6	0	11.3	30.9	538
Common bottlenose dolphins	18.9	0	11	24.9	42.1
Short-finned pilot whales	19.9	0	10.7	24.5	41
Sperm whales	6.5	0	14.3	40.53	58.1
Dwarf sperm whales	1892.2	193.2	9.8	25.4	35.5

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square

Table 22. Number of modeled cetaceans above exposure criteria at Survey site A for average 24 h sliding windows estimate scaled to full duration (5 or 30 days). Numbers in parenthesis represent the percentage change relative to the full duration estimate. Positive numbers indicate the scaled value is greater than full duration estimate. +100% is a doubling of the full duration estimate.

Marine mammal species	Injury			Behavior	
	zero-to-peak SPL	SEL	180 dB rms SPL	160 dB rms SPL	Step fxn. rms SPL
Bryde's whales	40.5 (−14)	527.5 (−1)	468.0 (35)	3390.0 (494)	3462.0 (444)
Cuvier's beaked whales	43 (−4)	0 (0)	315.0 (14)	1143.0 (98)	21459.0 (1006)
Common bottlenose dolphins	101.5 (−3)	0 (0)	327.0 (33)	966.0 (183)	1719.0 (291)
Short-finned pilot whales	105.5 (0)	1 (0)	306.0 (28)	885.0 (168)	1653.0 (289)
Sperm whales	14.5 (−3)	1 (0)	180.0 (8)	579.0 (66)	972.0 (152)
Dwarf sperm whales	9358.5 (33)	1038.5 (−1)	261.0 (25)	780.0 (127)	1494.0 (269)

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square

Table 23. Number of modeled cetacean animats above exposure criteria at Survey site B for average 24 h sliding windows estimate scaled to full duration (5 or 30 days). Numbers in parenthesis represent the percentage change relative to the full duration estimate. Positive numbers indicate the scaled value is greater than full duration estimate. +100% is a doubling of the full duration estimate.

Marine mammal species	Injury			Behavior	
	zero-to-peak SPL	SEL	180 dB rms SPL	160 dB rms SPL	Step fxn. rms SPL
Bryde's whales	53 (4)	468.5 (−3)	429.0 (37)	1248.0 (250)	2715.0 (412)
Cuvier's beaked whales	43 (13)	0 (0)	339.0 (13)	927.0 (89)	16140.0 (782)
Common bottlenose dolphins	94.5 (−5)	0 (0)	330.0 (30)	747.0 (162)	1263.0 (207)
Short-finned pilot whales	99.5 (−2)	0 (0)	321.0 (22)	735.0 (133)	1230.0 (188)
Sperm whales	32.5 (−7)	0 (0)	429.0 (13)	1215.9 (74)	1743.0 (121)
Dwarf sperm whales	9461 (31)	966 (8)	294.0 (22)	762.0 (126)	1065.0 (155)

SPL=sound pressure level; SEL=sound exposure level; rms=root-mean-square

Table 24. Percentage difference in number of modeled cetaceans above exposure criteria at Survey site A for 24 h sliding windows scaled to 4 day evaluation window.Positive numbers indicate the scaled value is greater than 4 day estimate. +100% is a doubling of the 4 day estimate.

Marine mammal species	Injury	
	zero-to-peak SPL	SEL
Bryde’s whales	8	12
Cuvier’s beaked whales	23	0
Common bottlenose dolphins	25	0
Short-finned pilot whales	13	−20
Sperm whales	−17	0
Dwarf sperm whales	43	10

SPL=sound pressure level; SEL=sound exposure level

Table 25. Percentage difference in number of modeled cetaceans above exposure criteria at Survey site B for 24 h sliding windows scaled to 4 day evaluation window. Positive numbers indicate the scaled value is greater than 4 day estimate. +100% is a doubling of the 4 day estimate.

Marine mammal species	Injury	
	zero-to-peak SPL	SEL
Bryde’s whales	9	12
Cuvier’s beaked whales	50	0
Common bottlenose dolphins	16	0
Short-finned pilot whales	15	0
Sperm whales	30	0
Dwarf sperm whales	39	21

SPL=sound pressure level; SEL=sound exposure level

Table 26. Amount of time that animats exceed NMFS threshold criteria at Survey site A for 30 days and 24 h. The average amount of time, in minutes, that animats exposed to levels exceeding the criteria remain above the criteria is shown. The maximum amount of time an animat exceeded the threshold is shown in parentheses. 30 days show the results for the entire duration of the simulation, 24 h show the average values from the 24-h sliding windows.

Marine mammal species	30 day		24 h	
	180 dB rms SPL	160 dB rms SPL	180 dB rms SPL	160 dB rms SPL
Bryde’s whales	2.2 (10)	75.6 (554)	1.6 (3.4)	18 (83)
Cuvier’s beaked whales	1.5 (4)	8.2 (48)	1.3 (2.4)	4.8 (16)
Common bottlenose dolphins	1.9 (8)	12.6 (115)	1.4 (2.7)	5.7 (17.8)
Short-finned pilot whales	1.8 (8)	12 (73)	1.4 (2.4)	5.7 (18.3)
Sperm whales	1.5 (6)	5.2 (35)	1.3 (2.1)	3.7 (10.5)
Dwarf sperm whales	1.5 (6)	8.6 (63)	1.3 (2.2)	4.6 (14.3)

SPL=sound pressure level; rms=root-mean-square

Table 27. Amount of time that animats exceed NMFS threshold criteria at Survey site B for 30 days and 24 h.The average amount of time, in minutes, that animats exposed to levels exceeding the criteria remain above the criteria is shown. The maximum amount of time an animat exceeded the threshold is shown in parentheses. 30 days show the results for the entire duration of the simulation, 24 h show the average values from the 24-h sliding windows.

Marine mammal species	30 day		24 h	
	180 dB rms SPL	160 dB rms SPL	180 dB rms SPL	160 dB rms SPL
Bryde's whales	2.2 (10)	20.5 (131)	1.6 (3.5)	8.1 (38)
Cuvier's beaked whales	1.5 (5)	6.2 (30)	1.3 (2.4)	3.9 (12.4)
Common bottlenose dolphins	1.8 (6)	8.8 (45)	1.4 (2.7)	4.4 (13.3)
Short-finned pilot whales	1.7 (7)	8.2 (58)	1.4 (2.7)	4.4 (13.5)
Sperm whales	1.4 (5)	5.3 (33)	1.3 (2.6)	3.5 (11.5)
Dwarf sperm whales	1.5 (6)	7.3 (52)	1.3 (2.4)	4.0 (11.7)

SPL=sound pressure level; rms=root-mean-square

6.5.1.3. Summary of Scaling Modeled Acoustic Exposure Results

6.5.1.3.1. Large-scale Animal Movement

Large-scale movements of cetaceans are driven primarily by migrations and temporally-varying prey concentrations (Hastie et al. 2004). Prey availability is ultimately driven by changes in production in the oceanic food web (Davis et al. 2001). These changes influence directly the availability of marine mammal prey, as is the case for plankton feeders such as Bryde's whales. The changes also cause a delayed, but often amplified, abundance of larger invertebrates (e.g., squid) and/or vertebrates (e.g., fish), the food source of most odontocetes, such as sperm and pilot whales and smaller dolphins (e.g., Davis et al. 2001).

The acoustically-modeled seismic surveys usually occur in deeper water (> 200 m). Five of the six representative cetacean species typically only occur in deeper water. Common bottlenose dolphins, however, have several distinct populations. One of these inhabits water deeper than 200 m and is the most likely population affected by seismic surveys of this Test Case. Most cetacean movement data is from inshore populations that have been studied more intensely and from migrating species, since information on movements of offshore species is sparse. None of the Test Case species is distributed evenly across the Gulf (Davis et al. 2001). All cetaceans surveyed in Davis et al. (2001) were found primarily in water depths ranging between 1200–2300 m, with the exception of common bottlenose dolphins, which also occurred in slightly shallower waters. There is no information indicating that any of the six modeled species migrate regularly on a large-scale in the Gulf; thus, large-scale movement was not integrated into the animal movement model.

6.5.1.3.2. Potential Biases in the Modeling Procedure

To investigate potential systematic, and possibly unknown, biases in the modeling procedure, behavioral exposure estimates were determined for subsets of the Test Case simulations (see Section 6.3.2). Behavioral exposure estimates were determined as a function of time by finding the number of exposures occurring in 24 h subsets using a sliding window that advanced in 4 h increments. Trends were evident, particularly at Survey site A, but the trends appeared to be the consequence of survey design, such as changing sound fields as the vessels move into different acoustic zones. The negative trend for most species at Survey site A reflected the survey design in that the survey vessels start operations in deeper water and proceed to shallower water toward the end of the simulation. Because the acoustic propagation range is generally longer in deeper water than at intermediate depths (see Tables 83–85 and Figures 126–128), the ensonified volume was larger at the beginning of the simulation than at the end and more exposures are registered per 24 h period earlier in the simulation. This was borne out in simulations with the vessel tracks reversed (starting in intermediate water depths and proceeding toward deeper water). Fewer exposures were registered at the beginning of the simulation and more toward the end of the simulation as the vessels proceeded into deeper water (Figure 27). For sperm whales, there was an additional bias due to their general avoidance of water depths < 1000 m. The area of Survey site A began at a location with water depth ~ 1500 m, but proceeds to depths < 200 m. Therefore, fewer sperm whale animats were within exposure range of the source later in the simulation. As expected, reversing the track lines of the vessels (starting in shallow water and proceeding to deeper water) lead to increased behavioral exposure estimate rates for sperm whales over time (Figure 27b). To determine if undesired, and unknown, systematic biases exist in the modeling procedure, simulations were run with the source stationary and with no limiting bathymetric constraints (depth > 1300 m). No clear trends were found (Figure 28), indicating that undesired systematic biases in the modeling procedure, if present, were small relative to the survey design and would not affect scaling up the results in time, if applied.

The results of the Test Case were presented as the number of animats (and animals) that were exposed to levels that exceed the threshold criteria for the entire simulation. SEL was accumulated throughout the simulation (5 days) and the maximum rms SPL exposure values were found for the whole simulation (30 days). Animats receiving levels exceeding threshold were only counted once, but there was no mechanism to account for potential recovery of hearing. For this reason a smaller time period for evaluating exposure risk was used and the animats' received levels were reset at the beginning of each period. The time period for evaluating exposure risk has not been standardized, but 24 h is often used. We compared the number of animats exposed to levels exceeding threshold for 24 h time periods scaled up by the number of days in the simulations to the number of animats exposed to levels exceeding threshold for the entire duration of the simulations. For metrics based on rms SPL (the NMFS criteria and the behavioral step function), scaling up the 24 h average estimates to 30 days (vastly) overestimates the number of animats exposed to levels exceeding threshold when determined over the entire simulation. This is an expected finding. It results because animats were commonly exposed to levels exceeding these thresholds and the relatively short reset period of 24 h means that individual animats were, in effect, counted several times during the scale up that would only have been counted once when evaluating over the entire simulation. SEL is an accumulation of energy, so unlike the SPL metrics evaluating over a longer period could result in more animats exposed to levels exceeding SEL threshold that would not when evaluated over a shorter period. The med-frequency species had only one or no animats above SEL threshold, so scaling trends could not be established for such rare events. Only Bryde's whales (low frequency) and dwarf sperm whales (high frequency) had significant numbers of animats exposed to levels exceeding SEL threshold. For Bryde's whales and dwarf sperm whales, scaling the 24 h average by 5 resulted in fewer animats exposed to levels exceeding threshold than the number of animats exposed to levels exceeding threshold for the entire simulation. The percentage shortfall, however, was much less than the overestimates seen in the NMFS criteria and behavioral step function in the 30 day simulations. In addition, it was observed that scaling the 24 h zero-to-peak SPL exceedance estimates could also result in a modest shortfall. Animats exceeding zero-to-peak SPL were only counted once per evaluation period and energy did not accumulate, so scaling up from a short reset period should overestimate the number of animats exposed to levels exceeding threshold. When using an overlap, the sliding window approach under-samples the edge time periods compared to the central time periods. When the number of animats exposed to levels exceeding the zero-to-peak SPL and SEL thresholds for 24 h was scaled up by 4 and compared to number of animats exposed to levels exceeding these thresholds during a 4 day period in the middle of the 5 day simulation, the scaled estimates again overestimated the longer time window results. (Except in the case of the sperm whales, which was an artifact of rounding a small number.) These edge effects of the sliding window sampling were small and exaggerated in the Test Case because the surveys start an end at extreme locations of the sound field and animal locations. Starting and ending surveys at the extremes of sound fields and animal depth restrictions is not typical, so the edge effects were not expected to significantly affect results.

6.5.1.3.3. Scaling Short-duration Simulations for Long-duration Operations

As discussed previously, large-scale animal movements can affect the real-world densities that are used to adjust model (animat) exposure estimates. If the simulation is short relative to the large-scale movement (or behavioral change), there is little effect on the estimated exposures (i.e., provided the behavioral states and acoustic fields remain relatively constant, exposure estimates from short-duration simulations can be adjusted for different seasonal density estimates).

Systematic trends in the modeling procedure were evident, indicating that survey design can affect exposure estimates when scaling is used. The minimum duration of a simulation should, therefore, include all of the acoustic environments likely to be encountered during the operation. For example, if a survey will range from deep to shallow water, then it is not sufficient to only simulate operations in deep water (unless it is known that exposures in deep water are always greater than in shallow water and a conservative estimate of the exposures is desired). When the evaluation period (or reset time) is short, e.g., 24 h, the simulation should still include all acoustic environments, and exposures should be presented as a function of time or averaged to get an expected value during the evaluation period.

Our suggested procedure for estimating exposures for long-duration surveys (i.e., three months):

1. Identify the shortest large-scale animal movement time-period (e.g., seasonal migration).
2. Identify acoustic environments over which the survey will occur (e.g., shallow, slope, deep, and associated geoacoustic parameters).
3. Identify the minimum period of validity for the acoustic model (e.g., month due to changing sound velocity profile).
4. Break the survey into parts that are shorter in duration than both large-scale animal movement times and the period of acoustic model validity.
5. Create animal movement simulations for acoustic exposure with adequate duration to meaningfully sample the exposure-estimating parameter (e.g., if a 24 h reset period is used then enough samples should be obtained to get a reliable mean value given the various acoustic environments).
6. If the simulation time is less than the duration of the survey parts determined in Step 4, then scale the results by the ratio of survey duration to simulation time (e.g., if the simulation time is one week, but the survey division is 28 days, then multiply the simulation exposure results by four).
7. Sum, or aggregate, the results from the survey parts to calculate exposures for the entire survey.

6.5.2. Test Scenario 2: Analysis of Uncertainty in Acoustic and Animal Modeling

The process of using computer models to predict acoustic effects on marine mammals requires making simplifying assumptions about oceanographic parameters, seabed parameters, and animal behaviors. These assumptions carry some uncertainty, which may lead to uncertainty in the form of variance or error in individual model outputs and in the final estimates of marine mammal acoustic exposures. For example, acoustic propagation models assume a specific shape of the sound speed profile in the ocean (speed of sound versus depth) for each season. We know, however, that the real sound speed profile regularly changes and that substantial variation within a season is possible. The assumption that a single profile represents the environment through a full season approximates real-world cases, but can, to some degree, cause errors. The uncertainty in model outputs caused by approximations like this can be investigated by examining how much the outputs change when the inputs are purposely offset. This type of investigation, referred to as parametric uncertainty analysis, provides a means to characterize the accuracy, or uncertainty, of the model results in light of errors in model inputs. It can also be used to characterize the expected variability in model results due to natural variations in some of the input parameters.

The exposure calculations used for biological effects assessment are performed using an animal movement model that simulates and tracks individual animals in space and time through the sound field. As with the acoustic model, the animat movement model requires inputs that approximate real-world values. In fact, the acoustic model results are one of the inputs to the animat model, and those inherently have uncertainty, as described above. The animat model outputs consequently also include uncertainty. By using a resampling technique, we can quantify the effects of uncertainty in exposure estimates due to uncertainty in acoustic and animal movement models.

6.5.2.1. Acoustic Modeling Uncertainty

Acoustic exposure estimates require knowledge of the sound fields to which marine mammals are exposed. Here we are concerned with estimating exposures from geotechnical and geophysical survey operations. Sound field modeling consists of two major stages: source characterization and acoustic propagation modeling. The uncertainty that arises in both of these stages is considered in the following sections.

6.5.2.1.1. Source Characterization Modeling Uncertainty

Characteristics of sound sources, such as the sound levels in different frequency bands and the directivity of the sources, were used with acoustic propagation modeling to determine quantify the received sound levels to which marine mammals are exposed. There were uncertainties associated with the source, such as variations in source level during operation, and uncertainty associated with a source model's predicted levels. Field measurements of an operating source that has been modeled can be used to determine the overall uncertainty associated with the source level modeling.

The sound source used in the Test Case (Section 6.3.1.1) was a generic 8000 in^3 airgun array. JASCO's airgun array source model (AASM) was used to characterize the far-field emission levels and directivity of the source. AASM is a numerical model that simulates the fluid dynamics and sound radiation of a collection of high-pressure air bubbles. As with other airgun models, AASM incorporates a number of simplifying assumptions about the underlying physics to make the numerical calculation tractable. Among these assumptions are that the bubbles are perfectly spherical and that the sound field radiated by each airgun is isotropic and point-like, which are only approximately true in practice. Furthermore, the physical model employed by AASM includes free parameters, which govern the rate of air injected into the bubble and the rate of heat transfer between the bubble and the surrounding water. The values of these free parameters are determined by fitting model predictions to the measured signatures for a large collection of airguns (MacGillivray 2006). Errors in AASM thus originate from two different sources: the approximations employed in the underlying physical model, and the experimental uncertainties in the model parameterization of the specific airguns.

Uncertainty associated with these errors can be estimated by comparing model predictions to acoustic field measurements of airgun arrays. Such comparisons are complicated because the source levels computed by the model must, by definition, be measured in the far field of the array. Since a model of sound propagation must be used to calculate received levels in the far field, it is thus impossible to completely decouple uncertainties in the source model from uncertainties in the sound propagation model. Nonetheless, uncertainties can be estimated from field data by comparing model predictions with sound level measurements at relatively short range, where propagation loss is reasonably well constrained.

Studies comparing AASM predictions with seismic array measurements have been carried at a number of sites, including in the Chukchi Sea (McPherson et al. 2005), the Beaufort Sea (Matthews and MacGillivray 2013), and offshore British Columbia (Austin et al. 2012). These studies have shown that the modeled SELs are typically within 3 dB of the measured values.

6.5.2.1.2. Acoustic Propagation Modeling Uncertainty

Transmission of sound is determined by the characteristics of the media (e.g., air, water, and seafloor sediments) in which that sound propagates. The acoustics model used here accepts several parameters describing the ocean environment in which sound propagation is modeled. The key inputs are sound speed variation with depth (sound speed profile), seabed composition and layering, and bathymetric variation between each sound source and receiver.

Uncertainty in acoustic environmental parameters leads to uncertainty in model outputs. The relationship between the input parameters and the output is complex and cannot be expressed with a simple rule. An empirical approach was taken to investigate how uncertainty in the inputs affects the modeled acoustic field. Sound fields were modeled using mean parameter values and a combination of parameter values, chosen from within their measured ranges, expected to maximize sound propagation. These sound fields, mean and maximum-propagation, were subtracted to determine the difference, which indicates the range of errors due to uncertainty in inputs. Three acoustic zones were analyzed: Shelf, Slope, and Deep. Each zone was modeled for three propagation directions: downslope, upslope, and along-slope. The upslope and downslope directions led respectively from the source into shallower and deeper waters. The along-slope direction followed a path of (approximate) constant depth (bathymetric contour) away from the source.

6.5.2.1.3. Sound Speed Profiles

A sound speed profile represents the water sound speed as a function of depth. In general, sound speed increases with increasing temperature and salinity. It also increases with increased hydrostatic pressure, so there is a systematic increase with depth. Sound speed profiles for the modeled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office’s Generalized Digital Environmental Model V 3.0 (GDEM, Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world’s oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy’s Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep), including 55 standard depths between 0 and 2000 m. The GDEM temperature-salinity profiles were converted to sound speed profiles according to the equations of Coppens (1981).

$$
\begin{aligned}
c(z,T,S,\phi) &= 1449.05 + 45.7t - 5.21t^2 - 0.23t^3 \\
&\quad + \left(1.333 - 0.126t + 0.009t^2\right)\left(S - 35\right) + \Delta \\
\Delta &= 16.3Z + 0.18Z^2 \\
Z &= \frac{z}{1000}\left[1 - 0.0026\cos(2\phi)\right] \\
t &= \frac{T}{10}
\end{aligned}
\tag{19}
$$

where z is water depth (m), T is water temperature (°C), S is salinity (psu), and ϕ is latitude (radians).

Sound speed profiles were obtained for three depth zones (Table 28) along the study line, south of Louisiana (Figures 29–31). Surface sound ducts, or channels, occur when the sound speed increases with depth below the surface leading to a positive sound speed gradient. This can occur physically when surface waters are cooler than underlying waters. Sounds propagating in the gradient are refracted upward and can become partially trapped near the surface, leading to enhanced sound propagation and higher near-surface sound levels. A weak surface sound channel is present during some months of the year in the Gulf of Mexico, with variations in the gradient and depth of the channel based on the month and zone. To account for varying sound speed profiles throughout the year, seasons were defined for each zone based on the sound speed at the surface and the gradient and depth of the sound channel in the top 200 m (Table 29). A negative gradient indicates a more downward refracting environment, whereas a positive gradient at the surface indicates a surface sound channel that can propagate sound to longer ranges.

Table 28. Depth zones along the study line.

Zone	Depths (m)	Range–Latitude (°N)	Range–Longitude (°W)
Shelf	25–200	28–28.75	
Slope	200–2000	26.5–28	89–91
Deep	> 2000	24.5–26.5	

Table 29. Modeled seasons and their characteristics.

Zone	Season	Period	Month used to acquire representative sound speed profile	Seasonal characteristics
Shelf	1	Dec–Mar	Feb	Strong sound channel at depths up to 50–75 m below surface
	2	Apr–Nov	Sep	Weak to no sound channel in top 20–40 m
Slope	1	Jul–Sep	Aug	Weak to no sound channel
	2	Oct–Jun	Mar	Downward refracting at surface
Deep	1	Jan–Dec	May	Very weak to no sound channel throughout year

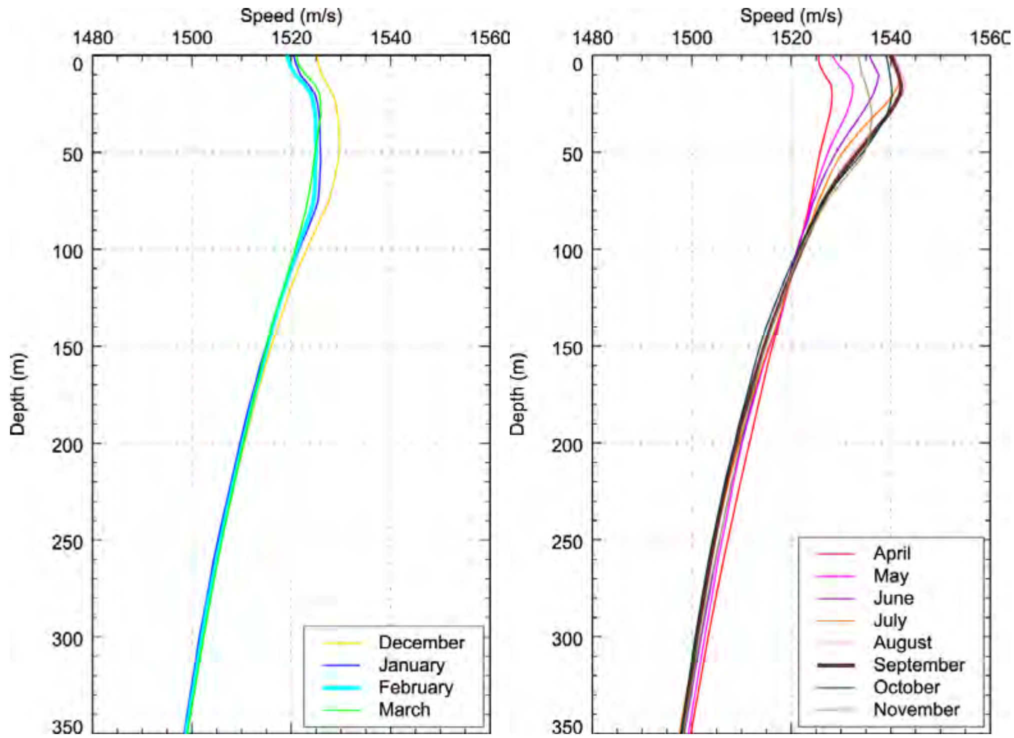


Figure 29. The Shelf zone (28.5° N, 90° W): Mean monthly sound speed profiles, separated into Seasons 1 (left) and 2 (right). Bolded profiles indicate average sound speed profile used for the season. Derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

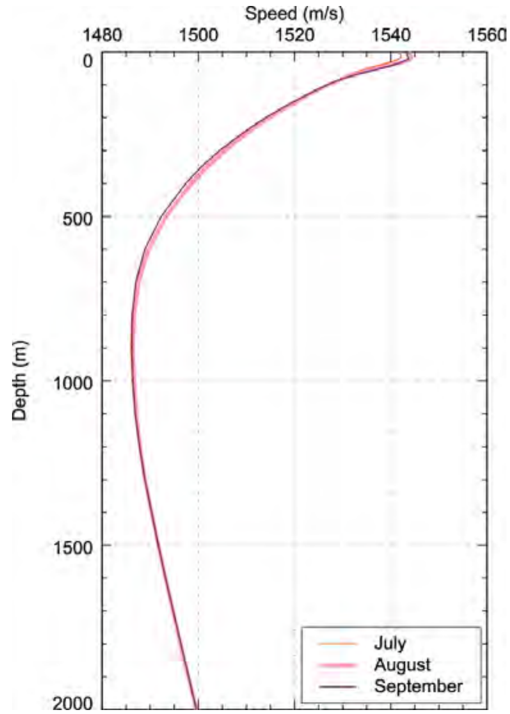


Figure 30. The Slope zone (27.25° N, 90° W): Mean monthly sound speed profiles, separated into Seasons 1 (left) and 2 (right). Bolded profiles indicate average sound speed profile used for the season. Derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

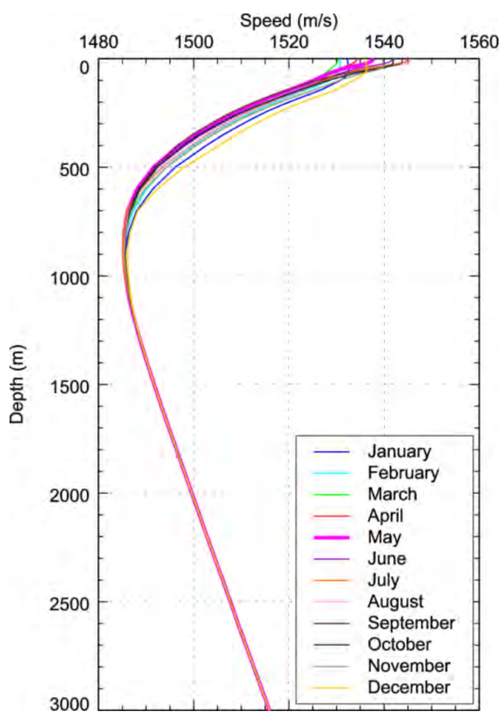


Figure 31. Deep zone (25.5° N, 90° W): Mean monthly sound speed profiles. Bolded profile indicates average sound speed profile used for the season. Derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

To determine uncertainty in the acoustic field propagation due to variability of the sound speed profiles within in each season, original CTD casts, containing temperature and salinity information, were extracted from NOAA's database. Spatial limits from W89° to W91° were applied during database query. Temperature and salinity data were processed to obtain sound speed profiles using Equation 19.

All sound speed profiles were plotted by month separately for each zone: Shelf, Slope, and Deep. Monthly groups of sound speed profiles were combined into seasons based on similarity of the features: variability within each month and presence of the surface sound channel.

Two periods (seasons) were distinguished for the Shelf zone:

- Dec–Mar
- Apr–Nov

Two periods (seasons) were distinguished for the Slope zone:

- Jul–Sep
- Oct–Jun

In the Deep zone, we established that the separation into seasons is unwarranted because variability of the sound speed profiles throughout the year is not significantly larger than the variability within individual months.

In each group of sound speed profiles, 16% of the profiles with the highest gradient in the top 25 m (with the most pronounced sound channel) were removed to avoid the most extreme conditions, for which the probability of occurrence is low. This step was taken to omit profiles that may have been distorted by measurement system temperature settling. The remaining profiles are plotted together in Figures 32–34. The maximum-propagation sound speed profile was chosen from the remaining profiles to reproduce the maximum gradient. The median sound speed profiles were obtained from GDEM profile of the central month of the season as identified in Table 29.

The maximum-propagation scenario sound speed profiles for both seasons in the Shelf zone exhibit a surface sound channel extending to 40 m depth. The difference between the sound speed at the top (surface) and bottom (at 40 m depth) of the channel is 15 m/s during Season 1 and 10 m/s during Season 2. In the Slope zone, the occurrence of the surface sound channel exists only during Season 1. Season 2 in the Slope zone is characterized by a small negative gradient in the sound speed profile over the top 75 m of the water column, so no surface channel exists. Data for the Deep zone show little variability of the shape of the sound speed profile throughout the year. A single season was, therefore, defined and used for modeling in that zone.

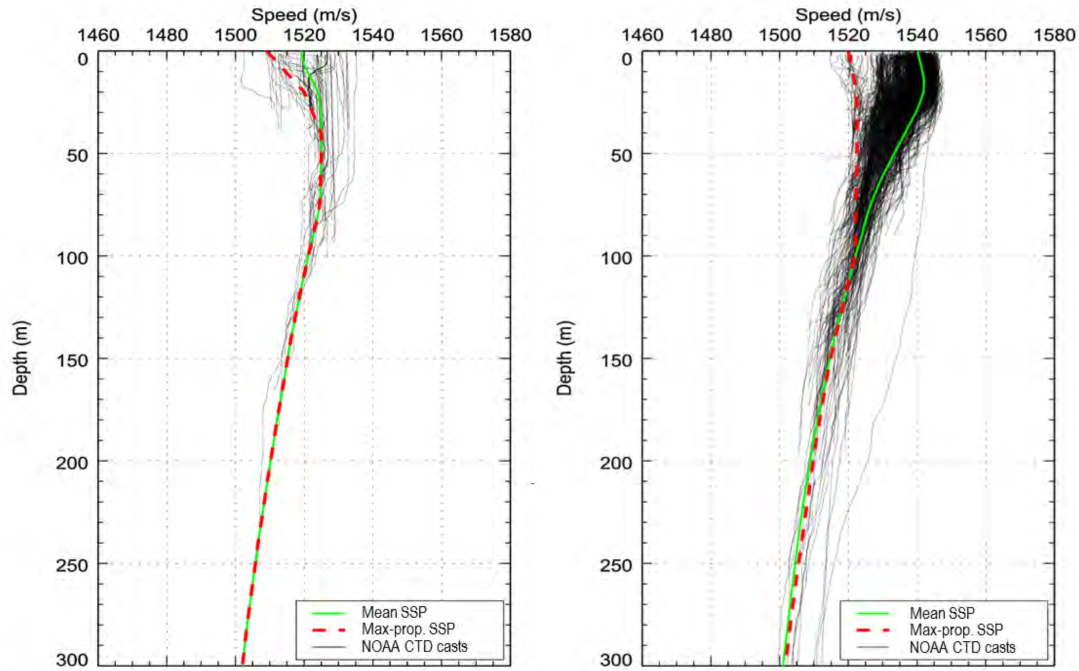


Figure 32. Shelf zone: Modeled average and maximum-propagation sound speed profiles based on variations in CTD cast data for Seasons 1 (left) and 2 (right). Raw profiles are derived from NOAA Gulf of Mexico CTD cast data and mean monthly profiles are derived from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

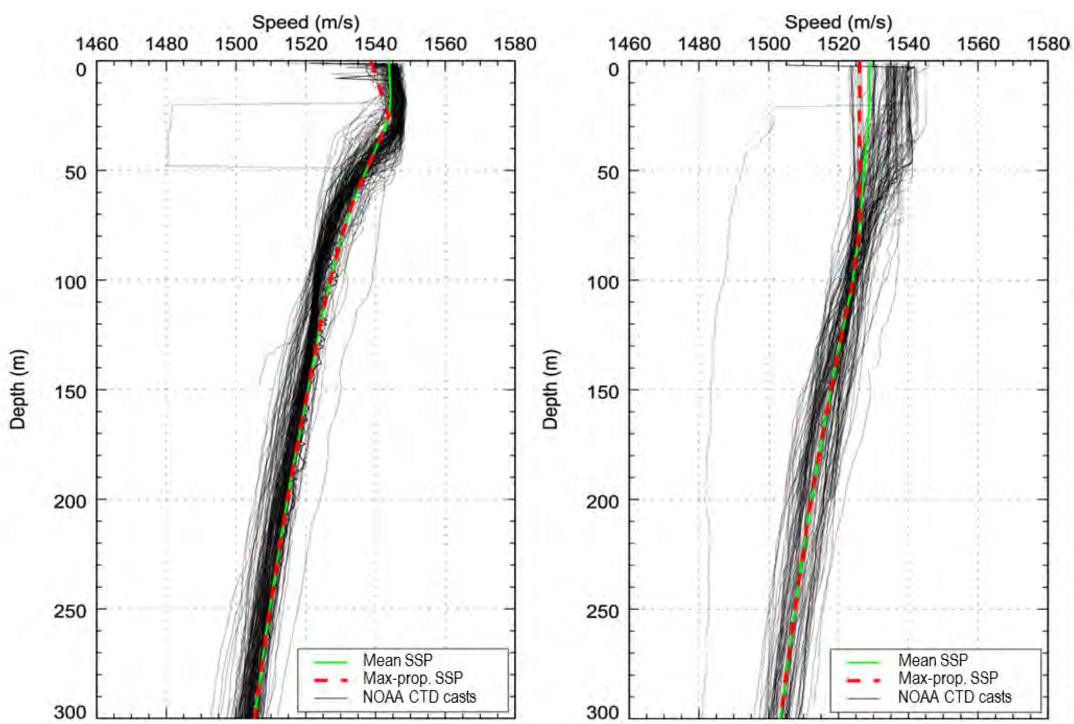


Figure 33. Slope zone: Modeled average and maximum-propagation sound profiles based on variations in CTD cast data for Seasons 1 (left) and 2 (right). Raw profiles are derived from NOAA Gulf of Mexico CTD cast data and mean monthly profiles are derived from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

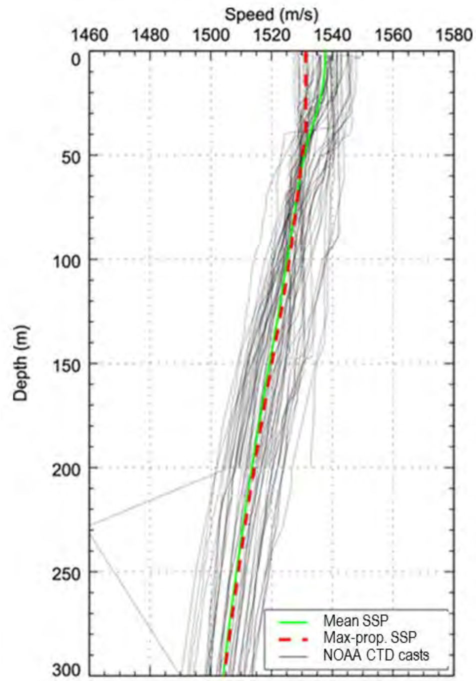


Figure 34. Deep zone: Modeled average and maximum-propagation sound speed profiles based on variations in CTD cast data. Raw profiles are derived from NOAA Gulf of Mexico CTD cast data and mean monthly profiles are derived from GDEM (Teague et al. 1990, Carnes 2009).

6.5.2.1.4. Sound Speed Profile Results

The analysis of acoustic field uncertainty due to sound speed profile uncertainty was performed by calculating and examining the differences in acoustic fields between the maximum-propagation and median case sound speed profiles. The source used for these runs was the 8000 in^3 airgun array, at 8 m depth. All model runs for this analysis used geoacoustic (seabed parameter) profiles with median reflectivity at all three zones. The comparisons performed for the Shelf and Slope zones were made for both of the seasonal sound speed profiles of those zones. Only the one season and a single corresponding sound speed profile exist for the Deep zone.

Shelf zone: December–March

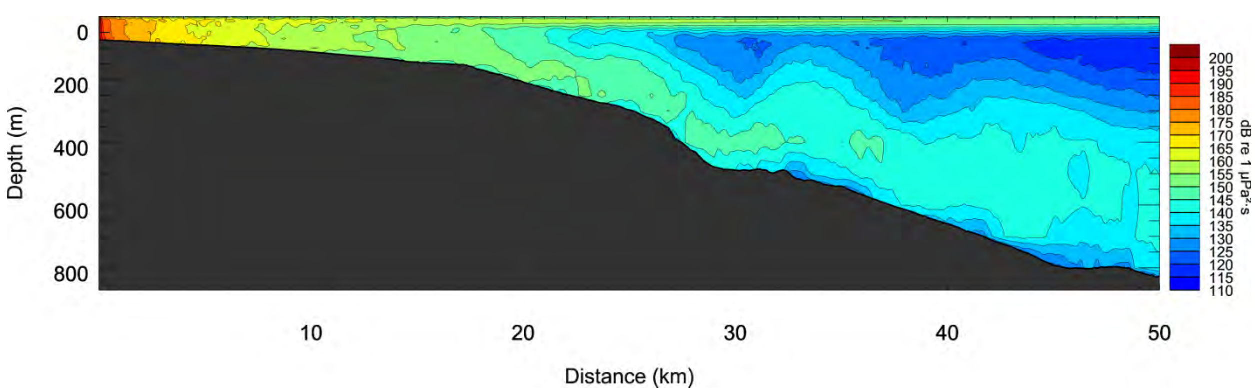


Figure 35. Shelf zone, Dec–Mar: Received SEL acoustic field using conservative (enhanced propagation) sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

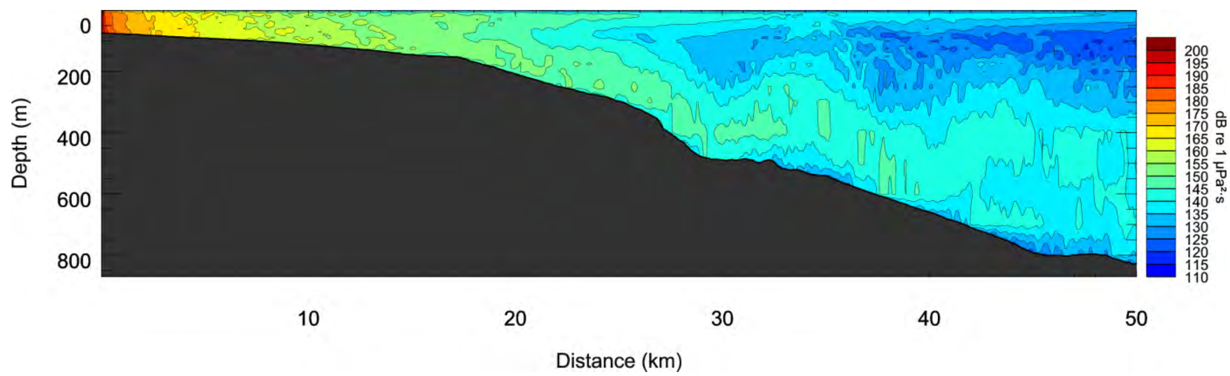


Figure 36. Shelf zone, Dec–Mar: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

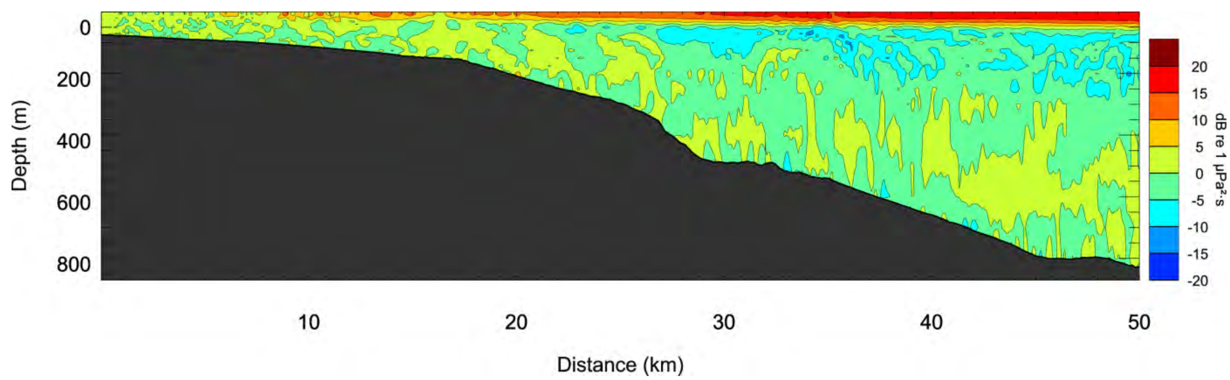


Figure 37. Shelf zone, Dec–Mar: Differential acoustic field due to variation in the sound speed profile. Downslope direction.

Shelf zone: April–November

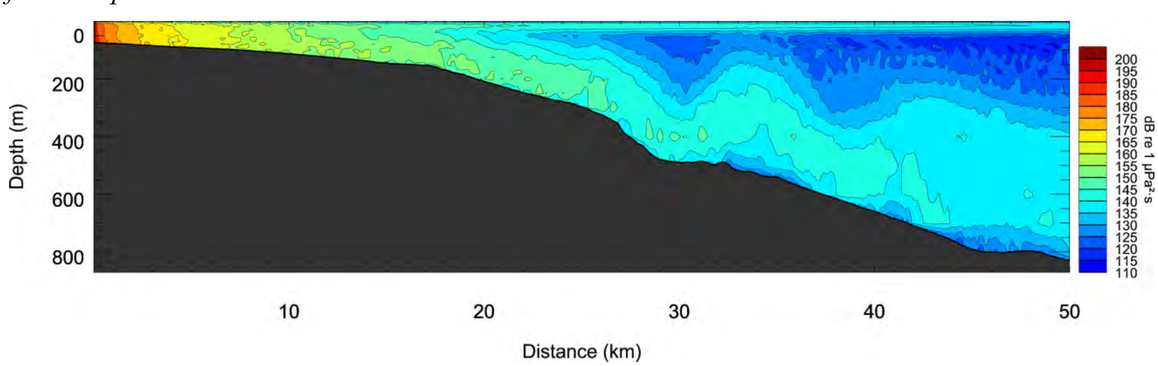


Figure 38. Shelf zone, Apr–Nov: Received SEL acoustic field using conservative sound (enhanced propagation) speed profile and median reflectivity geoacoustic parameters. Downslope direction.

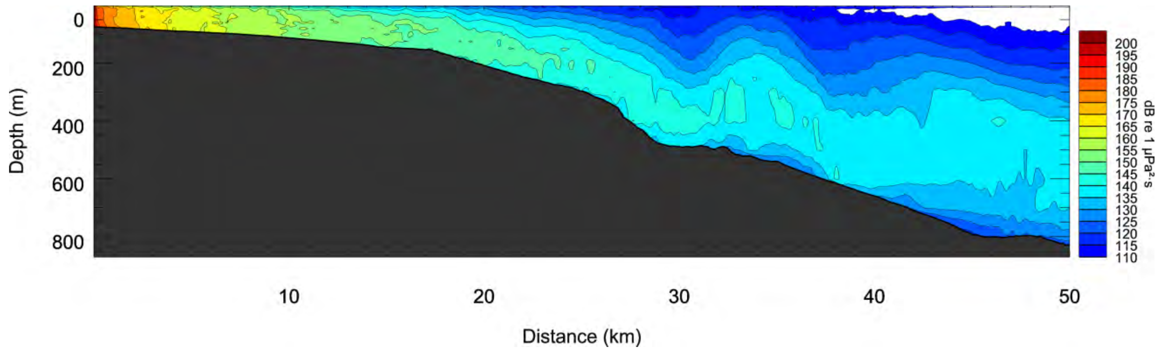


Figure 39. Shelf zone, Apr–Nov: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

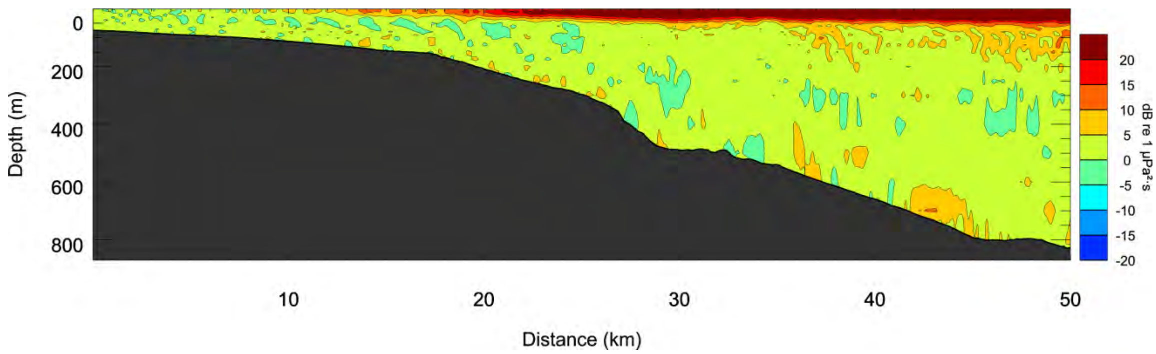


Figure 40. Shelf zone, Apr–Nov: Differential acoustic field due to variation in the sound speed profile. Downslope direction.

Slope zone: July–September

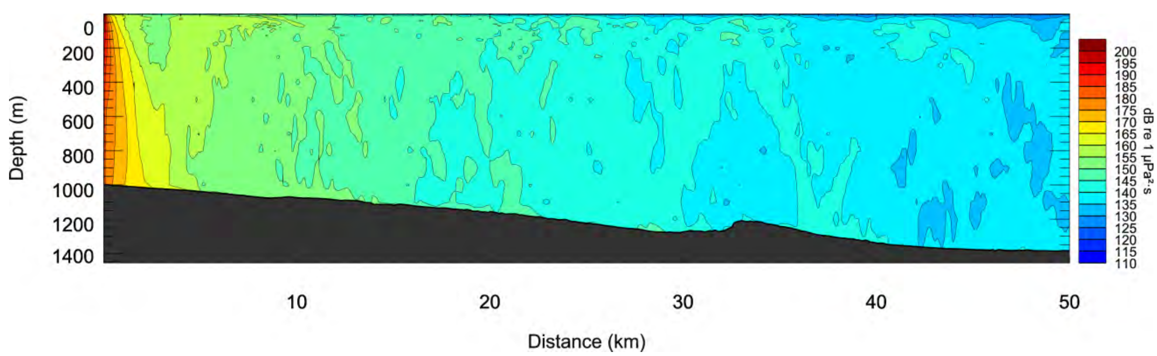


Figure 41. Slope zone, Jul–Sep: Received SEL acoustic field using conservative sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

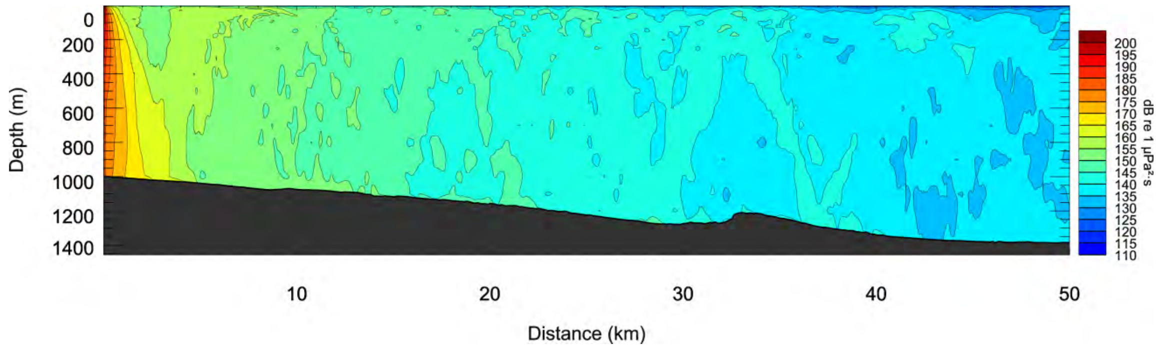


Figure 42. Slope zone, Jul–Sep: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

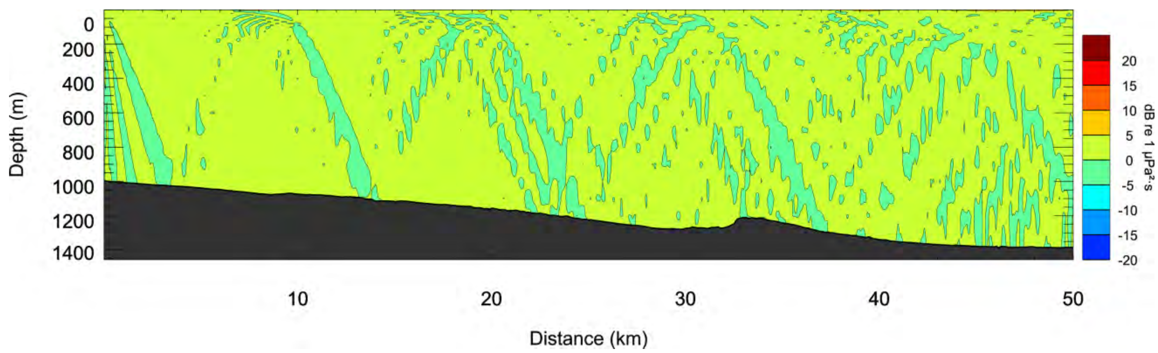


Figure 43. Slope zone, Jul–Sep: Differential acoustic field due to variation in the sound speed profile. Downslope direction.

Slope zone: October–June

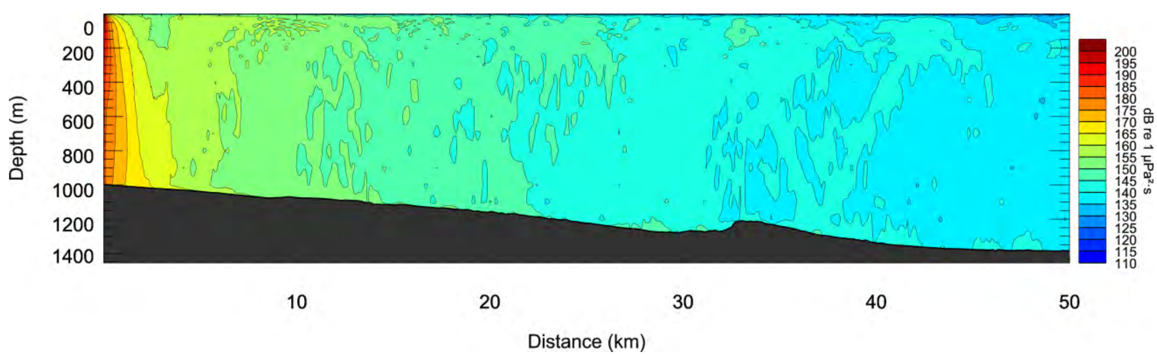


Figure 44. Slope zone: Received SEL acoustic field sing conservative sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

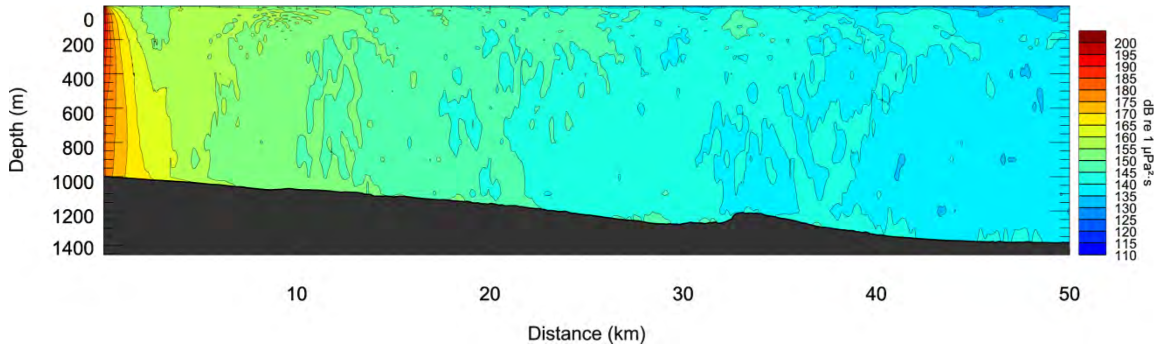


Figure 45. Slope zone, Oct–Jun: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

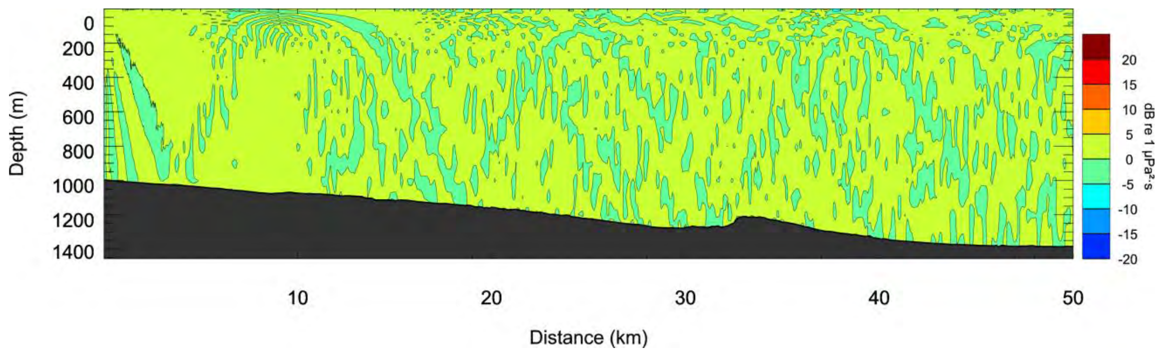


Figure 46. Slope zone, Oct–Jun: Differential acoustic field due to variation in the sound speed profile. Downslope direction.

Deep zone

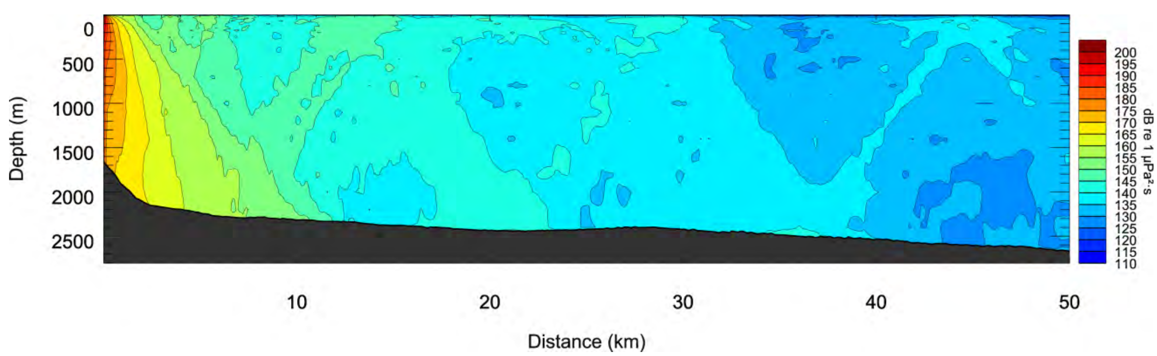


Figure 47. Deep zone: Received SEL acoustic field using conservative sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

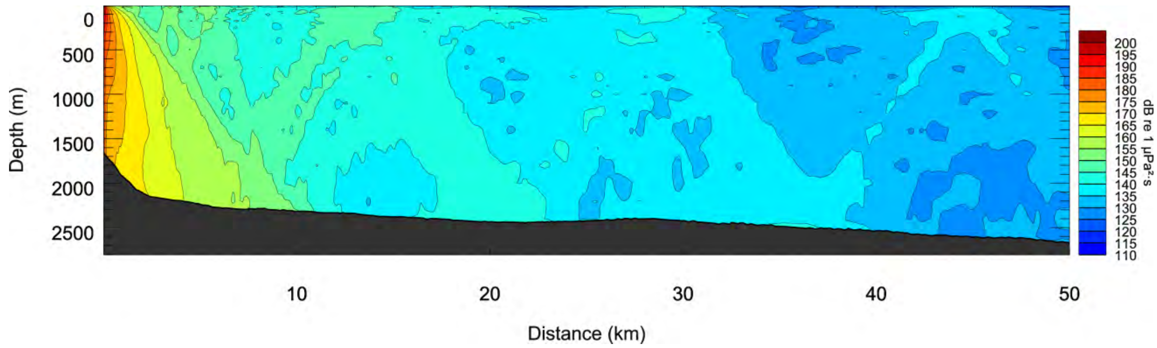


Figure 48. Deep zone: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

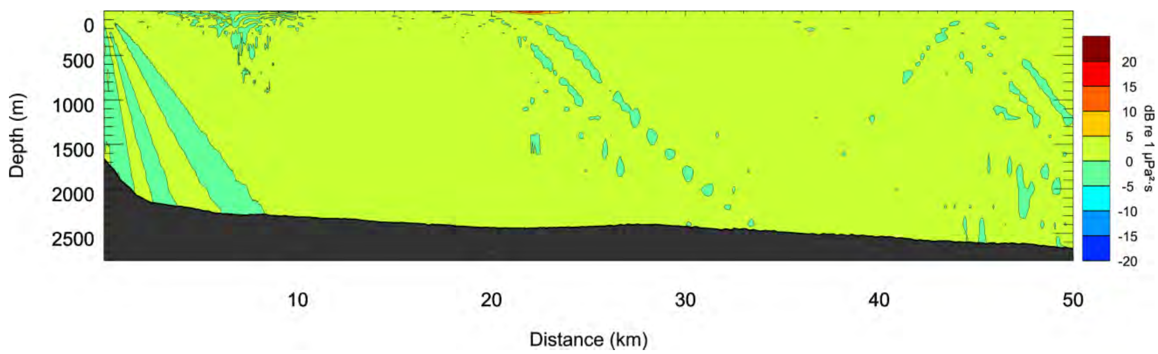


Figure 49. Deep zone: Differential acoustic field due to variation in the sound speed profile. Downslope direction.

In each zone, the acoustic field was propagated in three directions (downslope, upslope, and along slope). For each direction, the range to the rms SPL 160 dB re 1 µPa (153 dB re 1 µPa·s² SEL) threshold was estimated based on the maximum-propagation scenario acoustic field in the comparison pair. The average difference and standard deviation were calculated based on the differences at locations within a 5 km horizontal × 20 m deep box along the radials starting at the threshold range. The 20 m vertical extent was selected to emphasize the depths at which the animals spend much of their time. Table 30 shows the calculated average differences between the maximum-propagation and median case scenarios, and the distance at which the 160 dB re 1 µPa rms SPL threshold occurs.

Table 30. Acoustic field differences between maximum-propagation and average sound speed profile conditions. Column “R” shows the maximum distance in kilometers of 160 dB re 1 µPa rms SPL threshold exceedance. The Median (σ) column shows the median difference and standard deviation in decibels, over a range-depth zone containing many receivers, near the 160 dB re 1 µPa threshold location.

Direction	Shelf zone				Slope zone				Deep zone	
	Dec-Mar		Apr-Nov		Jul-Sep		Oct-Jun		Jan-Dec	
	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)
Downslope	30.6*	14.9 (1.0)	22.6	10.5 (2.7)	11.5	0.7 (0.6)	14.1	0.2 (0.5)	10	0.3 (0.3)
Along slope	23.5	7.0 (1.2)	12.2	5.7 (2.8)	8.8	2.0 (1.8)	8.3	0.7 (0.9)	6.7	−0.1 (0.3)
Upslope	14.3	5.0 (1.3)	9.2	6.5 (1.8)	7.7	1.2 (0.8)	8.9	0.4 (0.4)	9.4	3.8 (2.5)

* 163 dB re 1 µPa rms SPL threshold was used for this scenario since 160 dB re 1 µPa rms SPL threshold was beyond 50 km modeled range.

6.5.2.1.5. Geoacoustics

Geoacoustic parameters describe the acoustic properties of the seabed, including sound speeds in various layers. JASCO’s MONM-RAM model, a parabolic-equation-based acoustic propagation model, was used to calculate transmission loss from the source to locations within a vertical plane in the water column. MONM-RAM assumes a single geoacoustic profile of the seafloor for the entire modeled area (see 6.2.3 for required input parameters).

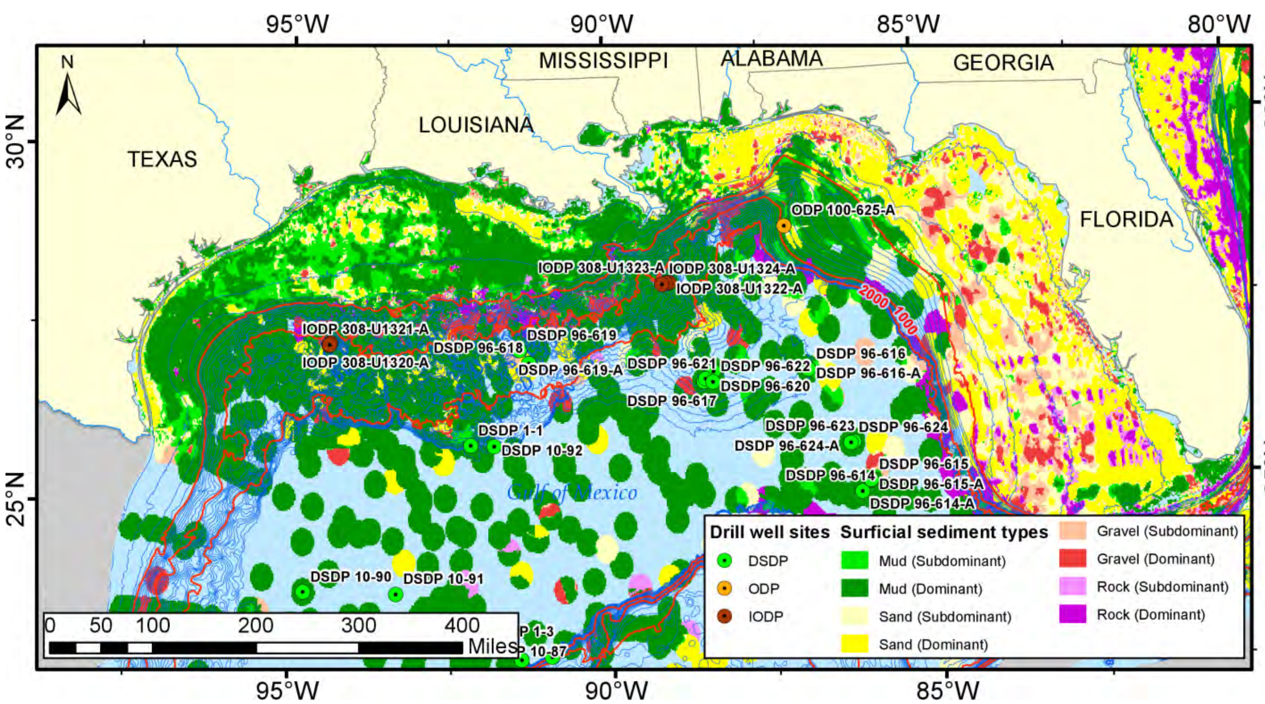


Figure 50. The map of dominant type for the surficial sediments (NOS 2013) and location of the drill wells in the Gulf of Mexico.

Two geoacoustic profiles—(1) the most likely (median) propagation conditions and (2) an extreme case of a more reflective bottom—were determined for each zone (Shelf, Slope, and Deep). The two profiles within each zone were based on similar sediment types, but the more-reflective variant was achieved by increasing the grain size and/or porosity of the sediment layers relative to the median case values.

The NOAA/NOS and USCGS Seabed Descriptions from Hydrographic Surveys (National Ocean Service 2013) were used to define the surficial sediment types for the specific zone (Figure 50). The well log data from DSDP/ODP/IODP legs were used to estimate the change of the porosity with depth. Sediment grain-shearing model (Buckingham 2005) was used to compute the acoustic properties of the sediments based on the porosity data and grain-size estimates. The grain size of the sediments is usually indicated by the parameter, φ, using an inverse logarithmic scale. From coarsest to finest, sand has φ from 0 to 4, for silt φ varies from 4 to 8, and for clay φ varies from 8 to 10.

The top layers of the seafloor in the Gulf of Mexico are represented by layers of unconsolidated sediments with the thickness of at least several hundred meters. The grain size of the surficial sediments follow the general trend for the sedimentary basins: the grain size of the deposited sediments decreases with the distance from the shore. The general surficial bottom type varies by zones: for the Shelf zone it was sand, for the Slope zone it was silt, and for the Deep zone it was clay.

The three sets of geoacoustic parameters for each zone, Shelf, Slope, and Deep, are presented in Tables 31, 32, and 33, respectively.

Table 31. Shelf zone: Median and higher reflectivity geoacoustic profiles. Sand is the dominant surficial sediment.

Depth below the seafloor (m)	Median reflectivity (φ=2)			Higher reflectivity (φ=1)		
	Porosity (%)	Rho (g/cm³)	V_P (m/s)	Porosity (%)	Rho (g/cm³)	V_P (m/s)
1	65	1.61	1610	60	1.70	1660
20	60	1.70	1900	55	1.78	2040
50	55	1.78	2090	50	1.87	2290
200	50	1.87	2500	45	1.96	2500
600	40	2.04	2500	40	2.04	2500

Table 32. Slope zone: Lower, median, and higher reflectivity geoacoustic profiles. Silt is the dominant surficial sediment.

Depth below the seafloor (m)	Lower reflectivity (φ=7)			Median reflectivity (φ=5)			Higher reflectivity (φ=4)		
	Porosity (%)	Rho (g/cm³)	V_P (m/s)	Porosity (%)	Rho (g/cm³)	V_P (m/s)	Porosity (%)	Rho (g/cm³)	V_P (m/s)
1	80	1.35	1490	75	1.44	1515	75	1.44	1530
20	65	1.61	1580	60	1.7	1670	60	1.7	1720
50	60	1.7	1640	60	1.7	1750	60	1.7	1830
200	50	1.87	1790	50	1.87	1970	50	1.87	1870
600	40	2.04	1980	40	2.04	2260	40	2.04	2040

Table 33. Deep zone: Lower, median, and higher reflectivity geoacoustic profiles. Clay is the dominant surficial sediment.

Depth below the seafloor (m)	Lower reflectivity (φ=9)			Median reflectivity (φ=8)			Higher reflectivity (φ=8)		
	Porosity (%)	Rho (g/cm³)	V_P (m/s)	Porosity (%)	Rho (g/cm³)	V_P (m/s)	Porosity (%)	Rho (g/cm³)	V_P (m/s)
1	75	1.44	1460	70	1.52	1472	60	1.70	1494
20	65	1.61	1520	60	1.70	1560	55	1.78	1570
50	60	1.70	1560	55	1.78	1610	50	1.87	1640
200	55	1.78	1650	50	1.87	1720	45	1.96	1750
600	45	1.96	1780	40	2.04	1890	40	2.04	1890

6.5.2.1.6. Geoacoustic Results

To analyze acoustic field uncertainty due to differences in the geoacoustic properties of the sea bottom, the respective median sound speed profiles were used to model in each zone. Sound fields were generated using the median and high reflectivity geoacoustic parameters (as defined above) and the resulting sound fields subtracted to determine the differences. The comparison was conducted separately for two seasons each in the Shelf and Slope zones and for the one season representing the entire year in the Deep zone.

Shelf zone: December–March

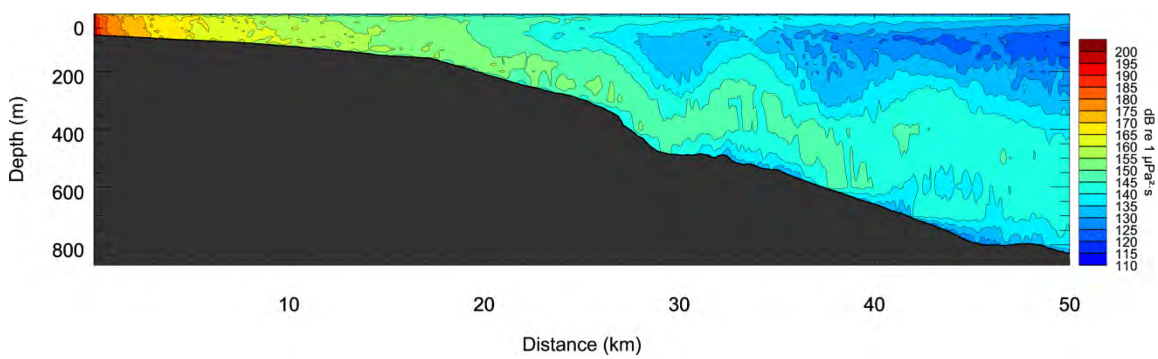


Figure 51. Shelf zone, Dec–Mar: Received SEL acoustic field using median sound speed profile and high reflectivity geoacoustic parameters. Downslope direction.

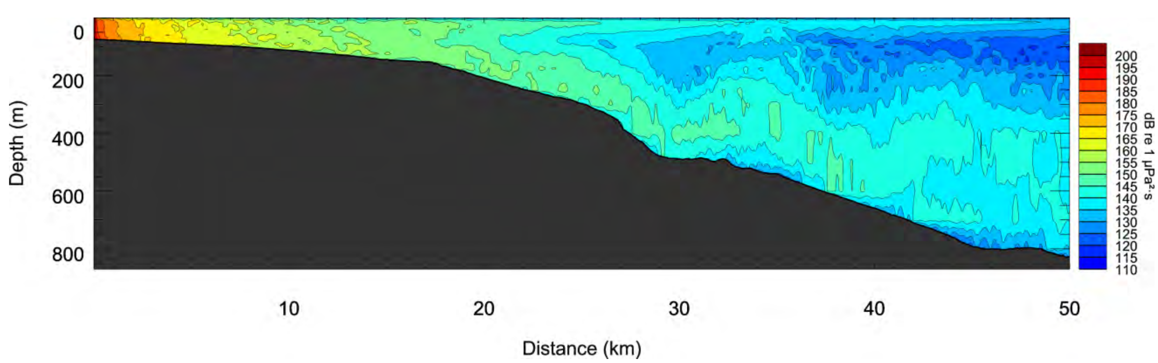


Figure 52. Shelf zone, Dec–Mar: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

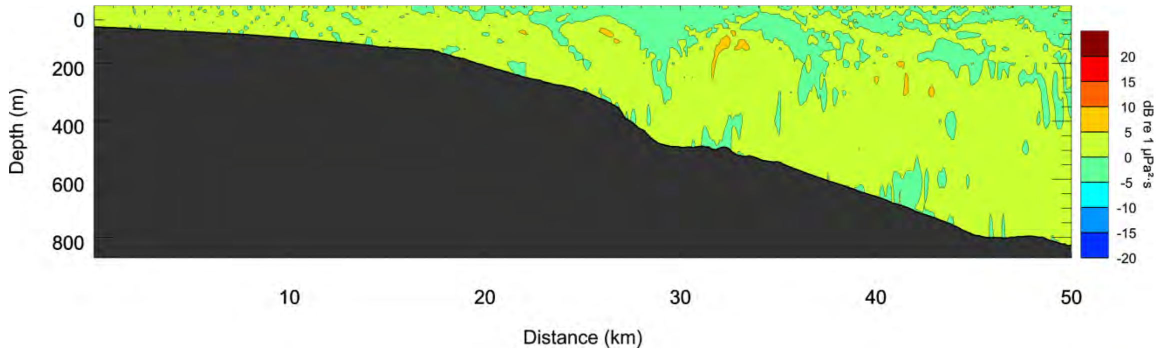


Figure 53. Shelf zone, Dec–Mar: Differential acoustic field due to variation in the bottom geoacoustic parameters. Downslope direction.

Shelf zone: April–November

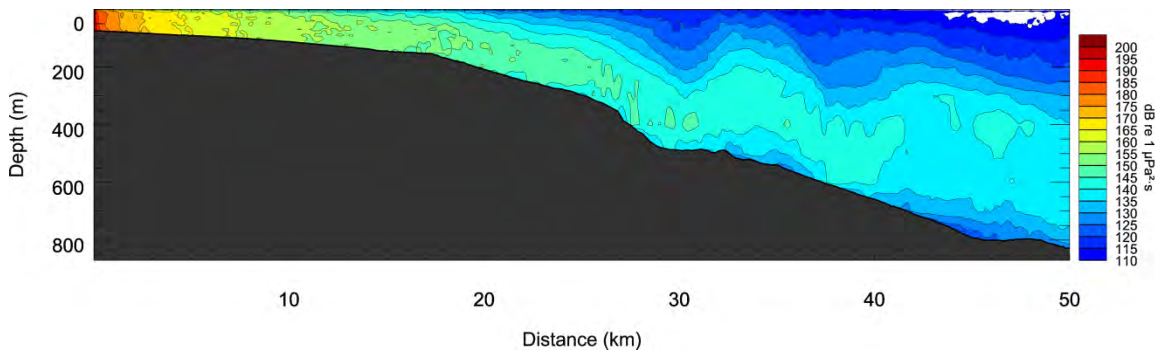


Figure 54. Shelf zone, Apr–Nov: Received SEL acoustic field using median sound speed profile and high reflectivity geoacoustic parameters. Downslope direction.

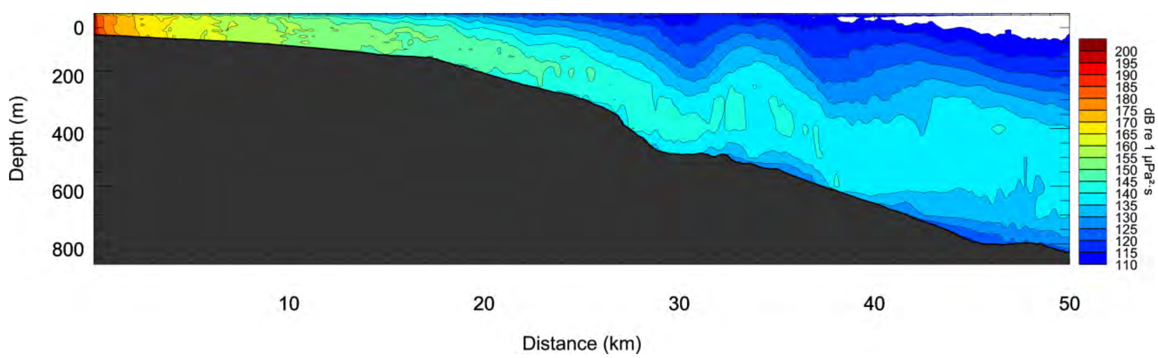


Figure 55. Shelf zone, Apr–Nov: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

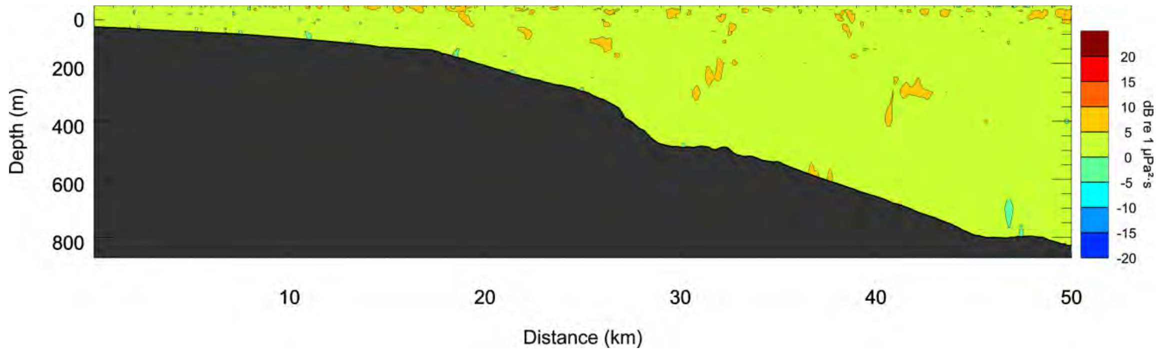


Figure 56. Shelf zone, Apr–Nov: Differential acoustic field due to variation in the bottom geoacoustic parameters. Downslope direction.

Slope zone: July–September

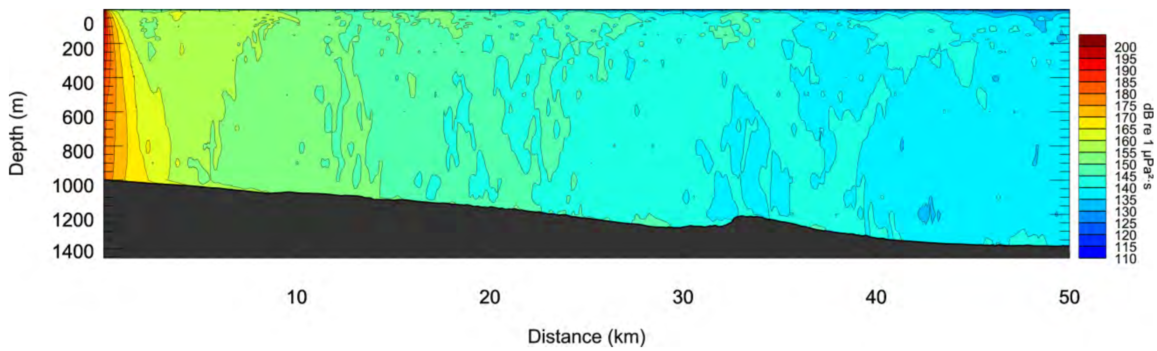


Figure 57. Slope zone, Jul–Sep: Received SEL acoustic field using median sound speed profile and high reflectivity geoacoustic parameters. Downslope direction.

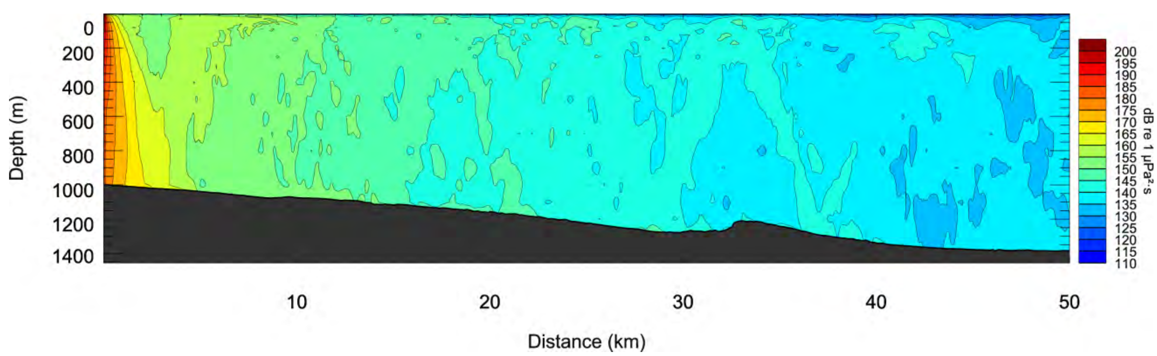


Figure 58. Slope zone, Jul–Sep: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

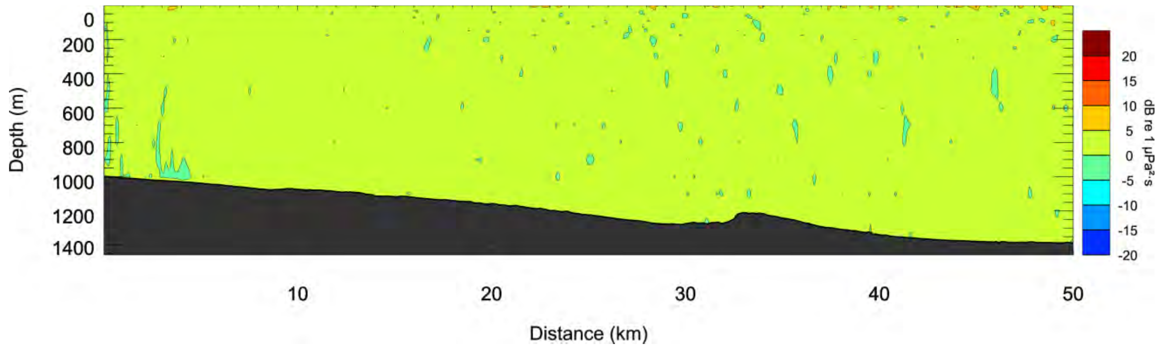


Figure 59. Slope zone, Jul–Sep: Differential acoustic field due to variation in the bottom geoacoustic parameters. Downslope direction.

Slope zone: October–June

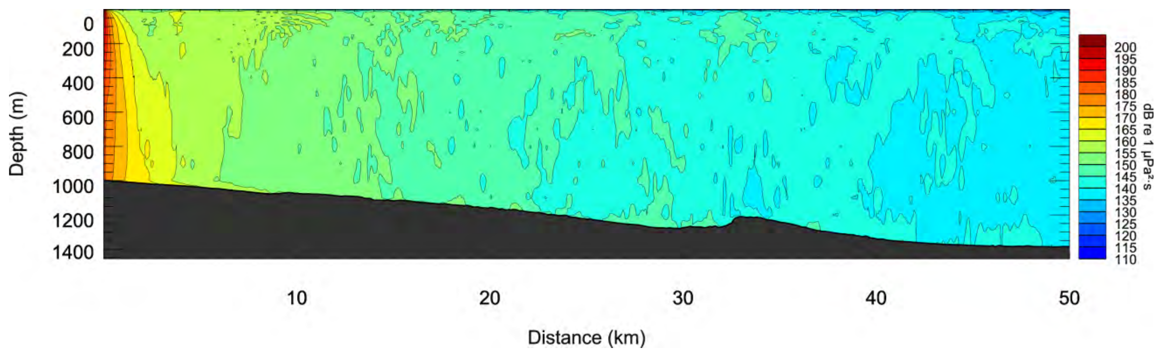


Figure 60. Slope zone, Oct–Jun: Received SEL acoustic field using median speed profile and high reflectivity geoacoustic parameters. Downslope direction.

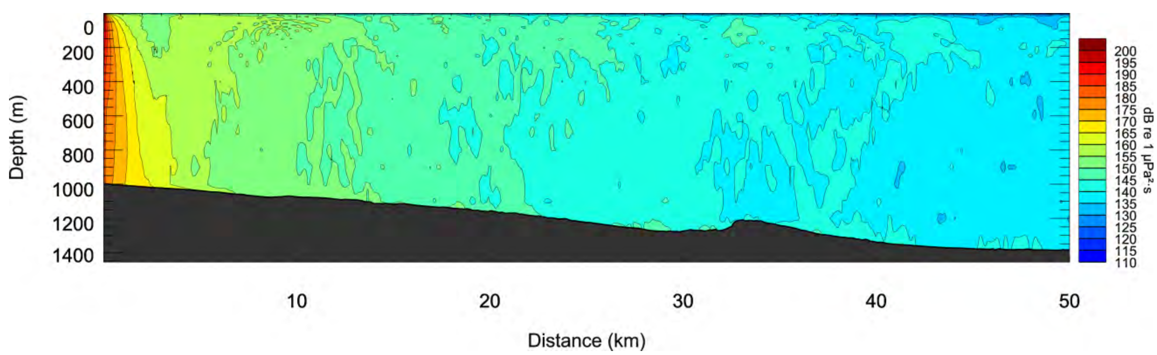


Figure 61. Slope zone, Oct–Jun: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

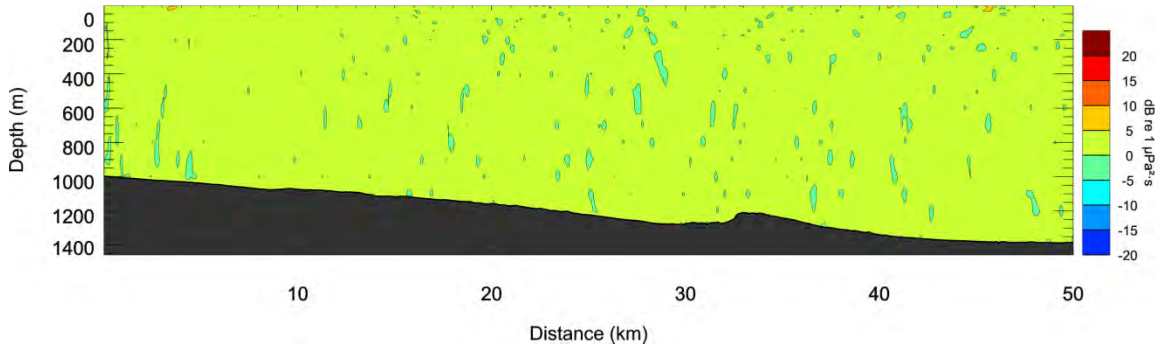


Figure 62. Slope zone, Oct–Jun: Differential acoustic field due to variation in the bottom geoacoustic parameters. Downslope direction.

Deep zone

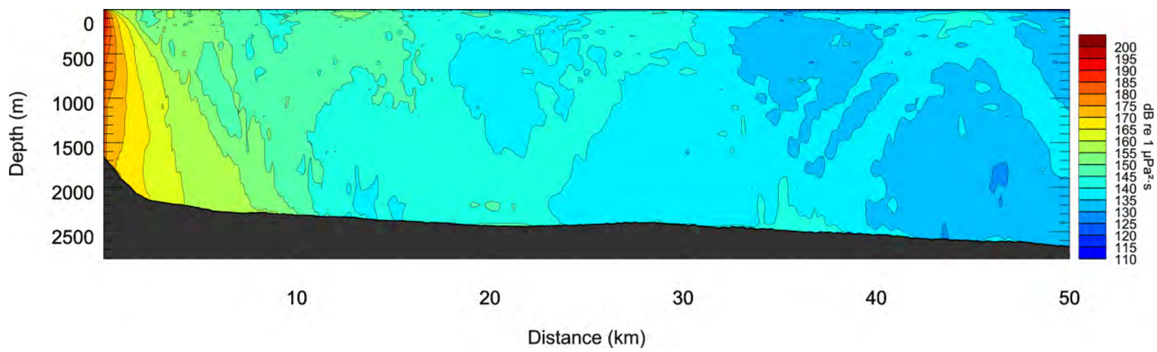


Figure 63. Deep zone: Received SEL acoustic field using median sound speed profile and high reflectivity geoacoustic parameters. Downslope direction.

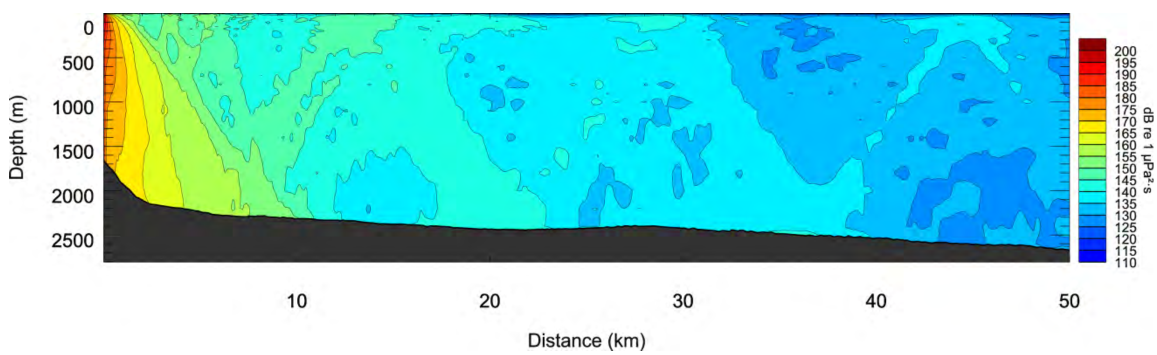


Figure 64. Deep zone: Received SEL acoustic field using median sound speed profile and median reflectivity geoacoustic parameters. Downslope direction.

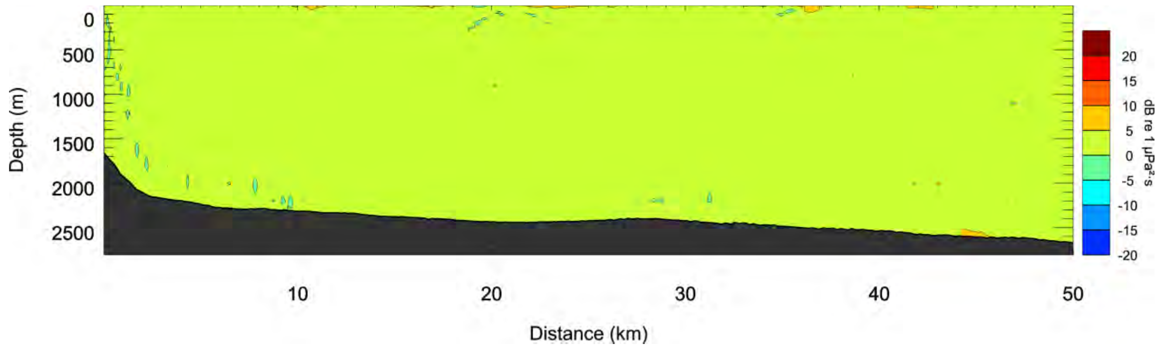


Figure 65. Deep zone: Differential acoustic field due to variation in the bottom geoacoustic parameters. Downslope direction.

As was done for the sound velocity profiles, the acoustic field in each zone was propagated in three directions (downslope, upslope, and along-slope), and for each direction the range to the 160 dB re 1 µPa rms SPL (153 dB re 1 µPa·s² SEL) threshold was estimated. The average difference and standard deviation were calculated based on the differences for individual receivers within a 5 km horizontal × 20 m deep box starting at the threshold range. The 20 m vertical extent was selected to emphasize the depths at which animals spend much of their time. Table 34 shows the calculated average differences between the maximum-propagation and median case scenarios, and the distance at which the 160 dB re 1 µPa rms SPL threshold occurs.

Table 34. Acoustic field differences between reflective and average geoacoustic conditions. Column "R" shows the maximum distance in kilometers of 160 dB re 1 µPa rms SPL threshold exceedance. Median (σ) column shows the median difference and standard deviation in decibels, over a range-depth zone containing many receivers, near the 160 dB re 1 µPa threshold location.

Direction	Shelf zone				Slope zone				Deep zone	
	Dec-Mar		Apr-Nov		Jul-Sep		Oct-Jun		Jan-Dec	
	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)	R (km)	Median (σ) (dB)
Downslope	24.1	−0.9 (0.7)	18.6	3.4 (1.7)	17.3	2.7 (1.1)	18.5	2.2 (1.2)	9.6	3.8 (1.5)
Along slope	16.5	1.3 (2.2)	11.6	3.5 (2.8)	8.5	3.4 (2.2)	10.9	1.8 (1.1)	6.8	4.0 (1.2)
Upslope	10.7	1.1 (1.3)	8.0	3.4 (1.3)	9.4	2.4 (1.0)	9.4	1.8 (0.9)	9.7	3.1 (1.9)

* 156 dB re 1 µPa rms SPL threshold was used for this scenario since 153 dB re 1 µPa rms SPL threshold was beyond 50 km modeled range.

6.5.2.1.7. Bathymetry

Water depth and local bathymetric features affect sound propagation. There is uncertainty associated with bathymetric accuracy and uncertainty in using sound fields generated for a specific location to represent a larger area. Here, a comparison is developed to show the variation in received levels with both the water depth at the source and with local features such as hills, troughs, and local slopes.

The purpose of this analysis was to delineate how acoustic propagation differences due to variations in bathymetry result in variations in the acoustic field in each of several water depth regimes (shallow, slope, deep vs. downslope, along-slope, upslope). The bathymetry variation in any one regime was represented as a pair of modeling sites at different, but nearby, water depths. The difference in the acoustic field modeled at these paired sites is reported as a mean and standard deviation over range and receiver depth. The bottom topography variation differences that exist between each paired site are included in the analysis. This is different from a sensitivity analysis that would examine variations in the acoustic field based on small perturbations in modeling bathymetry at individual modeling sites. As such, the analysis reported here estimates the uncertainty in the acoustic field due to bathymetric variations that occur within a given acoustic regime. This is directly relevant to the Phase II study because modeling results from one site were used as a proxy for the acoustic field produced by a source at various locations within a given modeling regime represented by that site.

6.5.2.1.8. Bathymetry Results

To analyze acoustic field uncertainty due to bathymetry, the acoustic fields calculated for the exposure modeling were used. Modeling sites were selected at 25, 75, and 150 m depth (Shelf zone), 300, 500, 750, 1000, and 1500 m depth (Slope zone), and 2000 and 2500 m depth (Deep zone). The sound propagation modeling for the analysis was performed for Season 1 (winter) sound speed profile and median reflectivity geoacoustic profile.

Acoustic fields at pairs of water depths were compared:

- 25 and 75 m
- 75 and 150 m
- 300 and 500 m
- 500 and 750 m
- 750 and 1000 m
- 1000 and 1500 m
- 2000 and 2500 m

The differential field was calculated by subtracting the received levels of the acoustic field at deeper site from the received levels at shallower site. The positive values of the differential field indicate that the received level at specific distance from the source and depth from the sea surface was greater for the site with shallower water depth at the source.

Shelf zone: 25 m to 150 m

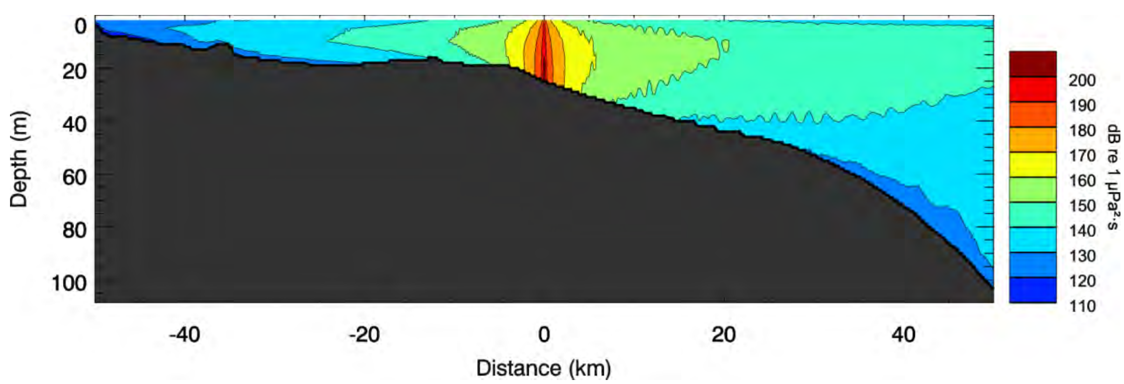


Figure 66. Shelf zone: The source when positioned at water column depth of 25 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

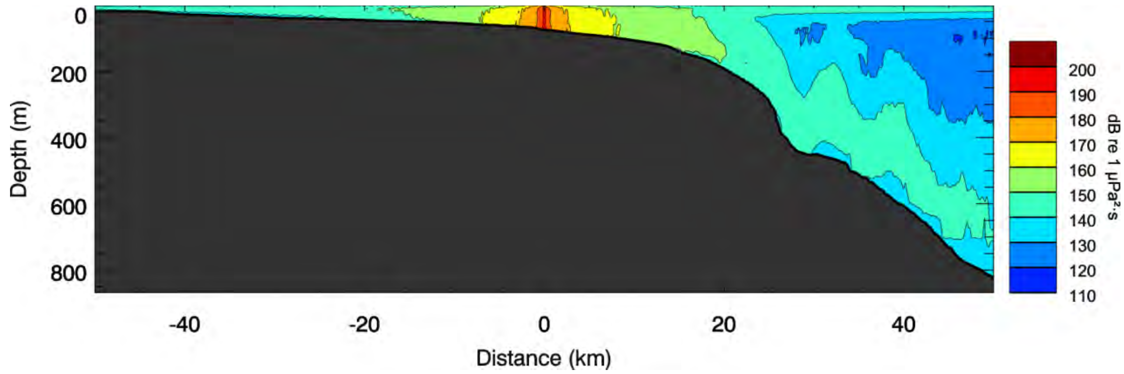


Figure 67. Shelf zone: The source when positioned at water column depth of 75 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

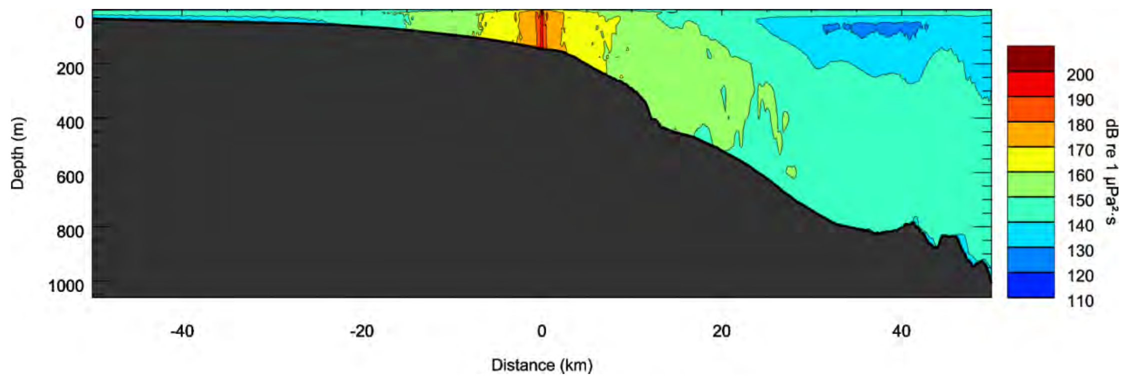


Figure 68. Shelf zone: The source when positioned at water column depth of 150 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

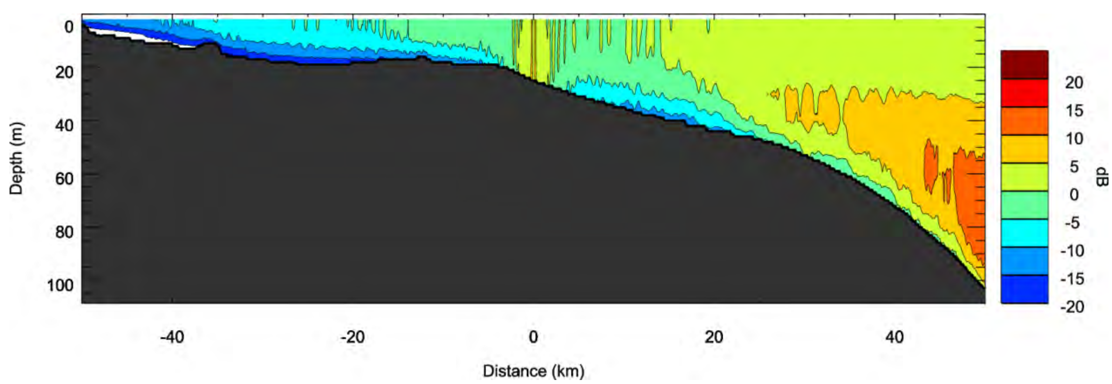


Figure 69. Shelf zone: Differential acoustic field for the source when positioned at water column depths of 25 and 75 m: Differential acoustic field due to variation of the water depth at the source. Cross-slope direction.

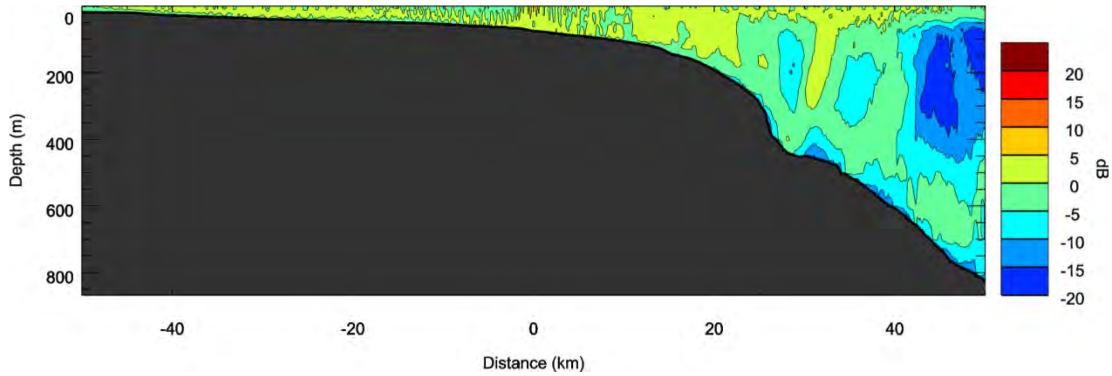


Figure 70. Shelf zone: Differential acoustic field for the source when positioned at water column depths of 75 and 150 m: Differential acoustic field due to variation of the water depth at the source. Cross-slope direction.

Slope zone: 300 m to 1500 m

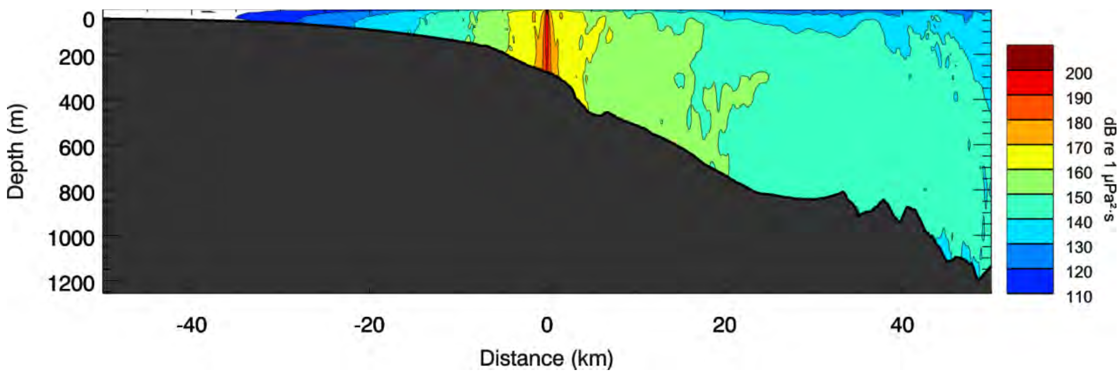


Figure 71. Slope zone: The source when positioned at water column depth of 300 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

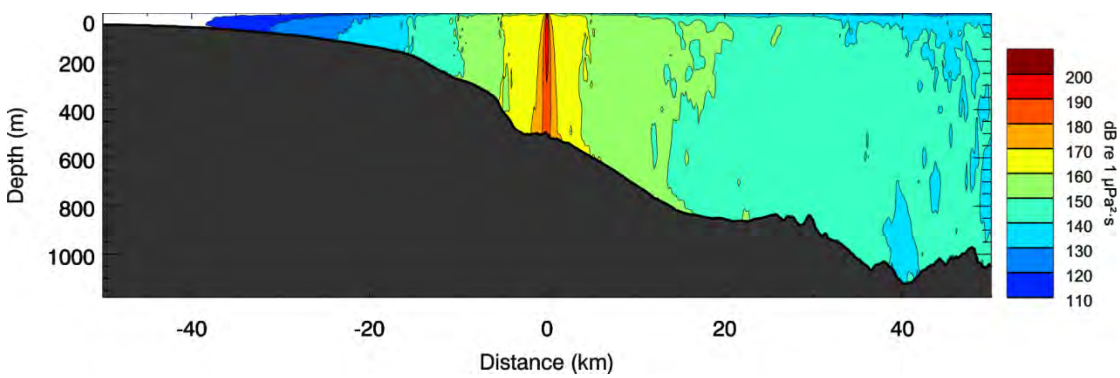


Figure 72. Slope zone: The source when positioned at water column depth of 500 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

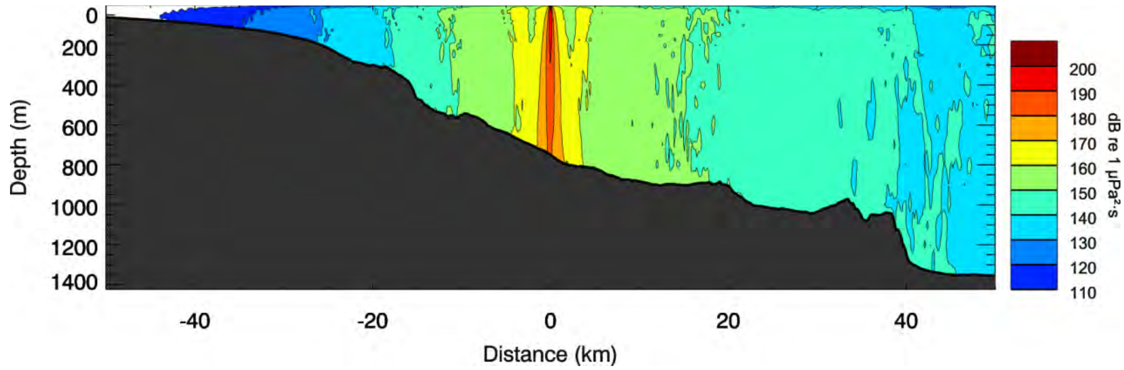


Figure 73. Slope zone: The source when positioned at water column depth of 750 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

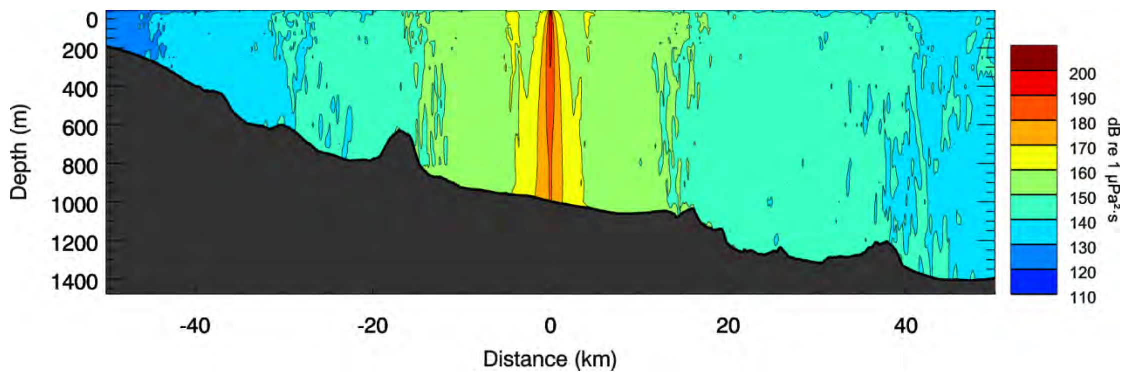


Figure 74. Slope zone: The source when positioned at water column depth of 1000 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

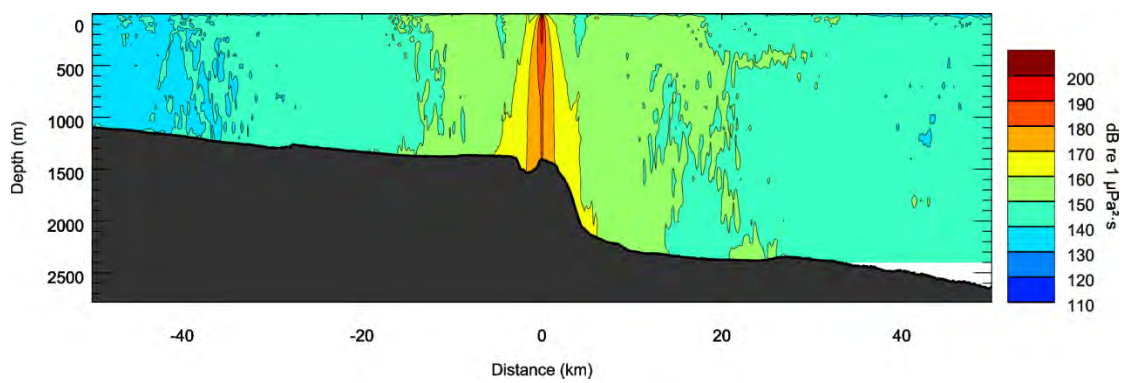


Figure 75. Slope zone: The source when positioned at water column depth of 1500 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

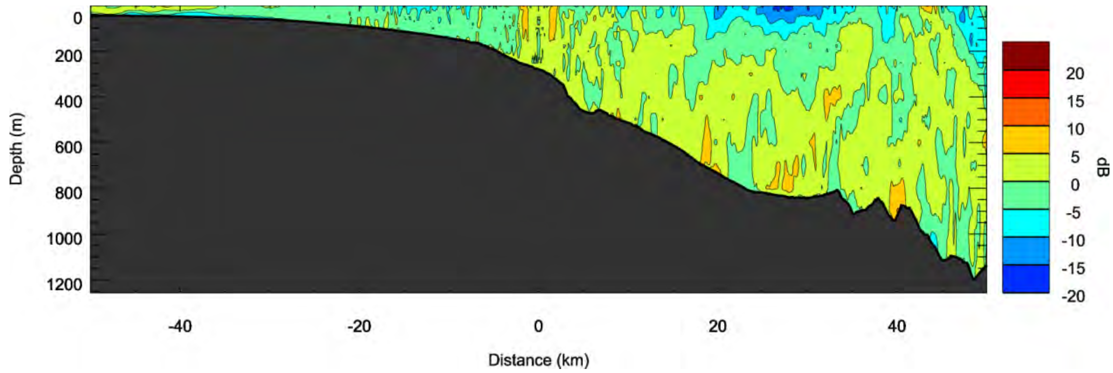


Figure 76. Slope zone: Differential acoustic field for the source when positioned at water column depths of 300 and 500 m. Cross-slope direction.

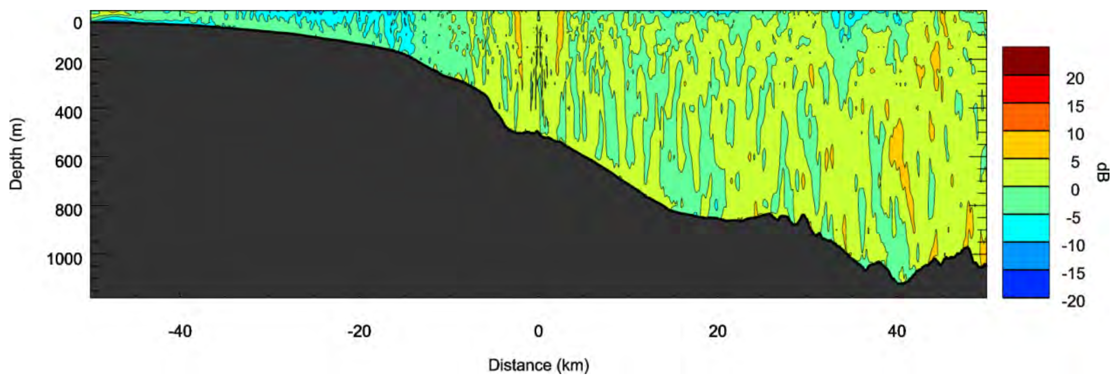


Figure 77. Slope zone: Differential acoustic field for the source when positioned at water column depths of 500 and 750 m. Cross-slope direction.

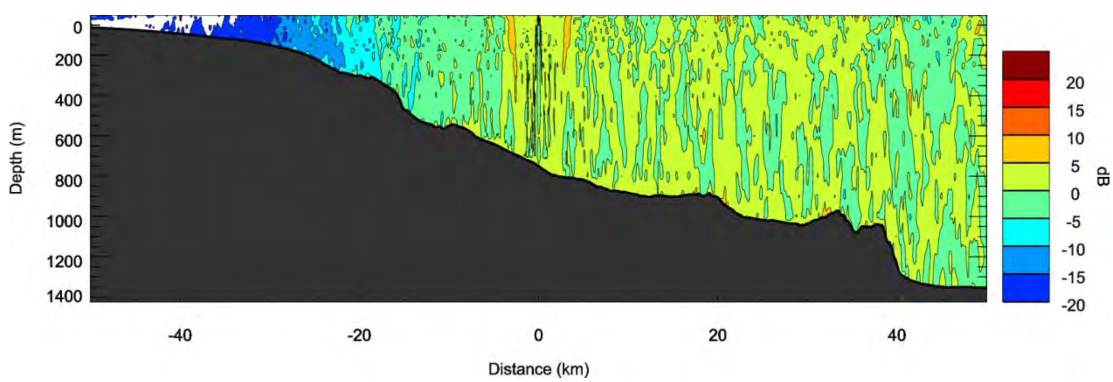


Figure 78. Slope zone: Differential acoustic field for the source when positioned at water column depths of 750 and 1000 m. Cross-slope direction.

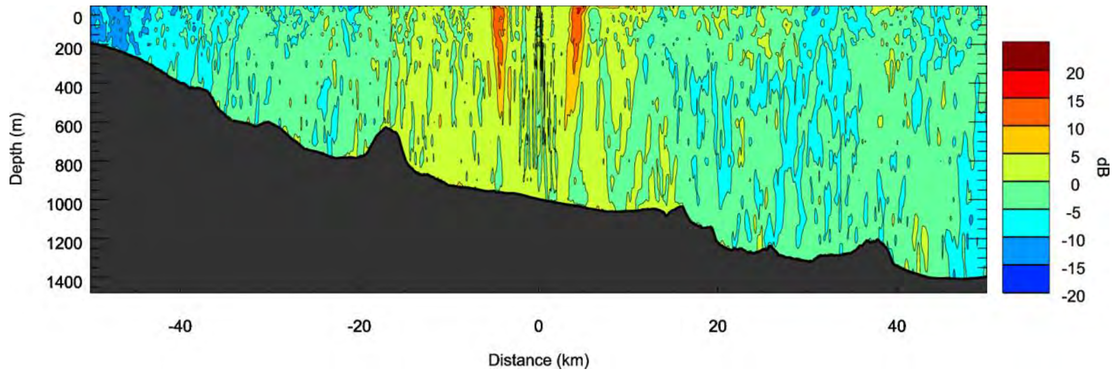


Figure 79. Slope zone: Differential acoustic field for the source when positioned at water column depths of 1000 and 1500 m. Cross-slope direction.

Deep zone: 2000 m to 2500 m

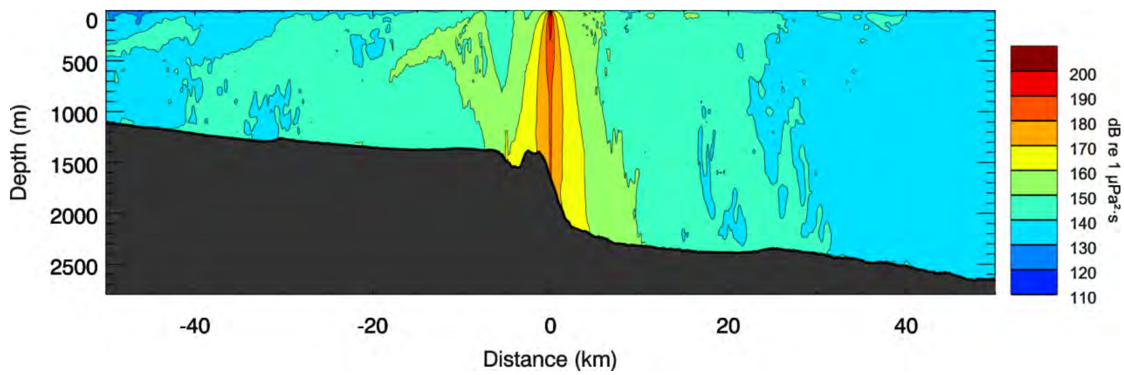


Figure 80. Deep zone: The source when positioned at water column depth of 2000 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

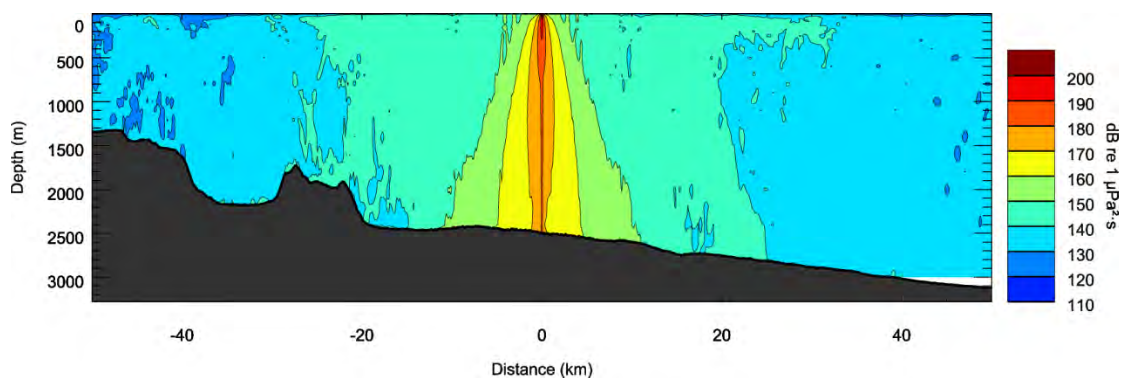


Figure 81. Deep zone: The source when positioned at water column depth of 2500 m: Received SEL acoustic field using Season 1 sound speed profile and median reflectivity geoacoustic parameters. Cross-slope direction.

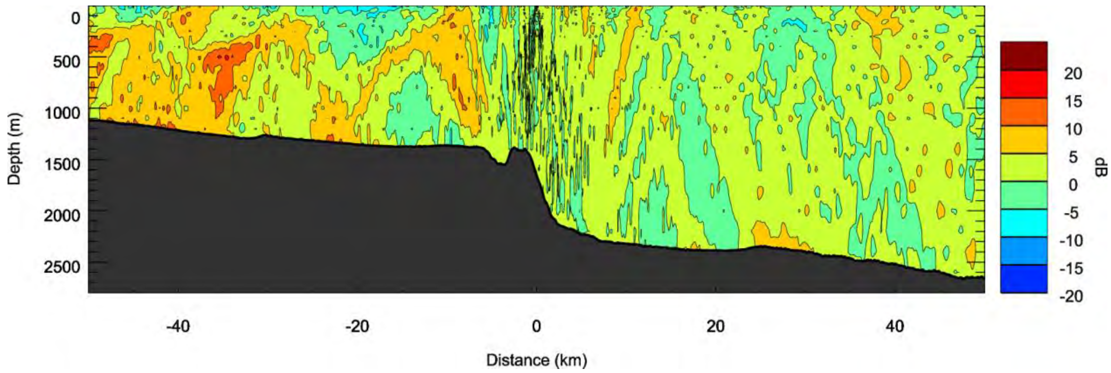


Figure 82. Deep zone: Differential acoustic field for the source when positioned at water column depths of 2000 and 2500 m Cross-slope direction.

For each scenario, the acoustic field was propagated in three directions: downslope, upslope, and along-slope. Two sites at adjacent water depths were compared. The average difference and standard deviation were calculated for a set of ranges from the source: 500, 1000, 2000, 5000, and 10,000 m. The received levels at the individual receivers within the selected ranges and the top 20 m were considered. The 20 m vertical extent was selected to emphasize the depths at which the animals spend much of their time. Table 35 provides the calculated average differences in the selected volume between the acoustic fields calculated for the adjacent sites.

Table 35. Acoustic field uncertainty due to variations in the water depth at the source. Median value and σ (number in brackets) are provided in dB for various averaging ranges from the source and direction of the propagation.

Range/ Direction	Shelf zone		Slope zone				Deep zone
	25–75 m	75–150 m	300–500 m	500–750 m	750–1000 m	1000–1500 m	2000–2500 m
500 m							
Downslope	3.8 (2.6)	3.6 (2.8)	1.2 (1.3)	0.6 (0.8)	0.4 (0.8)	0.1 (0.5)	0.3 (0.7)
Along slope	4.4 (4.1)	3.8 (4.5)	0.9 (1.7)	0.5 (1.3)	0.3 (1.1)	0.2 (0.8)	−0.0 (0.1)
Upslope	3.8 (2.9)	3.9 (3.1)	1.4 (1.3)	0.8 (1.0)	0.3 (0.7)	0.4 (0.9)	−0.1 (0.4)
1000 m							
Downslope	2.9 (2.2)	2.3 (2.6)	0.9 (1.3)	1.3 (1.0)	1.1 (1.1)	1.2 (1.4)	1.6 (1.9)
Along slope	3.4 (3.5)	3.0 (3.8)	0.6 (1.9)	0.8 (1.9)	0.8 (1.6)	0.6 (1.9)	0.3 (1.3)
Upslope	2.8 (2.5)	2.3 (2.9)	1.5 (1.3)	1.5 (1.2)	1.0 (1.1)	1.8 (1.8)	−0.1 (1.2)
2000 m							
Downslope	1.7 (2.2)	1.4 (2.2)	3.4 (3.3)	1.3 (1.0)	1.0 (1.0)	1.7 (1.8)	1.8 (3.2)
Along slope	2.4 (3.2)	1.9 (3.5)	4.2 (4.6)	0.9 (2.1)	0.6 (1.7)	0.8 (2.4)	−0.5 (2.2)
Upslope	1.7 (2.2)	1.0 (2.6)	3.7 (3.1)	1.5 (1.3)	1.0 (0.9)	2.3 (3.2)	1.0 (2.2)
5000 m							
Downslope	0.0 (2.2)	0.5 (2.0)	0.3 (3.8)	1.5 (2.7)	1.8 (2.4)	4.9 (5.2)	2.2 (3.3)
Along slope	1.0 (3.0)	0.8 (3.3)	2.1 (4.4)	2.9 (3.6)	2.8 (3.4)	3.5 (3.8)	1.0 (2.9)
Upslope	−0.8 (3.1)	−0.3 (2.2)	0.8 (3.5)	1.8 (2.4)	1.8 (2.7)	4.1 (5.0)	0.4 (4.0)
10000 m							
Downslope	−0.6 (1.9)	0.5 (1.7)	−1.2 (3.9)	−0.1 (2.8)	1.0 (2.2)	4.9 (4.2)	1.4 (3.6)
Along slope	−1.2 (3.8)	0.4 (3.5)	0.0 (4.2)	1.4 (3.8)	2.4 (3.6)	1.9 (5.4)	2.0 (4.3)
Upslope	−3.2 (4.3)	−0.6 (1.9)	−1.4 (3.8)	0.4 (2.6)	0.4 (2.5)	2.7 (4.2)	0.4 (4.6)

* 156 dB re 1 μPa rms SPL threshold was used for this scenario since 153 dB re 1 μPa rms SPL threshold was beyond 50 km modeled range.

6.5.2.1.9. Sea State

A smooth sea surface is a near-perfect reflector of sound waves incident from below. However, ocean waves at the sea surface, due to local winds or from distant weather disturbances, can scatter sound in a non-uniform way. The degree of scattering depends on the amplitude of the surface roughness (wave height and wave crest separation), the wavelength of the sound energy, and the angle at which the sound energy is incident onto the surface. In very rough seas, breaking waves can entrap air bubbles, blurring the actual position of the water-air interface. In general, scattering effects are small when the dimension of the surface roughness is small relative to the wavelength of the sound. Surface wave height is (typically) a function of wind speed, so higher frequency sounds are generally affected at lower wind speeds than lower frequency sounds. Sea-surface roughness generally has negligible effect on the propagation of sounds with frequencies < 50 Hz, where acoustic wavelengths are greater than 30 m. There can be a moderate effect on frequencies between 50 and 200 Hz, and a more significant effect on frequencies > 200 Hz in higher sea states. The additional coherent reflection losses at the air-sea interface due to the roughness of the boundary usually range from 0 to 2 dB per interaction and greatly depend on the grazing angle of the incoming wave (Long et al. 1989).

Scattered sound energy is not lost and does not reduce the total amount of acoustic energy in the water. Scattering, however, has the effect of randomizing the phase of reflected sounds, thereby blurring the coherent interaction of reflected energy with sound that does not reflect. This results in a reduction of the strength of interference maxima and minima in the water column. The overall effect is to even out the otherwise more-variable spatial variations of sound levels in the water. In very rough conditions, when air is entrapped by breaking waves at the surface, high frequency sounds can be attenuated through absorption and high frequency levels can be reduced.

Surface roughness depends on weather conditions, duration of increased winds, proximity to land, and on distant sea state patterns. For the acoustic propagation modeling here, we assumed perfectly calm conditions and a flat air-sea interface. This scenario leads to near perfect acoustic reflections. Although such conditions are rarely observed exactly, it is an often realistic approximation. It should be noted, however, that propagation in sound speed profiles that cause surface sound channels can be quite strongly affected, as sound can be scattered out of the duct. In those cases, sound levels in the channel can be substantially reduced. In the absence of a surface sound channel, or when sea state is low or moderate, the effects will generally be small.

6.5.2.1.10. Summary of Acoustic Uncertainty

Uncertainties in the results of acoustic propagation modeling were estimated by examining the variation in model outputs when model inputs were offset by realistic errors. The environmental properties were selected so that the median, or expected, value could be compared to a maximum-propagation outcome, which was generated by selecting extreme values for several input parameters. These comparisons represent the maximum errors in the predicted sound fields that result from incorrect specification of the parameters tested. Most of the comparisons were made at selected locations in the top 20 m of the water column, where marine mammals spend a substantial amount of time.

For uncertainty in the sound speed profile, a difference of > 10 dB between the median and maximum-propagation scenarios was observed in the Shelf zone in both seasons (Table 30). The maximum-propagation scenario for the December–March period exhibited a strong surface duct (30 m/s difference between speed at the surface and maximum speed) that trapped the acoustic energy and propagated it with lower transmission loss. A surface duct was present in the median sound speed profile for the same period, but the maximum difference in sound speed was only 5 m/s. The difference in the sound fields for the April–November season was primarily due to a difference in the negative gradient below the surface duct where the maximum-propagation scenario sound speed profile was significantly less downward refracting. Surface ducts in the other zones were weaker, and variations in their sound speed profiles lead to less pronounced changes in sound propagation. The difference between the maximum-propagation and median scenarios in the Slope and Deep zones was < 4.0 dB.

The greatest uncertainty due to geoacoustic parameters of the sea bottom is 4 dB, in the Deep zone (Table 34). The effect of the geoacoustic uncertainty increased when the sound speed profile was downwardly refracting. In the case of a surface channel (Slope zone, winter season), the average difference between the median and maximum-propagation was only 0.5 dB, i.e., in this case the geoacoustic parameters had virtually no effect on the sound levels at the top of the water column. Because the interaction of sound waves with the ocean bottom is most important in downward refracting environments, the uncertainty in the sound speed profile and geoacoustic parameters are negatively correlated.

Unlike the geoacoustic parameters, bathymetry is better documented and, unlike the sound speed profile, it does not change with time. For seismic surveys with moving sources, however, it is not practical to model the acoustic field for every possible source position. The common practice is to model acoustic propagation in a limited number of source positions and to use these derived fields as representative of the source operating in similar bathymetric regions. With this approach, there is uncertainty in the acoustic fields due to the presence or absence of local bathymetric features. Local features of the sea bottom generally affect specific azimuths and/or ranges while differences in the water depth affect regions of the sound field. The analysis of uncertainty due to bathymetry showed that uncertainty varies with range from the source and there is a dependence on the water depth—the greater the water depth, the greater the range at which the highest uncertainty occurs. Comparison of the two cases in the Shelf zone revealed an uncertainty of about 4.5 dB within 500 m from the source (Table 35). In the Deep zone, the highest uncertainty occurred 5–10 km from the source. On average, the received levels differed by about 1.6 dB between the source operating in 2500 m and 2000 m depths.

The weather-driven sea state also adds to the uncertainty in the acoustic field by changing the roughness at the air-sea interface. Scattering diminishes the extremes in the sound field, especially at higher frequencies. Sea-surface roughness negligibly affects the propagation of acoustic waves with frequencies < 50 Hz and moderately affects frequencies between 50 and 200 Hz, and can significantly affect higher frequency sounds. It is expected to have more effect when surface sound duct propagation is present. The acoustic propagation modeling assumed a flat air-sea interface, and because the airgun array was a low-frequency source minimally affected by sea state, little uncertainty was expected due to sea state changes.

Uncertainties in the acoustic field discussed here represent a multi-dimensional envelope that can be wrapped around the main modeling results. This envelope is meant to enclose the modeled acoustic field and the real world acoustic field. The uncertainties in the different dimensions of this envelope (sound speed profile, geoacoustics, bathymetry, and sea state) cannot be summed to yield a "total" uncertainty as this would be a meaningless quantity. The overall uncertainty is measured for the volume of the multi-dimensional uncertainty envelope, but this is a difficult concept to use in operational planning. The best way to visualize the overall uncertainty is in terms of the different dimensions of the uncertainty envelope, as discussed above.

6.5.2.2. Animal Modeling Uncertainty

The exact location, behavioral, and motivational state of animals during an operation are not known and, as such, are the main sources of uncertainty in this modeling project. Those uncertainties are best addressed with animal movement simulations and Monte Carlo sampling which combines simulated animal movement from the Marine Mammal Movement and Behavior Model (3MB, Houser 2006) with the modeled sound fields of geotechnical and geophysical operation. Each simulated animal (animat) acts as a receiver and samples the sound field in a way real animals are expected to experience the sound field. With multiple animats sampling the sound field (Monte Carlo sampling), the distribution of received levels for the operation can be estimated as a probability of exposure. Exposure estimates can then be calculated from the exposure probability.

6.5.2.2.1. Animal Movement Parameters Uncertainty

The movement parameters for 3MB are based on a two level process—a) preselected behavioral states and their temporal variation provide a framework for animat movements that b) follow a preselected stochastic processes for movement within the selected behavior states. The user-chosen parameters and preselected movement processes determine how simulated members of each species (animats) sample the sound fields. Uncertainty about the underlying motivation for any animal's location choice means there is uncertainty in the parameters chosen for the model, and consequently uncertainty in the sampled received levels. Because there are many variables and a large range of possible parameter values, and oftentimes there are few data to support the model parameter values chosen, the uncertainty level can be high. It is impractical to conduct a parametric sensitivity analysis (as was done for Acoustic Modeling Uncertainty), but the results from the six Test Case species (Section 6.3 and see Table 14 for species) can be compared. Because each species has distinct parameters that govern their movements, we were able to qualitatively compare how the different behavioral parameters might affect exposure estimates.

6.5.2.2.2. Summary of Animal Movement Parameter Uncertainty

Animal movement is simulated using an animal movement model, such as the 3MB (Houser 2006), and combined with the modeled sound fields of an operation. The 3MB incorporated many parameters to produce realistic animal movement. Each parameter could affect the estimated exposure levels independently or in association with each other. The results of the different modeled species are compared, giving a semi-quantitative indication of how different animal movement types affect exposure.

The primary differences in the modeled exposure estimates among species are due to differences in animal acoustic sensitivity (Tables 14–15):

- Beaked whales have lower behavioral response thresholds than other species
- High-frequency dwarf sperm whales have lower injury thresholds than other species
- There is a larger range for potential injury due to accumulated energy for low-frequency species relative to the other species because of the weighting functions used; the low-frequency weighting function admits more acoustic energy from the low-frequency airgun source to propagate.

When the same filtering and thresholds were applied, comparisons between animals resulted in similar exposure estimates. The exposure estimates for potential injury and exposure estimates for potential behavioral disruption for common bottlenose dolphins, short-finned pilot whales, and, to some extent sperm whales, were similar. For sperm whales, however, there was a marked difference in modeled exposure estimates between Survey sites A and B. This was due to a behavioral depth restriction for this species—sperm whales usually occur in water deeper than 1000 m. Because much of the survey area at Survey site A was shallower than 1000 m, few animats were near the source and the exposure levels were low through much of the modeling. Sperm whales also showed greater potential of behavioral response to noise exposure than other species with the same auditory thresholds. Sperm whales are deep divers; in this downward refracting environment they appear to be consistently exposed relative to the shallow divers such as Cuvier's beaked whales, also a deep diving species, but with lower behavioral thresholds.

Related to animal location and movement, but not currently captured by our animal movement modeling, are behavioral aspects that could increase uncertainty. Factors that affect the motivation of animals to remain at a certain location or to leave that location include the presence of prey and predators, which influence density. Another potential uncertainty is the socio-ecological need of animals to aggregate in groups. The sections below detail the effects of animal density and social group size on exposure estimates.

6.5.2.2.3. Animal Density Estimates Uncertainty

The Monte Carlo simulations are run using a fixed animat density. Real-world animal density estimates are used to adjust the modeled (animat) exposure estimates to get real-world exposure estimates. Real-world density estimates are, very likely, the second largest source of uncertainty in the modeling project. Density estimates come from visual surveys (aerial and shipboard) and acoustic surveys. They are expensive, time consuming, and typically only examine small portions of populations for short times and often miss longer term and seasonal distribution patterns The best available data currently are from the U.S. Navy OPAREA Density Estimate (NODE) for the Gulf of Mexico (Department of the Navy 2007). For one region, the density estimates include minimum, maximum, mean, and standard deviation per area, e.g., km^2, assuming animals are normally, if not uniformly, distributed across the region. We often incorporated the uncertainty into the density estimates by reporting the impacts for the minimum, maximum, and mean density estimates, which bracket the range of expected impacts. We also used a resampling technique (bootstrap resampling) to estimate exposures with sample sizes scaled for the real-world density estimate.

6.5.2.2.4. Animal Density Estimates Uncertainty Results

Estimates for the number of animats exposed to levels exceeding injury and behavioral response thresholds were determined in the 3-D WAZ survey of the Test Case (Section 6.3.2, Tables 14–15). Real-world exposure estimates were also determined and presented in the Test Case report (Tables 16–17). The real-world exposure estimates were obtained using the real-world density estimates (Table 36), which were used to adjust the modeled exposure estimates (Tables 14–15) to get the real-world exposure estimates (Tables 16–17).

Table 36. Real-world density estimates for summer at Survey sites A and B.

Modeled marine mammal species	Survey site A				Survey site B			
	Min	Max	Mean	σ	Min	Max	Mean	σ
Bryde's whales	0	0.000105	0.000081	0.000044	0	0.000105	0.000097	0.000029
Cuvier's beaked whales	0.000003	0.004121	0.000676	0.000918	0	0.004121	0.000809	0.00092
Common bottlenose dolphins	0	0.2905	0.02181	0.027384	0	0.09859	0.003227	0.007823
Short-finned pilot whales	0	0.006277	0.004845	0.002657	0	0.006277	0.005785	0.001704
Sperm whales	0.000036	0.008154	0.002761	0.001859	0.000365	0.005395	0.002311	0.001496
Dwarf sperm whales	0	0.004605	0.000673	0.000912	0.000002	0.01558	0.001589	0.002174

min=minimum; max=maximum; σ=standard deviation

Bootstrap resampling

Bootstrap resampling is a random re-sampling (with replacement) technique used to quantify distribution accuracy for a sample estimate (e.g., Whitlock and Schluter 2009). Bootstrap resampling was used in this project to quantify the distribution accuracy of exposure probabilities and real-world exposure estimates (the number of animals above threshold) obtained from the Monte Carlo simulations of the six Test Case species. The exposure probabilities were the received-level frequency of occurrence, which were expressed as histograms (Figure 83A). The exposure probability histograms were randomly resampled, with replacement, and the number of animats exposed to levels above threshold was found (as the sample estimate). This process was repeated many times to get an expected distribution of animats with exposures above threshold. One sample drawn from the exposure probability is one bootstrap sample, one group of samples drawn from the exposure probability to represent a sample population is a bootstrap replicate.

For example, there were 16,000 Bryde's whale animats in the simulation, to maintain the same density throughout the resampling process 16,000 bootstrap samples could be taken as one bootstrap replicate, and 10,000 bootstrap replicates (of 16,000 samples each) obtained and the sample estimate calculated for each replicate. The sample estimate distribution is the distribution of animats exposed to levels above threshold for the bootstrap replicates (Figure 83B). Without resampling, there were 534 simulated Bryde's whales at Survey site A with received levels above SEL 187 dB re 1 $\mu Pa^2 \cdot s$ (Table 14). Resampling obtained the range of animats above threshold and their probability of occurrence. In Figure 83B, the mean number of animats above threshold for the bootstrap replicates was also ~ 534, with a 5% likelihood of getting 495 or less animats and a 95% likelihood of 573 or less animats. There was 90% chance that the number of animats above threshold was between 496 and 573.

Without bootstrap resampling, the number of animats exposed to levels above threshold (Tables 14 and 15) was adjusted by the real-world density (Table 36) to calculate the number of animals expected to be exposed to levels exceeding threshold (Tables 16 and 17). For Bryde's whales at Survey site A, adjusting the 534 animats above threshold by the mean density estimate of 0.000081 resulted in 0.02 animals with above threshold exposures. When the minimum and maximum density estimates were used, the number of animals above threshold was < 0.01 and 0.03, respectively. With bootstrap resampling, changing the number of bootstrap samples in the bootstrap replicate is equivalent to changing the modeling density. To incorporate the uncertainty in the density estimates (standard deviation), the number of bootstrap samples in the bootstrap replicate was scaled by the ratio of the real-world density (± standard deviation) to the modeled density. The resulting distribution of real-world Bryde's whales exposed to sound levels above threshold after resampling had a mean value of 0.0195, with a 98% likelihood of no animals above threshold, a 99.8% likelihood of 1 animal or less above threshold, and a maximum of 2 animals above threshold (Figure 83C). Note that the mean values with or without bootstrap resampling were about the same at 0.02 animals receiving levels above threshold and the range was also comparable, but the resampling procedure provided a more complete description of the sample estimate distribution. Similar to the Bryde's whales, the number of dwarf sperm whale animats exposed to levels above SEL injury threshold without resampling was 1053 at Survey site A and the real-world exposure estimate was 0.35 animals. After bootstrap resampling was applied to the modeled animat exposure probability distribution and after the sample size for each bootstrap replicate was adjusted to reflect real-world animal density, the distribution of animals exposed to levels above threshold had a mean of 0.4019 with 71% of samples with no animals exposures above threshold. The number of animals receiving levels above threshold increased to 2 when 97.6% of replicates were considered while up to 7 animals could be exposed to levels above threshold when 99.5% of replicates were considered (Figure 83D). The remaining species (Cuvier's beaked whales, common bottlenose dolphins, short-finned pilot whales, and sperm whales) either had 1 or no animats receiving levels above SEL injury threshold, so the sample distribution was essentially zero mean with zero variance (not shown).

The same approach was used to obtain a distribution for potential behavioral responses. Figure 83E and F, show the real world behavioral disruption exposure estimate distributions for Bryde's whales and dwarf sperm whales. For Bryde's whales, the mean value matched the adjusted exposure estimate of 0.59 animals (Table 16) and distribution includes 60% of bootstrap samples with zero animals exposed to levels above threshold, 95% of samples with 2 or fewer animals, and a maximum of 5 animals. For dwarf sperm whales, the mean number of animals with a potential behavioral response was 3.5 (close to the exposure estimate without resampling of 3.03 in Table 16); 30% of bootstrap samples showed no animals with a behavioral response, 50% showed 3 or fewer animals, 95% showed 10 or fewer, and the maximum was 20 animals exhibiting a behavioral response. For the remaining Test Case species, Figure 84 shows the resampled behavioral disruption exposure estimates and resampled exposure estimates adjusted for real-world densities. All means matched the (unadjusted) modeled exposure estimates (Table 14) within ~ 2%. The means of the bootstrap resampled exposure estimates with bootstrap sample size were also close to the adjusted exposure estimate values (Table 16) for short-finned pilot whales and sperm whales, but were high for common bottlenose dolphins (120 versus 67) and Cuvier's beaked whales (27 versus 23 animals). Common bottlenose dolphins and Cuvier's beaked whales had larger standard deviation of the density estimate than the mean density estimate. The ranges of exposure estimates with resampling for the species also matched the adjusted exposure estimates (maximum density in Table 16) reasonably well.

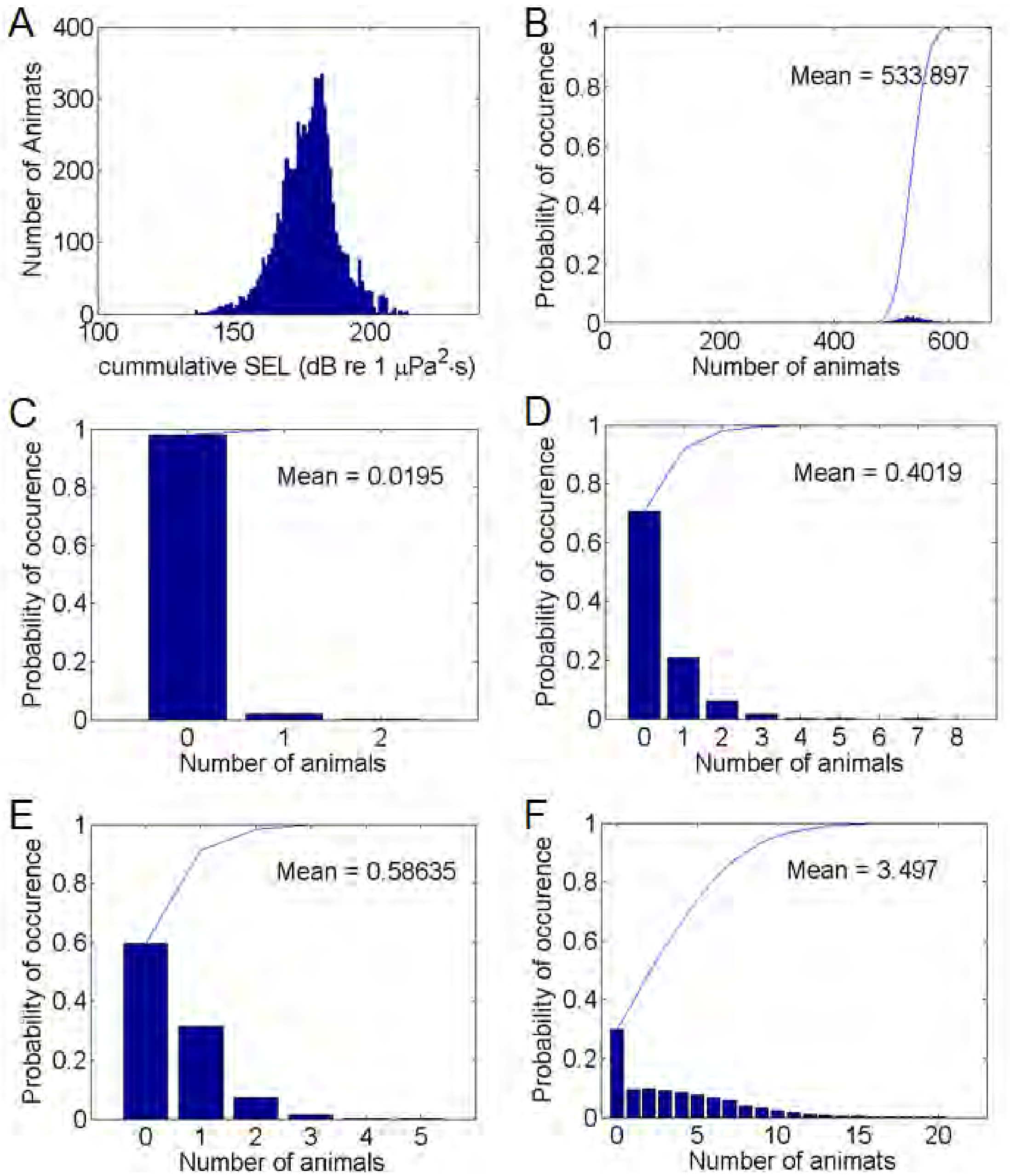


Figure 83. Bootstrap resampling and SEL injury and behavioral response exposure estimation for Bryde's whales and dwarf sperm whales. A) Exposure probability for Bryde's whales from modeling expressed as a histogram, B) Estimated number of Bryde's whale animats (modeled exposures) above SEL 187 dB re 1 μPa^2·s using bootstrap resampling (10,000 bootstrap replicates, where each bootstrap replicate consisted of an equal number of bootstrap samples as the number of animats in simulation), and C) Estimated number Bryde's whales (real-world exposures) above 187 dB SEL (re 1 μPa^2·s) using bootstrap resampling with sample size adjusted for real-world mean ± standard deviation density estimate (10,000 bootstrap replicates, where the number of bootstrap samples in the replicate was scaled for the real-world density; in this case, the number of animats in simulation × 0.0000405 ± 0.000022). D) Estimated number of dwarf sperm whales (real-world exposures) above SEL 161 dB re 1 μPa^2·s using bootstrap resampling with bootstrap sample size adjusted for real-world mean ± standard deviation density estimate (10,000 bootstrap replicates). E) and F) Behavioral

disruption exposure estimate distribution for Bryde's and dwarf sperm whales, respectively (10,000 bootstrap replicates with number of bootstrap samples adjusted for real-world density). Blue line shows cumulative probability in each plot.

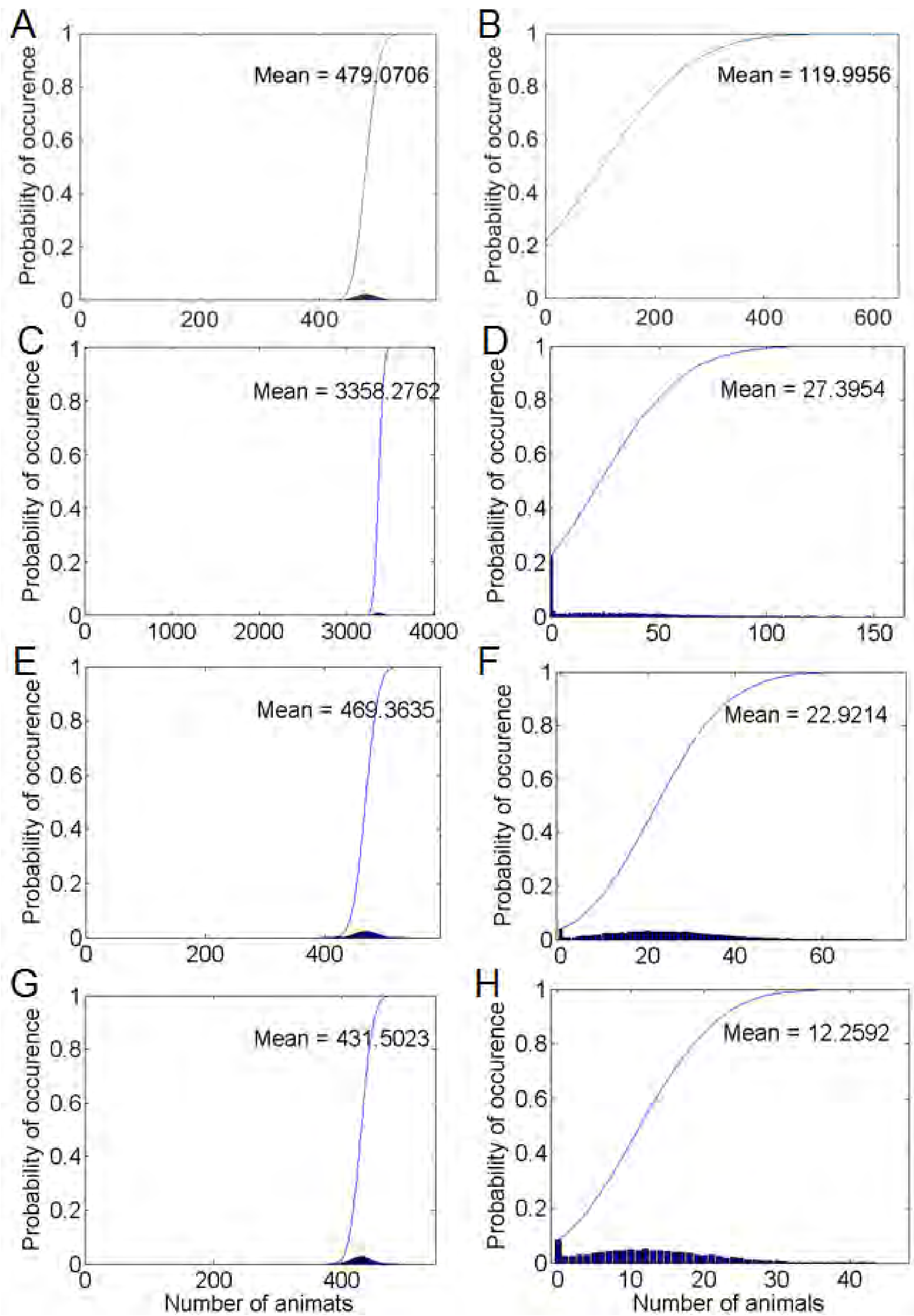


Figure 84. Bootstrap resampled behavioral disruption exposure estimate distribution for modeled results and adjusted for real-world density estimate mean ± standard deviation at Survey site A, A) model results and B) real-world exposure estimates for common bottlenose dolphins; C)

model results and D) real-world exposure estimates for Cuvier's beaked whales; E) model results and F) real-world exposure estimates for short-finned pilot whales; and G) model results and H) real-world exposure estimates for sperm whales. 10,000 bootstrap replicates were obtained with the number of bootstrap samples scaled for real-world density. Blue line shows the cumulative probability in each plot.

6.5.2.2.5. Summary of Animal Density Estimate Uncertainty

The 3MB was run using animat densities (animats/km^2) that are typically much higher than in the real-world densities. Higher modeling densities were used so the sound field of an operation could be thoroughly sampled and provide a good estimate of exposure probability.

To determine the expected number of real-world animals affected by an operation, the model results had to be adjusted by the real-world animal density estimates. There is uncertainty in the real-world density estimates, which can be quantified and presented as minimums, maximums, means, and standard deviations. As a way of bounding the range of potential impacts, the expected number of animals exposed to levels exceeding threshold can be determined for the minimum, maximum, and mean real-world density estimates. This method is most often used when presenting exposure estimates, i.e., the expected number of Level A or Level B exposures (see results in Section 6.3.2).

Another method that can be used to incorporate the uncertainty of real-world density estimates into exposure estimates is to use a resampling technique and include the mean and standard deviation of the real-world density estimate during the resampling process. We used a bootstrapping method (see Section 6.5.2.2.3) to resample the exposure probability distribution; the length of the bootstrap sample was adjusted by the mean and standard deviation of the real-world density estimate. The result of this bootstrap resampling was an exposure estimate distribution based on the number of potential real-world animals affected. Unlike the bracketing method, incorporating real-world density estimate standard deviation into the resampling process quantifies the probability of exposures as a range of potential exposures reflecting the variance of the density estimates. The mean value of the distribution essentially remains the same as the number of exposures calculated using the mean density estimate when bounding is used, but additional information is available in the shape of the distribution. The shape of the distribution could help evaluate the risk an operation poses. Knowing the likelihood that no animals will be exposed to levels exceeding threshold during an operation, or the number of animals exposed to levels exceeding threshold in 95% of the cases, gives a fuller picture of the risk due to the operation.

To illustrate how this information helps us better understand risk, consider the Bryde's whales for the 3-D WAZ survey at Survey site A, for which the real-world mean number of animals above the injury threshold (Level A exposure) was 0.0195. There is a 98% likelihood that none of these animals would exceed threshold during the operation, a 99.8% likelihood that one or no animal exceeds threshold, and no more than two animals above threshold (Figure 83C). For dwarf sperm whales, the real-world mean number of animals above the injury threshold was 0.4019 with a 71% likelihood that no animals would be above threshold, a 97.6% likelihood that two or fewer animals would be above threshold, and a 99.5% likelihood that seven or fewer animals would exceed threshold (Figure 83D).When incorporating the variability of the density estimates into the exposure estimate, we assumed that the uncertainty ascribed to the density estimates (i.e., minimum, maximum, mean, and standard deviation) reflects the real-world uncertainty in the density estimate for each of the modeled locations. In other words, we did not consider potential errors in the density estimates that were not captured by their own uncertainty estimates.

6.5.2.2.6. Impact of Social Group Size on Exposure Estimates

Many animals form temporary or permanent social groups. When animals move in groups, the likelihood of their exposure within the sample region decreases, but the effect when exposure occurs increases proportionally with group size. Group size can affect how impacts should be interpreted, but this has not yet been quantified.

6.5.2.2.7. Impact of Social Group Size on Exposure Estimates: Methods

Bootstrap resampling was used to determine the distribution of exposure estimates assuming animats were in groups of animals, instead of a single animal. Group sizes might be large and disperse, but to more simply illustrate the effects of group sizes on exposure estimates, all members of a potential group were assumed to have the same received levels.

Table 37. Published (social) group size statistics for Test Case species. The comments column describes how we used the source information to determine the mean group sizes suitable for post-process modeling.

Mean	SE	Range	Reference and area	Comments
Common bottlenose dolphins				
21	2	1–154	Maze-Foley and Mullin (2006) Gulf of Mexico	NOAA separates Gulf animals into three ecotypes: inshore animals inhabiting bays and estuaries, coastal types mainly found on the shelf, and offshore types found on the shelf and upper slope (Waring et al. 2013). The three ecotypes support varying group sizes. Mean group sizes reported by Maze-Foley and Mullin (2006) likely include all three ecotypes. Toth et al. (2012) reported mean group size for coastal and offshore ecotypes in the Atlantic. Maximum value reported by Shane et al. (1986) represents offshore types off South Africa. Variations in observed group size are mainly due to whether the group was a feeding aggregate or if the group was traveling, etc. Deeper water groups are generally larger sizes.
42		31–53	Toth et al. (2012) Atlantic	
1000 (max.)			Shane et al. (1986) South Africa	
Cuvier's beaked whales				
2	< 1	1–4	Maze-Foley and Mullin (2006) Gulf of Mexico	The similar group sizes encountered around the Hawaiian Islands and in the Gulf would indicate these are typical group sizes for the species.
3	2	1–5	McSweeney et al. (2007) Hawaii	
Sperm whales				
12		3–24	Christal et al. (1998) Galapagos	Results from Maze-Foley and Mullin (2006) and Richter et al. (2008) were generated from some of the same survey data, but Richter et al. included newer survey data and used different detection probability method. Congruence of group sizes reported by Christal et al. (1998) in the Pacific and by Richter et al. (2008) in the Gulf indicates typical group size is ~ 11–15 animals. The higher mean in the Gulf data includes surveys performed in a year with unusual oceanographic conditions. These Gulf groups primarily consist of females, calves, and sub-adult males. Adult males temporarily joined groups. Stable female groups are based on long-term associations between individuals (Christal et al. 1998).
3	< 1	1–11	Maze-Foley and Mullin (2006) Gulf of Mexico	
11 or 15	3		Richter et al. (2008) Gulf of Mexico	
20			Whitehead and Arnbom (1987) Pacific	

Mean	SE	Range	Reference and area	Comments
Dwarf sperm whales				
2		1–10	Baird (2005) Hawaii	Groups around the Hawaiian Islands and in the Gulf are similar in size, which indicates these group sizes are likely typical for the species.
2	< 1	1–8	Maze-Foley and Mullin (2006) Gulf of Mexico	
Short-finned pilot whales				
31		14–52	Kasuya and Marsh (1984) Pacific	The different methods of assessment are the likely reason reported group sizes vary considerably. Kasuya and Marsh (1984) captured animals during whaling operations. (Heimlich-Boran 1993) used long-term photo-identification of social groups. Mullin and Fulling (2004) and Maze-Foley and Mullin (2006) used ship surveys.
12–16		2–33	Heimlich-Boran (1993) Canary Islands	
34			Mullin and Fulling (2004) Gulf of Mexico	
25	4	3–85	Maze-Foley and Mullin (2006) Gulf of Mexico	
Bryde's whales				
1		1–15	Tershy (1992) Gulf of California	More than 90% of the time Tershy (1992) encountered whales, they were alone. Given the similarity of the reported means in these references, we assumed a typical group size of two animals.
2			Barlow (2006) Hawaii	
2	<1	1–5	Maze-Foley and Mullin (2006) Gulf of Mexico	

SE = standard error

6.5.2.2.8. Impact of Social Group Size on Exposure Estimates: Results

For the species whose group size mean or median is similar across different regions and for which the measured variance or range was relatively small—such as Cuvier's beaked whales, dwarf sperm whales, and Bryde's whales—the reported mean or median and estimated standard deviation were used during the bootstrap resampling processing. For species with a much larger group size range, and for which normality of the size distribution could not be tested, the highest reported mean was used and a standard deviation was estimated from the range of reported group sizes. The social group sizes used to evaluate the effects of group size on the distribution of exposure estimates are shown in Table 38.

Table 38. Social group size (number of individuals ± standard deviation) used to evaluate effects on exposure estimates.

Species	Group size
Bryde's whales	2 ± 1
Cuvier's beaked whales	3 ± 1.5
Common bottlenose dolphins	42 ± 6
Short-finned pilot whales	34 ± 10
Sperm whales	15 ± 3
Dwarf sperm whales	2 ± 1

During bootstrap resampling, each animat was considered to be a group of animals with the species-specific group size listed in Table 38. In the Bryde's whales simulation at Survey site A, there were 534 animats exposed to SEL above 192 dB re 1 $\mu Pa^2 \cdot s$ and 727.3 animats predicted to incur a behavioral response (Table 14). Figure 84A and B show that after bootstrap resampling was applied to the modeled animat exposure probability distribution and social group size was included, the sample estimate distribution of animats above threshold had a mean of 535 and 732, respectively for SEL injury and behavior (nearly the same as predicted in Table 14), but ~ 50% of the bootstrap samples had no animats above exposure threshold. In addition, the potential number of animats above threshold was much greater than the mean value; 95% of bootstrap samples had 1752 and 2326 (or less) animats above threshold with maximum estimates of 3134 and 3646 animats above threshold for injury and behavior, respectively. The results were very similar for dwarf sperm whales, where the mean exposure estimates after resampling are 1058 and 442 (Figure 85C and D) versus 1053 and 451 (Table 14) for injury and behavior.

The social group size used for both Bryde's whales and dwarf sperm whales was 2 ± 1 animals. The effects of group size on the distribution of behavioral disruption exposure estimates for species with larger groups was even more pronounced. Nearly 98% of bootstrap samples indicate no animals with a behavioral response for common bottlenose dolphins (Figure 86A), 97% for short-finned pilot whales (Figure 86C), and 95% for sperm whales (Figure 86D), and in each case the number of potential animals impacted was much greater than the mean value.

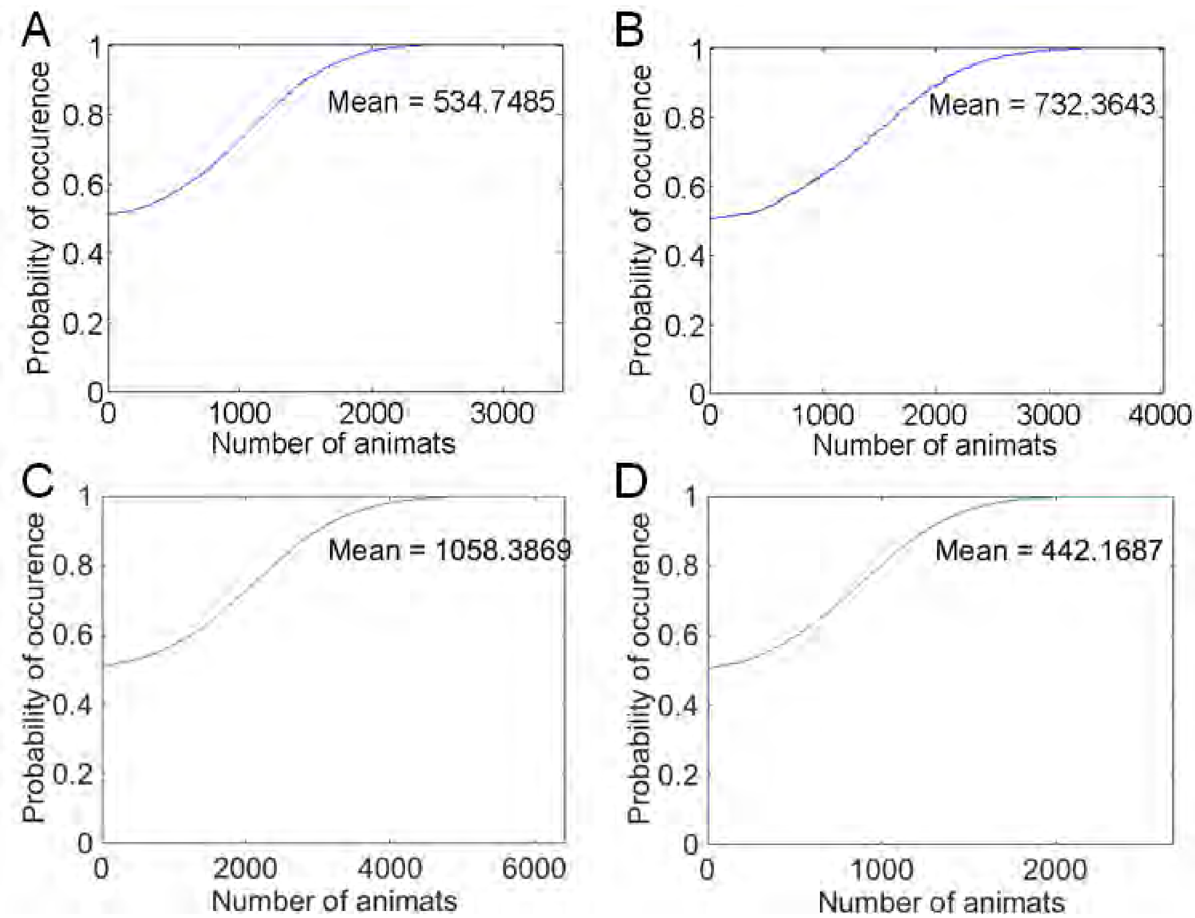


Figure 85. SEL Injury and behavioral disruption exposure estimate distributions for Bryde's whales and dwarf sperm whales at Survey site A. A) SEL injury SEL exposure estimate distribution for Bryde's whales. B) Behavioral response exposure estimate distribution for Bryde's whales. C) SEL injury exposure estimate distribution for dwarf sperm whales. D) Behavioral disruption exposure estimate for dwarf sperm whales. All exposure estimate distribution were determined with 10,000 bootstrap samples, each bootstrap sample size was equal to the total number of animats in the simulation, and each animat was treated as a social group of size 2 ± 1 animals (Table 38). Blue line shows the cumulative probability in each plot.

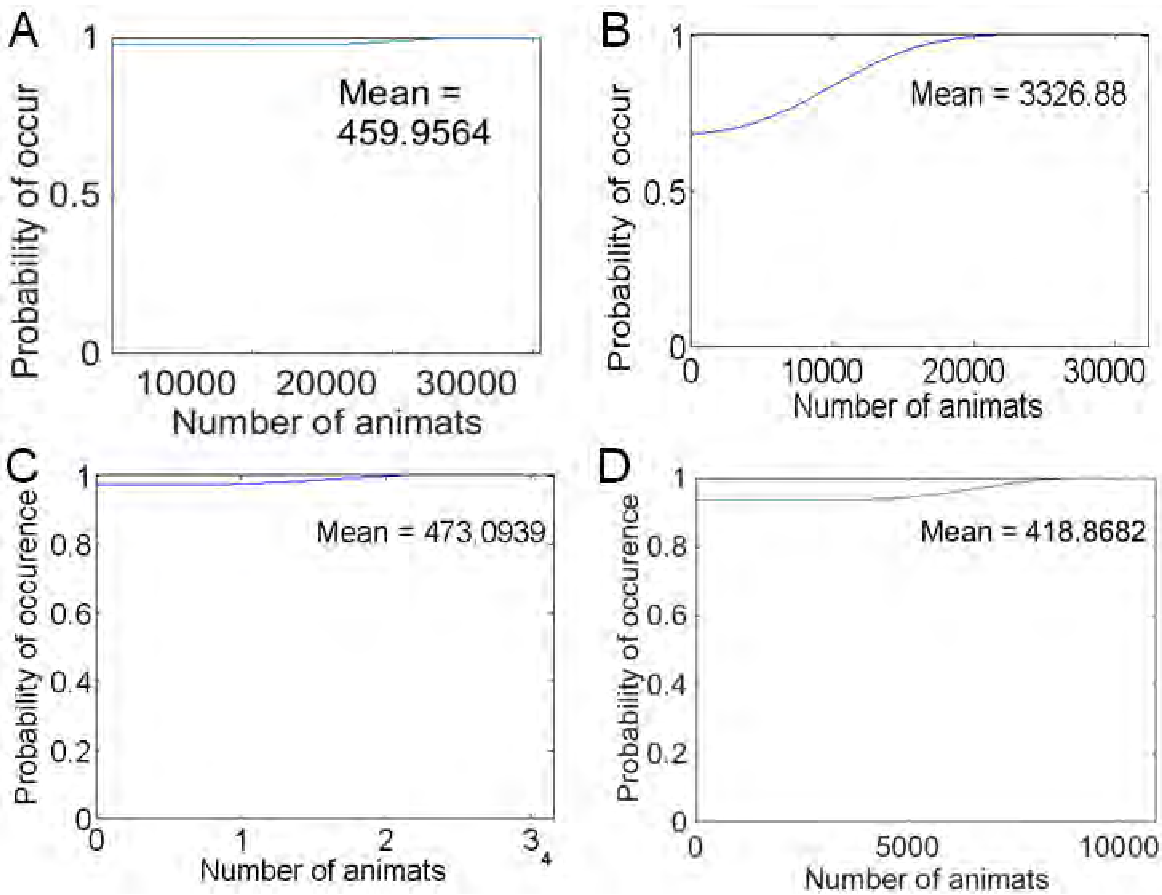


Figure 86. Behavioral disruption exposure estimate distributions with social group size at Survey site A for A) Common bottlenose dolphins, B) Cuvier's beaked whales, C) Short-finned pilot whales, D) Sperm whales. All exposure estimate distributions were determined with 10,000 bootstrap samples, each bootstrap sample size was equal to the total number of grouped animats in the simulation based on the group size listed in Table 38. Blue line shows the cumulative probability in each plot.

6.5.2.2.9. Summary of Impact of Social Group Size on Exposure Estimates

Most animals have some ecologically driven grouping behaviors. Many cetaceans aggregate due to patchy food distribution (e.g., Jaquet and Gendron 2002, Burkhardt and Lanfredi 2012). Stable groups and a distinct social organization are key elements of the population structures of many, if not all odontocete species (Connor et al. 1998, Toth et al. 2012). While feeding aggregations create temporal fluctuations in group sizes, social group sizes may remain stable for a number of years (e.g., sperm whales, Christal et al. 1998, Christal and Whitehead 2001) and possibly for their whole lives (e.g., pilot whales, Amos et al. 1993, and possibly some beaked whales Kasuya et al. 1997). Interactions between social groups are characterized by temporary associations or avoidance, perhaps to reduce inter-group competition for food, a behavior that spatially influences animal distributions in populations.

Group formation can affect exposure estimates in that grouping reduces the probability of exposure occurrence, but at the same time increases the number of impacted animals when exposures occur. Incorporating social groups into the animal movement modeling is difficult because temporary random associations and dissociations, such as group formation and dissolution, which could be related to patchy food availability, might form. Even long-term groupings might alter their makeup, move, or sample the space differently than individuals. Social groups, by their very name, fulfil social functions, such as sharing care of young. Within social groups, individuals move in a more synchronized fashion than those in random feeding groups or groups of cooperative hunters that move in an even more coordinated fashion than other social groups. Allomothering, or babysitting, is an example of a group behavior seen in a number of cetaceans that directly affects group diving and swimming (Whitehead 1996, Hill and Campbell 2014). Allomothering creates groups of varying numbers of diving animals A number of animals remain at the surface or within the top 10 m of the water column at all times. Any acoustics effect that increases exposure in surface waters (e.g., surface ducting) will either increase the risk of animals staying at the surface and/or cause groups of animals to leave an area earlier than under quiet conditions, thus potentially affecting the amount of food required for optimal survival. Furthermore, higher exposure in surface waters will selectively affect younger animals because they do not dive to depth.

The effects of social grouping on exposure estimates can be shown by assuming that animats within the simulation are groups of animals instead of individuals. (As a note–groups can be simulated and the received level of individuals within the group can be tracked, but for simplicity in evaluating the effects of grouping, each animat was assumed to represent a group in which all individuals had the same exposure history.) During resampling, each animat was considered to be a population with a mean and standard deviation. Because each animat represents a group of animals, the effective modeling density was increased by the mean value of the group size, so the probability of exposure must be reduced by the same amount to account for the reduced likelihood of exposure. When group size was incorporated during the resampling process, the mean value of the exposure estimate distribution does not change relative to animats being considered as individuals, but the shape of the distribution can change markedly. For example, in the Bryde's whale simulation at Survey site A there were 534 animats above the SEL injury threshold and 727.3 animats predicted to incur a behavioral response (Table 14). After bootstrap resampling was applied with group size included, the exposure estimate distribution of animats above threshold had means of 535 and 732, respectively for SEL injury and behavior. There was, however, a 50% likelihood that no animats above threshold or predicted to have behavioral responses, and the potential number of animats above threshold was much greater than the mean value. The same group size (2 ± 1) was used for Bryde's whales and dwarf sperm whales and thus the results were similar for the two species. Species with larger group sizes showed more pronounced exposure estimate distributions. Common bottlenose dolphins exhibited a 98% likelihood that no animals would have a behavioral response, short-finned pilot whales a 97% likelihood, and sperm whales a 95% likelihood. In each case, the number of potential animals affected was much greater than the mean value (Figure 86).

6.5.2.3. Exposure Estimate Uncertainty

Both the uncertainty in acoustic modeling and uncertainty in the animal modeling contributed to the overall uncertainty in the exposure estimates. These uncertainties could be combined during the bootstrap resampling process to estimate exposure distributions that included the uncertainties from the various sources.

6.5.2.3.1. Exposure Estimate Uncertainty: Results

Acoustic uncertainty can be incorporated in the bootstrap resampling process by adding the uncertainty to the animats' received levels. For potential injury, the primary acoustic uncertainly was the source level variance. Airguns are designed to have low inter-shot variability and predicted source levels within 3 dB (Section 6.5.2.1.1). A conservative estimate of ±3 dB standard deviation was used to investigate the effects of source level variance on SEL injury exposure estimates. We did not investigate effects of peak SPL variance because these were calculated based on range to the source, which was only ~ 18 m for most species. The effects of small changes in a small volume would be difficult to determine. Figure 87A shows that the mean number of animats above SEL threshold increases relative to the expected value (938 vs. 534 for Bryde's whales, and 1134 vs. 1053 for dwarf sperm whales). The exposure estimate distributions, however, did not change much; for both species, the range from 5% to 95% was about 100 animats with or without acoustic variance. For potential behavioral disruption, propagation uncertainty also contributes to the uncertainty in the acoustic modeling predictions. Figure 87B shows the behavioral disruption exposure estimation distributions for Bryde's whales and dwarf sperm whales when 6 dB of acoustic uncertainty (standard deviation) was included in the received levels during bootstrap resampling. 6 dB was chosen as a test to include the ~ 4 dB uncertainty in propagation plus 3 dB in source variance. For behavior, the mean behavioral disruption exposure estimates (727 versus 727 for Bryde's whales and 459 versus 451 for dwarf sperm whales) and the distribution ranges (put ranges here) stay approximately the same when ± 6dB of acoustic variability was included.

During resampling, acoustic uncertainty (3 dB for injury, 6 dB for behavior), can be combined with real-world density (mean ± standard deviation), and social group size (mean ± standard deviation). Figure 88 shows the potential real-world number of animals above the SEL injury threshold for Bryde's whales (SEL > 192 dB re 1 $\mu Pa^2 \cdot s$) and dwarf sperm whales (SEL > 161 dB re 1 $\mu Pa^2 \cdot s$). In the exposure estimate distributions, about 70% of the bootstrap replicates predict no animals above threshold (73% for Bryde's and 64% for dwarf sperm whales). When 95% of the Bryde's whales replicates were considered 5 animals or less are above threshold and a maximum of 20 animals exceed the threshold in 100% of replicates. The corresponding values for dwarf sperm whales were 95% of the replicates have 49 animals or less above threshold with a maximum of 146 animals exposed to levels exceeding the threshold. For behavior, Bryde's whales had 76% of replicates with no behavioral response; when increased to 95% 3 or less animals were impacted, and a maximum of 15 animals were above behavioral response threshold for all of the replicates. Dwarf sperm whales had 65% of replicates with no behavioral response and up to 19 or less animals in 95% of replicates, up to a maximum of 78 animals for all replicates. For Cuvier's beaked whales, a species with lower behavioral thresholds, 75% of replicates showed no behavioral response of animals, while 3585 or less animals could potentially be affected when 95% of replicates were taken into account. Because of larger group sizes, common bottlenose dolphins, short-finned pilot, and sperm whales all showed no predicted behavioral responses in well over 90% of the replicates, but the potential number of animals impacted was much higher than the mean.

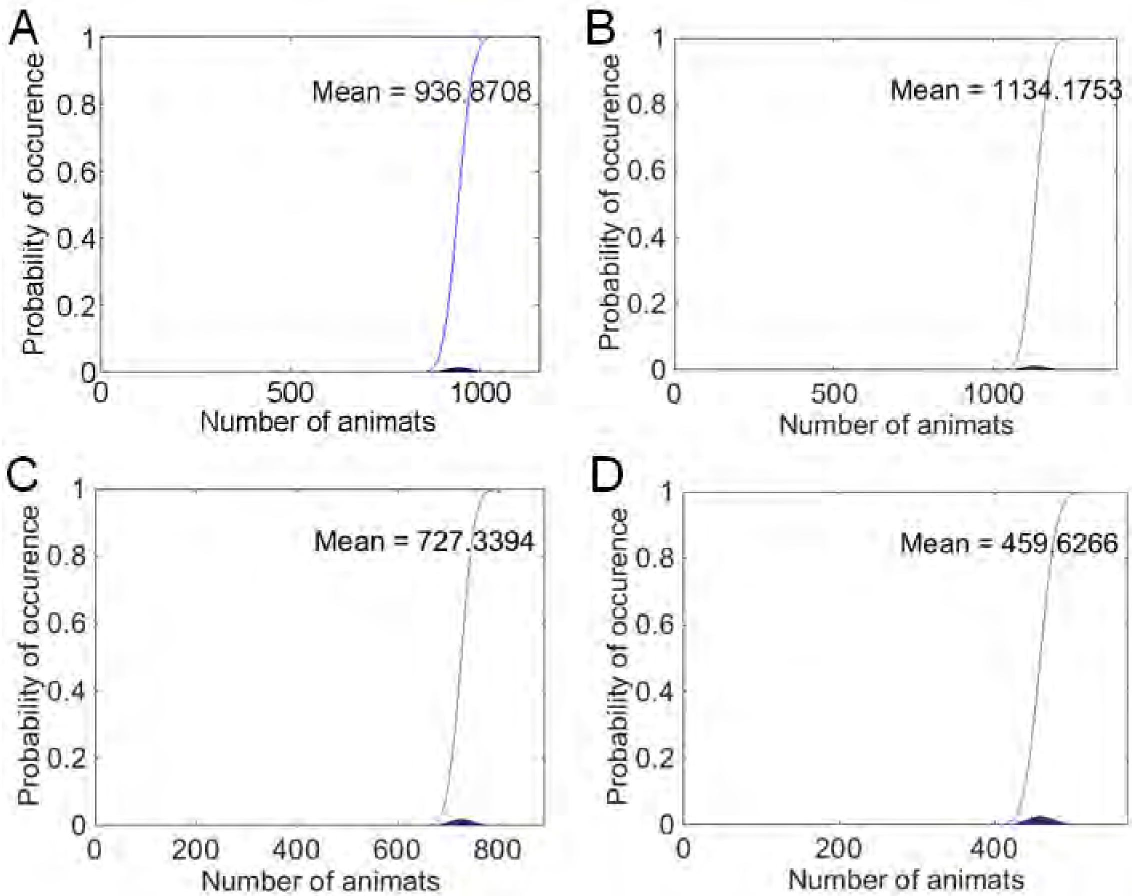


Figure 87. Bootstrap resampling with acoustic uncertainty for SEL injury potential behavioral response for Bryde's whales and dwarf sperm whales at Survey site A. A) Bryde's whales and B) Dwarf sperm whales potential SEL injury. The exposure estimate distributions are the number of animats above SEL 187 (Bryde's whales) and 161 (dwarf sperm whales) dB re 1 $\mu Pa^2 \cdot s$ with 10,000 bootstrap replicates where the number of bootstrap samples was equal to the number of animats in the simulation and the animat received level includes a standard deviation of 3 dB. C) Bryde's whales and D) Dwarf sperm whales potential behavioral response. The exposure estimate distributions are the number of animats above the rms SPL step function with 10,000 bootstrap replicates where the number of bootstrap samples was equal to the number of animats in the simulation and the animat received level includes a standard deviation of 6 dB. Blue line shows the cumulative probability in each plot.

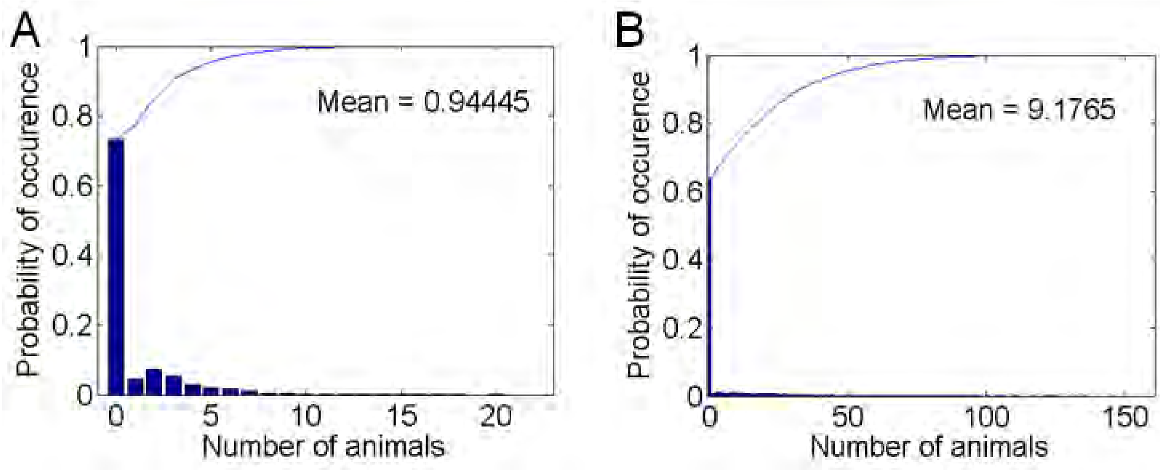


Figure 88. Bootstrap resampling for SEL injury for A) Bryde's and B) Dwarf sperm whales at Survey site A with 3 dB of acoustic uncertainty, bootstrap sample size adjusted for real-world mean density ± standard deviation, and social group size of 2 ± 1 for both species. The exposure estimate distributions are the number of animals with the potential to receive an injurious exposure; 10,000 bootstrap replicates were obtained, and the blue line shows the cumulative probability in each plot.

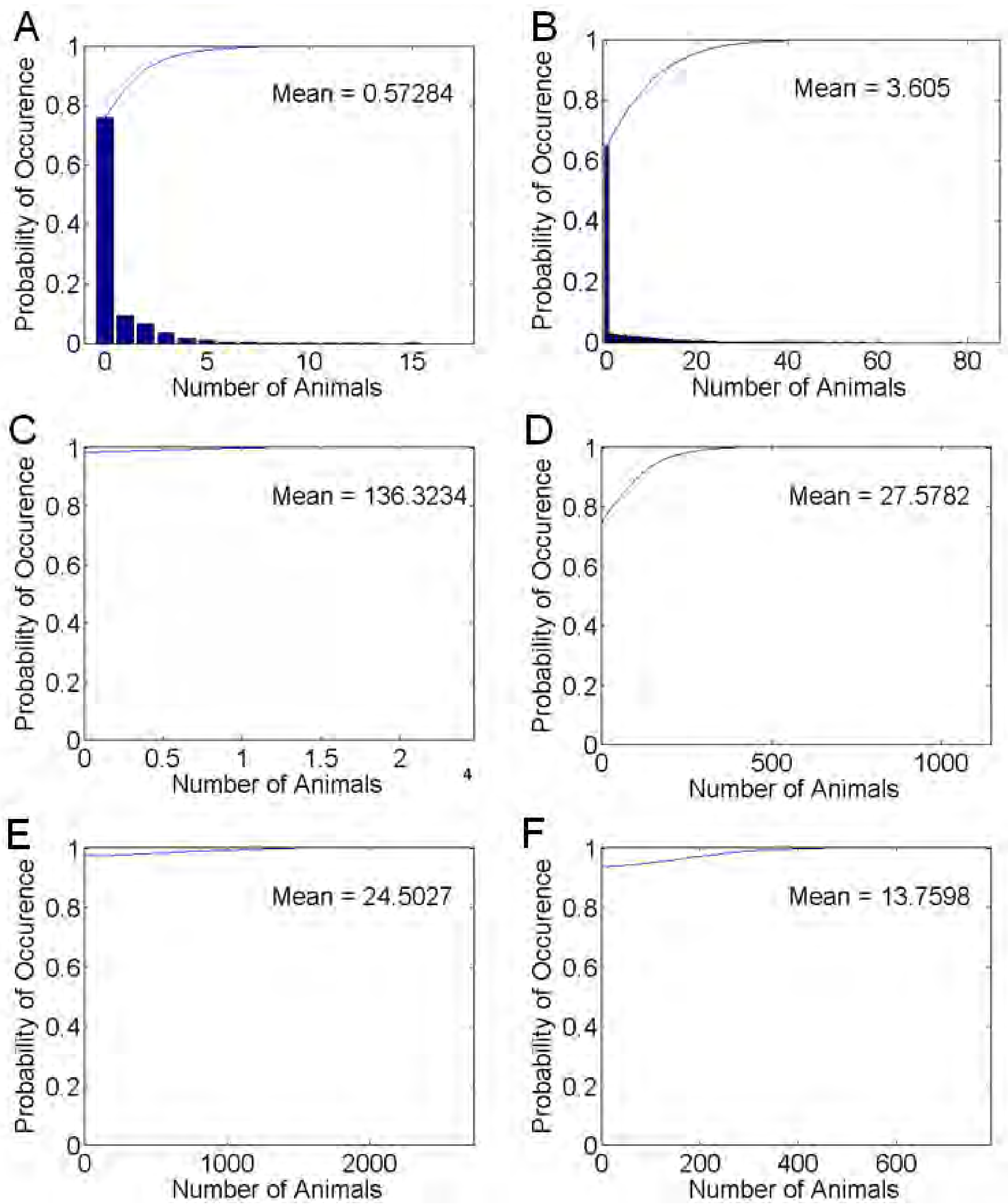


Figure 89. Potential behavioral response exposure estimates of species at Survey site A from bootstrap resampling with acoustic uncertainty (± 6 dB), real-world density (mean ± standard deviation; Table 36), and social group size (mean ± standard deviation). A) Bryde's whales, B) Dwarf sperm whales, C) Common bottlenose dolphins, D) Cuvier's beaked whales, E) Short-finned pilot whales, F) Sperm whales. The exposure estimate distributions are the potential number of animals predicted to have a behavioral response. 10,000 bootstrap replicates were obtained and the blue line shows the cumulative probability in each plot.

6.5.2.3.2. Summary of Exposure Estimate Uncertainty

Traditionally, only a limited indication of uncertainty is included when presenting exposure estimates. The exposure estimate is usually the number of animals expected to exceed a threshold. Presenting a single value as the exposure estimate does not allow for a quantitative description of the variance in the modeling process. By presenting the exposure estimate as a distribution, a measure of uncertainty can be included in the exposure estimate. The exposure estimate distribution gives the probability of certain events occurring, such as the probability that an operation would not result in any animals above a defined threshold.

Various sources of model uncertainty can be included in the resampling process to provide an exposure estimate distribution with uncertainty. In general, the uncertainty associated with the animals (density and group size) does not change the mean exposure estimate, but can profoundly affect the exposure estimate distribution. This phenomenon is especially pronounced when group size is included during the resampling process because the likelihood of exposure decreases by approximately the mean group size, concurrent with increasing consequences of the exposure (by approximately the mean group size). Uncertainty in the acoustic modeling can change the mean value of the exposure estimate because sampling near the tails of the exposure distribution is asymmetric, meaning more animats are typically slightly below threshold than slightly above it, so uncertainty in the received level results in relatively more animats exposed to levels exceeding threshold.

6.5.3. Test Scenario 3: Mitigation Effectiveness

Mitigation procedures to reduce adverse effects of sound exposures to marine mammals are often implemented during seismic surveys. The most common form of mitigation for injurious effects involves turning off the sound source (e.g., seismic array) when a protected animal is visually, or in some cases acoustically, detected within a pre-defined exclusion zone. Survey work resumes at a specified time interval after detection, allowing the animal to leave the exclusion zone. The effectiveness at reducing marine mammal exposure to potentially injurious sound levels with this commonly used approach is unknown. Mitigation effectiveness varies with the ability to detect an animal in the exclusion zone. Some species spend little time at the surface, so they are difficult to see. Others emerge frequently and visibly spout, so are easily seen. Detectability may decrease as the sea state increases as it is more difficult to visually-detect an animal in rough seas than in calm water. Detectability, and consequently mitigation efficacy, depends on the species, potentially individual animal characteristics, survey configuration, and environmental conditions.

This Test Scenario uses a modeling approach to quantify the potential reduction in the numbers of exposures at or above Level A thresholds for selected species by comparing acoustic exposure estimates with and without mitigation (array shutdown). Specifically, a 3-D wide azimuth seismic survey was simulated for six representative species at two sites within the Gulf of Mexico (Figure 10). For each species, a range of detection probabilities was considered.

6.5.3.1. Mitigation Effectiveness Methods

Level A exposure estimates associated with the 5-day wide-azimuth survey simulation described in the Test Case simulations (Figure 20) were calculated with and without a mitigation procedure. Exposure estimates were computed relative to SEL, peak SPL, and rms SPL (180 dB re 1 μPa) exposure criteria (Section 5.4). Airgun shutdown was modeled by zeroing all animat received levels when an animat was detected within an exclusion zone. The animat detection was registered when the horizontal range of an animat from the source was less than an exclusion zone radius of 500 m, its depth was < 50 m, and a random draw indicated detection. The 500 m exclusion zone was chosen based on the BOEM JOINT Notice to Lessees No. 2012-G02 (Lydersen and Kovacs 1999).

To determine the effectiveness of mitigation, a measure of animal detection probability is needed. In cetacean surveys, the generally adopted methodology to determine animal abundance and density involves an assessment of the detection probability $g(0)$, which is estimated from visual or acoustic surveys for animals. Detection probability is the likelihood of detecting an animal within an area along a trackline (usually a circle around a survey vessel) and is biased by availability (detection is limited due to environmental factors) and perception (observers miss detecting an available animal). The estimated probability is based on the statistical correlation between two independent, but temporally correlated observations assumed to be those of the same animals (Buckland 2001). The metric include parts the vertical water column cylinder below the surface that can be surveyed simultaneously, so it depends on survey methodology. The accuracy of $g(0)$ is higher for simultaneously conducted visual and acoustic surveys than for two visual surveys due to lower availability bias, but accuracy varies with species and environmental conditions (e.g., sea state, wind, rain and resulting ambient noise level) and ultimately availability of animals for detection is limited for both survey methods (Barlow 2013). The $g(0)$ during visual surveys has been estimated for a number of species in a variety of conditions (see Section 6.5.3.1.2 below). The positions of animats in the simulation are known and reported in short time steps. The $g(0)$, however, is the probability of detecting an animal along the trackline as the survey passes through an area, rather than for an individual time step. For this Test Scenario, $g(0)$ is used as estimate of the detection probability for animats near the surface and close to the vessel.

Simulations typically use a much higher animat density than the real-world animal density. For these reasons, we reduced the number of animats (see Section 6.5.3.1.1 below) to that of the real-world density for each species and checked for detection only once for each animat that entered the exclusion zone. To assign detections, a random value from a uniform distribution between 0 and 1 was generated for each animat in the exclusion zone and whose depth was < 50 m. The value for each animat was thresholded against $g(0)$. If the random value was less than $g(0)$, the detection was registered, the time of the closest point of approach (CPA) was found, and the received levels for all animats were zeroed for 30 min before and after the CPA. Normally the true shutdown would occur for 1 h following the detection, but for our purposes the specific timing is not important as animats are independent, and the centered window conveniently allowed the detected animat to avoid being exposed.

For the purposes of the simulation, it was assumed that array shutdown was the only mitigation procedure performed, and it was assumed that portions of the survey line missed during shutdown were re-surveyed (i.e., shutdowns result in an increase in the overall survey duration in order to keep the distance surveyed the same as the unmitigated case). Shutdown was assumed to occur only for the source (array) around which the animat was detected. Other sources present in the simulation continued operating. Because it is impossible to accurately predict $g(0)$ for an operation, a likely range was used for each species (Section 6.5.3.1.2).

6.5.3.1.1. Bootstrap Resampling

We used bootstrap resampling (see *Bootstrap Resampling* in Section 6.5.2.2.4) to quantify the number of animals exposed to levels above Level A thresholds obtained from the Monte Carlo simulations of the six Test Case species, with and without mitigation. Again, the exposure probabilities are the received-level frequency of occurrence expressed as histograms. 10,000 bootstrap replicates were obtained, where the number of bootstrap samples in each replicate were adjusted by the ratio of the real-world density to the model density, and the number of animats exposed to levels above threshold (SEL or peak SPL) was found for each bootstrap replicate. Without mitigation, the resampling provides a baseline distribution of expected exposures, which is compared to the exposure estimate distribution with mitigation. The mean difference and the relative change between the two estimate distributions were calculated to quantify the effect of mitigation on exposure estimates. Mitigation was incorporated into the bootstrap process during each replicate by testing if an animat was within the exclusion zone and detected. If a detection occurred the received levels for each animat in the replicate were zeroed for 30 min before and 30 min after the detection to simulate a shutdown.

6.5.3.1.2. Detection Probability

In surveys designed to determine animal presence or abundance, independent observations along different tracklines or temporally shifted observations along the same trackline (such as circling back in aerial surveys) provide an indication of all or a known fraction of detectable animals and can be used to estimate detection probability, typically $g(0)$ (Buckland et al. 2001).

Detection probability varies with species, environmental conditions, and group size. Large whales that spend considerable time with portions of their body above the water surface and exhale a visible spout when resurfacing are more easily spotted than cryptic species that spend much of their time submerged and only break the surface for short breaths. Likewise, there are more opportunities to spot large groups than solitary animals. Detection probability decreases for all species as sea state increases, but the greatest decrease is for the difficult-to-detect species (MacIntyre et al. In Press). For example, Moore and Barlow (2013) noted a decrease in $g(0)$ for Cuvier's beaked whales from 0.23 at Beaufort sea state 0 (calm) to 0.024 at sea state 5 (wave height 2–3 m). Table 39 shows $g(0)$ reported for the six test species for a range of sea states (Beaufort sea states 0–5). These data are from surveys at locations around the world, as indicated in the table footnotes, but are good proxies for trackline detection probabilities of the Gulf of Mexico species.

Model simulations were run for detection probabilities of 0.05 to 0.45 simulate an assumed range of probabilities for animats in the upper 50 meters of the water column independent of the species. Simulations were run in increments of 0.05, to estimate the likely range of detection probabilities for beaked whales and dwarf sperm whales (for which Barlow (2006) noted low detection probabilities). Simulations for all other species were modeled with $g(0)$ ranging from 0.5 to 0.9, in increments of 0.1.

Table 39. Estimates of trackline detection probability, $g(0)$, coefficients of variation (CV) for $g(0)$, and mean group size. The CV for each estimate of $g(0)$ is shown in parentheses.

Species	$g(0)$ Estimates for group size ranges*	
	1–20	> 20
Common bottlenose dolphins[a]	0.76 (0.14)	1.00 (n/a)
Short-finned pilot whales[a]	0.76 (0.14)	1.00 (n/a)
Sperm whales[b]	0.87 (0.09)	0.87 (0.09)
Dwarf sperm whales[c]	0.35 (0.29)	
Cuvier's beaked whales[c]	0.23 (0.35)	
Bryde's whales[a]	0.90 (0.07)	

* In Barlow (2006) Table 2, pg. 451.
[a] The $g(0)$ estimates from Barlow (1995), based on his categories of small delphinids, large delphinids, and other large whales. Large and small delphinids are pooled based on the similarity in their $g(0)$ values (0.74 and 0.77, respectively, for groups of less than 20).
[b] The $g(0)$ estimates from Baird et al. (2006a) for sperm whales with 30-min dives.
[c] The $g(0)$ estimates from Barlow (1999) based on his categories of *Kogia spp*., *Mesoplodon spp*., and *Ziphius cavirostris*.

6.5.3.2. Mitigation Effectiveness Results

The average number of cetaceans exposed to sounds above Level A exposure criteria was computed for Survey sites A (shallower water) and B (deeper water) for the six sample species. Exposure estimates were computed both with and without mitigation, producing an estimate of the mitigation effectiveness for each site and species modeled (Tables 40–44). For all species except the high-frequency dwarf sperm whales, no or a vanishing small number of SEL exposures were registered with and without mitigation. In the case of Bryde's whales, some animats were exposed to sound exceeding the SEL or SPL thresholds, however, their low real-world density meant only rarely was an animat exposed to levels above threshold chosen during bootstrap resampling.

Sample plots of the probability distribution of peak SPL and rms SPL exposure estimates, without and with mitigation, are shown in Figures 90–94 for five of the six species modeled at Survey site A (results for Bryde's whales were trivial, as noted above). Each figure shows the example for the mid-range detection probability.

Table 40. Cuvier's beaked whales: Modeled Level A exposure estimates and mitigation efficiency for peak SPL and rms SPL.

Metric	Detection probability	Average number of cetaceans above exposure criteria					
		Survey site A			Survey site B		
		Without mitigation	With mitigation	Mitigation effectiveness	Without mitigation	With mitigation	Mitigation effectiveness
peak SPL	0.05	0.032	0.032	0.001 (2%)	0.040	0.040	0.001 (2%)
	0.15	0.032	0.030	0.002 (5%)	0.038	0.036	0.002 (6%)
	0.25	0.030	0.028	0.003 (9%)	0.039	0.036	0.003 (8%)
	0.35	0.034	0.028	0.005 (16%)	0.036	0.031	0.005 (14%)
	0.45	0.031	0.024	0.007 (21%)	0.038	0.032	0.006 (16%)
rms SPL	0.05	0.123	0.120	0.003 (2%)	0.136	0.135	0.001 (1%)
	0.15	0.122	0.115	0.007 (6%)	0.138	0.130	0.008 (6%)
	0.25	0.126	0.113	0.013 (11%)	0.137	0.124	0.013 (10%)
	0.35	0.121	0.104	0.016 (14%)	0.144	0.129	0.015 (11%)
	0.45	0.122	0.099	0.023 (19%)	0.141	0.117	0.024 (17%)

Table 41. Common bottlenose dolphins: Modeled Level A exposure estimates and mitigation efficiency for peak SPL and rms SPL.

Metric	Detection probability	Average number of cetaceans above exposure criteria					
		Survey site A			Survey site B		
		Without mitigation	With mitigation	Mitigation effectiveness	Without mitigation	With mitigation	Mitigation effectiveness
peak SPL	0.5	1.364	0.778	0.586 (43%)	0.189	0.096	0.092 (49%)
	0.6	1.353	0.741	0.612 (45%)	0.203	0.089	0.114 (56%)
	0.7	1.329	0.654	0.675 (51%)	0.187	0.062	0.125 (67%)
	0.8	1.335	0.553	0.781 (59%)	0.188	0.051	0.137 (73%)
	0.9	1.354	0.398	0.956 (71%)	0.190	0.028	0.162 (85%)
rms SPL	0.5	4.510	2.561	1.949 (43%)	0.627	0.335	0.292 (47%)
	0.6	4.505	2.386	2.119 (47%)	0.630	0.281	0.349 (55%)
	0.7	4.528	2.128	2.400 (53%)	0.624	0.214	0.411 (66%)
	0.8	4.527	1.703	2.825 (62%)	0.623	0.153	0.470 (75%)
	0.9	4.520	1.104	3.416 (76%)	0.631	0.087	0.544 (86%)

Table 42. Short-finned pilot whales: Modeled Level A exposure estimates and mitigation efficiency for peak SPL and rms SPL.

Metric	Detection probability	Average number of cetaceans above exposure criteria					
		Survey site A			Survey site B		
		Without mitigation	With mitigation	Mitigation effectiveness	Without mitigation	With mitigation	Mitigation effectiveness
peak SPL	0.5	0.275	0.155	0.120 (44%)	0.334	0.186	0.148 (44%)
	0.6	0.284	0.143	0.141 (50%)	0.339	0.157	0.181 (54%)
	0.7	0.274	0.108	0.166 (61%)	0.341	0.135	0.205 (60%)
	0.8	0.281	0.085	0.196 (70%)	0.338	0.105	0.234 (69%)
	0.9	0.277	0.057	0.220 (80%)	0.339	0.064	0.275 (81%)
rms SPL	0.5	0.989	0.535	0.454 (46%)	1.225	0.663	0.562 (46%)
	0.6	0.993	0.454	0.539 (54%)	1.212	0.563	0.649 (54%)
	0.7	0.986	0.369	0.617 (63%)	1.216	0.456	0.760 (63%)
	0.8	0.991	0.271	0.720 (73%)	1.228	0.340	0.888 (72%)
	0.9	0.980	0.162	0.818 (83%)	1.224	0.206	1.017 (83%)

Table 43. Sperm whales: Modeled Level A exposure estimates and mitigation efficiency for peak SPL and rms SPL.

Metric	Detection probability	Average number of cetaceans above exposure criteria					
		Survey site A			Survey site B		
		Without mitigation	With mitigation	Mitigation effectiveness	Without mitigation	With mitigation	Mitigation effectiveness
peak SPL	0.5	0.086	0.072	0.013 (15%)	0.121	0.102	0.019 (16%)
	0.6	0.086	0.073	0.013 (15%)	0.119	0.098	0.021 (18%)
	0.7	0.084	0.064	0.020 (24%)	0.121	0.095	0.026 (21%)
	0.8	0.087	0.068	0.019 (22%)	0.124	0.095	0.029 (24%)
	0.9	0.081	0.058	0.022 (28%)	0.117	0.084	0.033 (29%)
rms SPL	0.5	0.344	0.295	0.049 (14%)	0.395	0.337	0.058 (15%)
	0.6	0.336	0.281	0.055 (16%)	0.399	0.332	0.067 (17%)
	0.7	0.337	0.267	0.069 (21%)	0.399	0.322	0.077 (19%)
	0.8	0.337	0.264	0.073 (22%)	0.399	0.315	0.084 (21%)
	0.9	0.330	0.249	0.082 (25%)	0.388	0.294	0.094 (24%)

Table 44. Dwarf-sperm whales: Modeled Level A exposure estimates and mitigation efficiency for 5-day SEL, peak SPL, and rms SPL.

Metric	Detection probabilit y	Average number of cetaceans above exposure criteria					
		Survey site A			Survey site B		
		Without mitigation	With mitigation	Mitigation effectiveness	Without mitigation	With mitigation	Mitigation effectiveness
5-day SEL	0.05	0.320	0.311	0.009 (3%)	0.635	0.620	0.015 (2%)
	0.15	0.321	0.277	0.044 (14%)	0.632	0.557	0.076 (12%)
	0.25	0.326	0.253	0.072 (22%)	0.632	0.493	0.139 (22%)
	0.35	0.322	0.216	0.106 (33%)	0.630	0.424	0.206 (33%)
	0.45	0.304	0.177	0.127 (42%)	0.639	0.372	0.267 (42%)
peak SPL	0.05	0.865	0.869	−0.004 (0%)	1.955	1.989	−0.034 (−2%)
	0.15	0.871	0.859	0.012 (1%)	1.947	1.943	0.004 (0%)
	0.25	0.880	0.847	0.033 (4%)	1.932	1.886	0.047 (2%)
	0.35	0.865	0.814	0.051 (6%)	1.950	1.841	0.109 (6%)
	0.45	0.861	0.780	0.081 (9%)	1.935	1.769	0.166 (9%)
rms SPL	0.05	0.055	0.054	0.001 (1%)	0.130	0.127	0.003 (2%)
	0.15	0.055	0.047	0.008 (14%	0.127	0.114	0.014 (11%)
	0.25	0.055	0.043	0.012 (22%)	0.129	0.101	0.029 (22%)
	0.35	0.053	0.037	0.017 (31%)	0.130	0.089	0.040 (31%)
	0.45	0.055	0.033	0.023 (41%)	0.134	0.078	0.056 (42%)

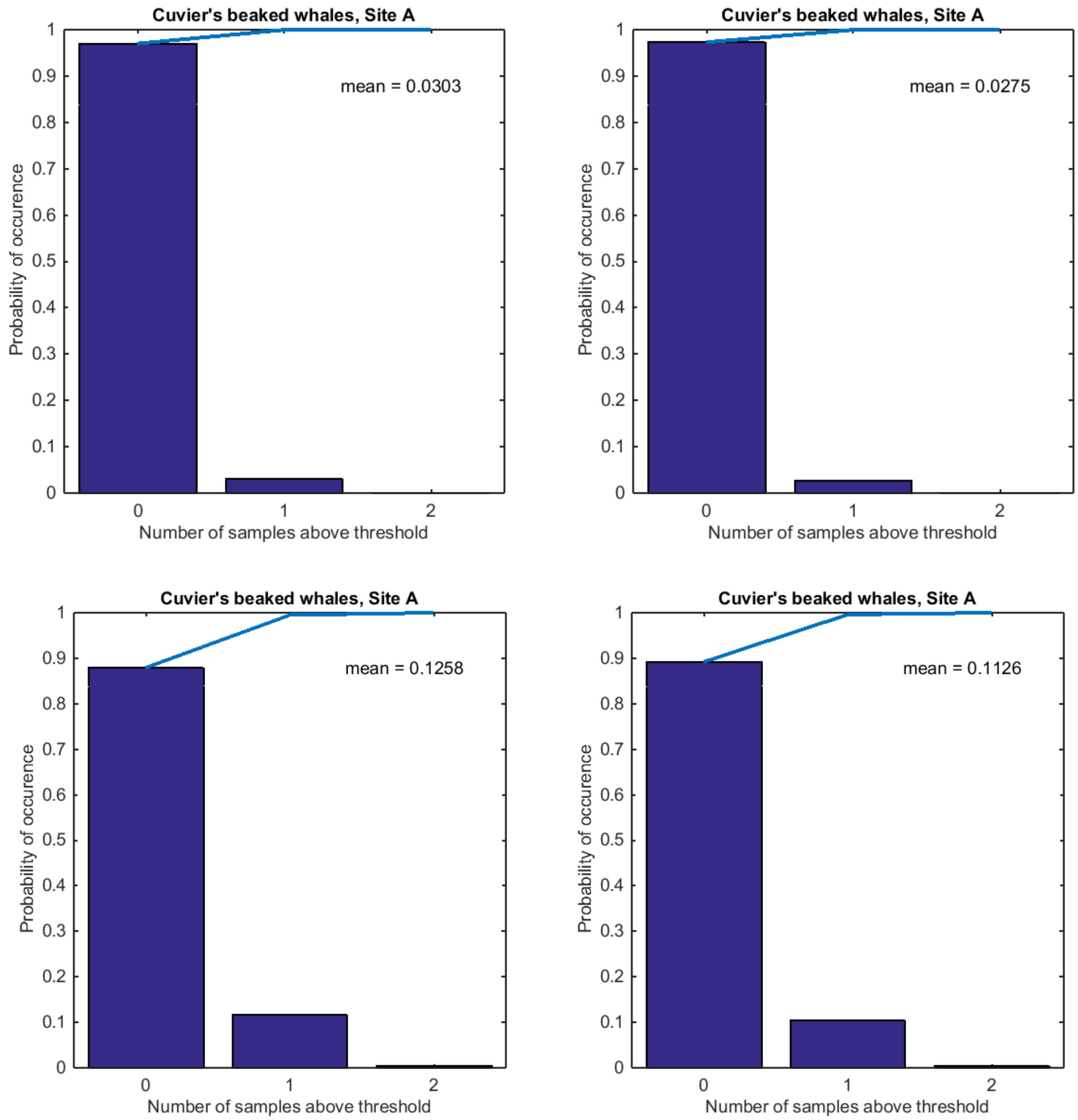


Figure 90. Cuvier's beaked whales: Probability of exposure above injury thresholds at Survey site A without (left panels) and with mitigation (right panels) for peak SPL (top panels) and rms SPL (bottom panels). Detection probability is 0.25. The blue line is the cumulative distribution.

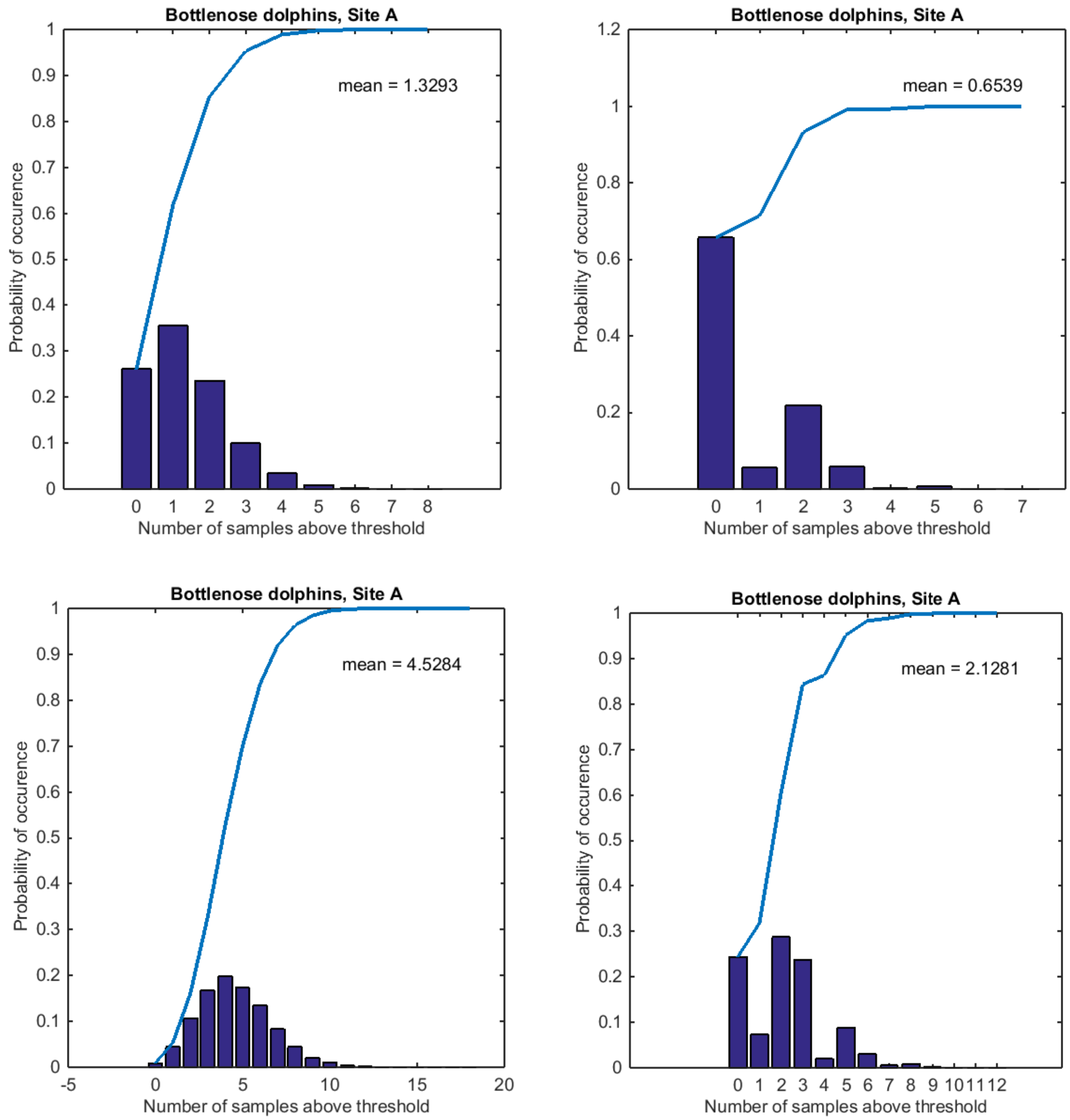


Figure 91. Common bottlenose dolphins: Probability of exposure at or above injury thresholds at Survey site A without (left panels) and with mitigation (right panels) for peak SPL (top panels) and rms SPL (bottom panels). Detection probability is 0.7. The blue line is the cumulative distribution.

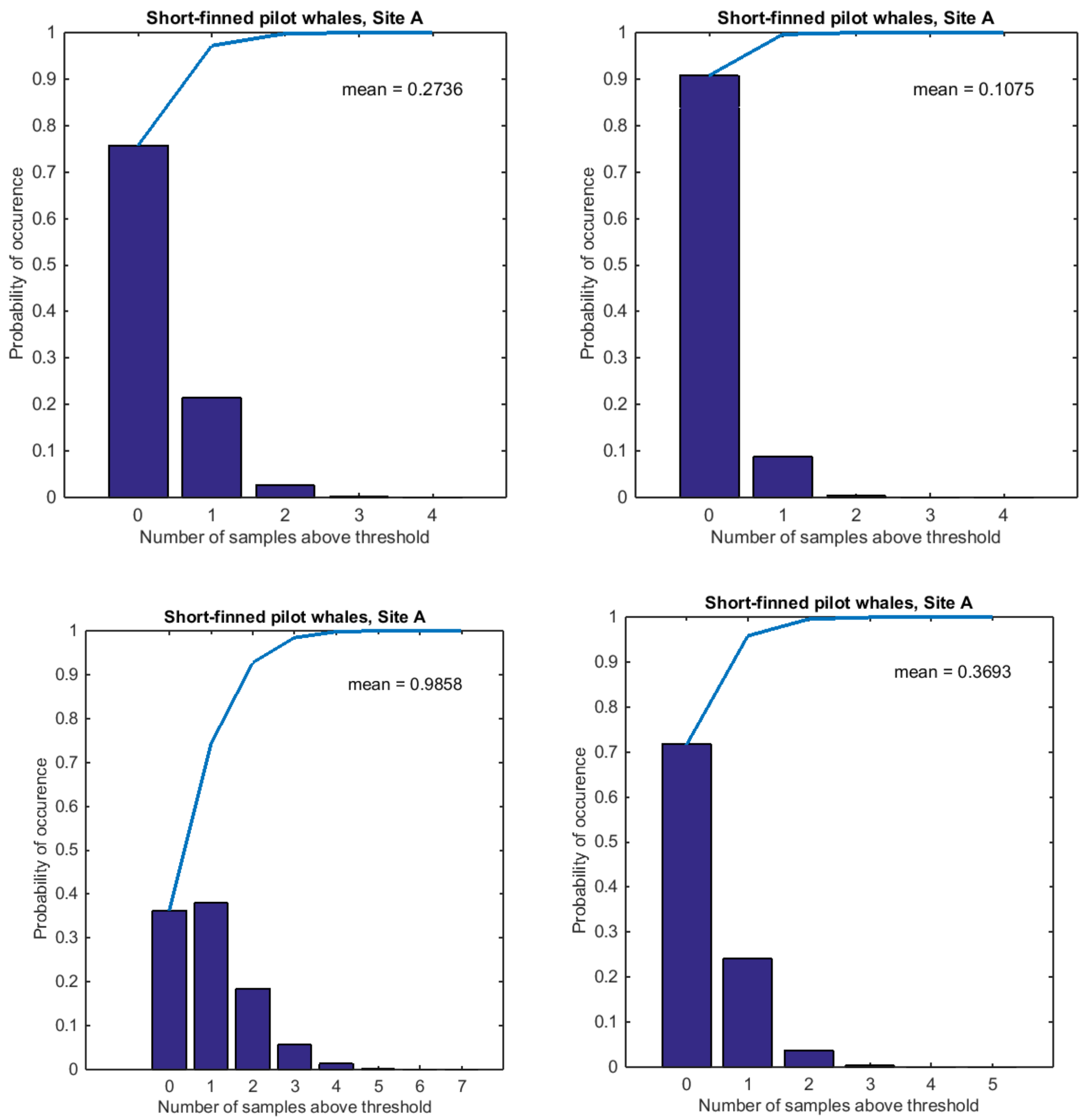


Figure 92. Short-finned pilot whales: Probability of exposure at or above injury thresholds at Survey site A without (left panels) and with mitigation (right panels) for peak SPL (top panels) and rms SPL (bottom panels). Detection probability is 0.7. The blue line is the cumulative distribution.

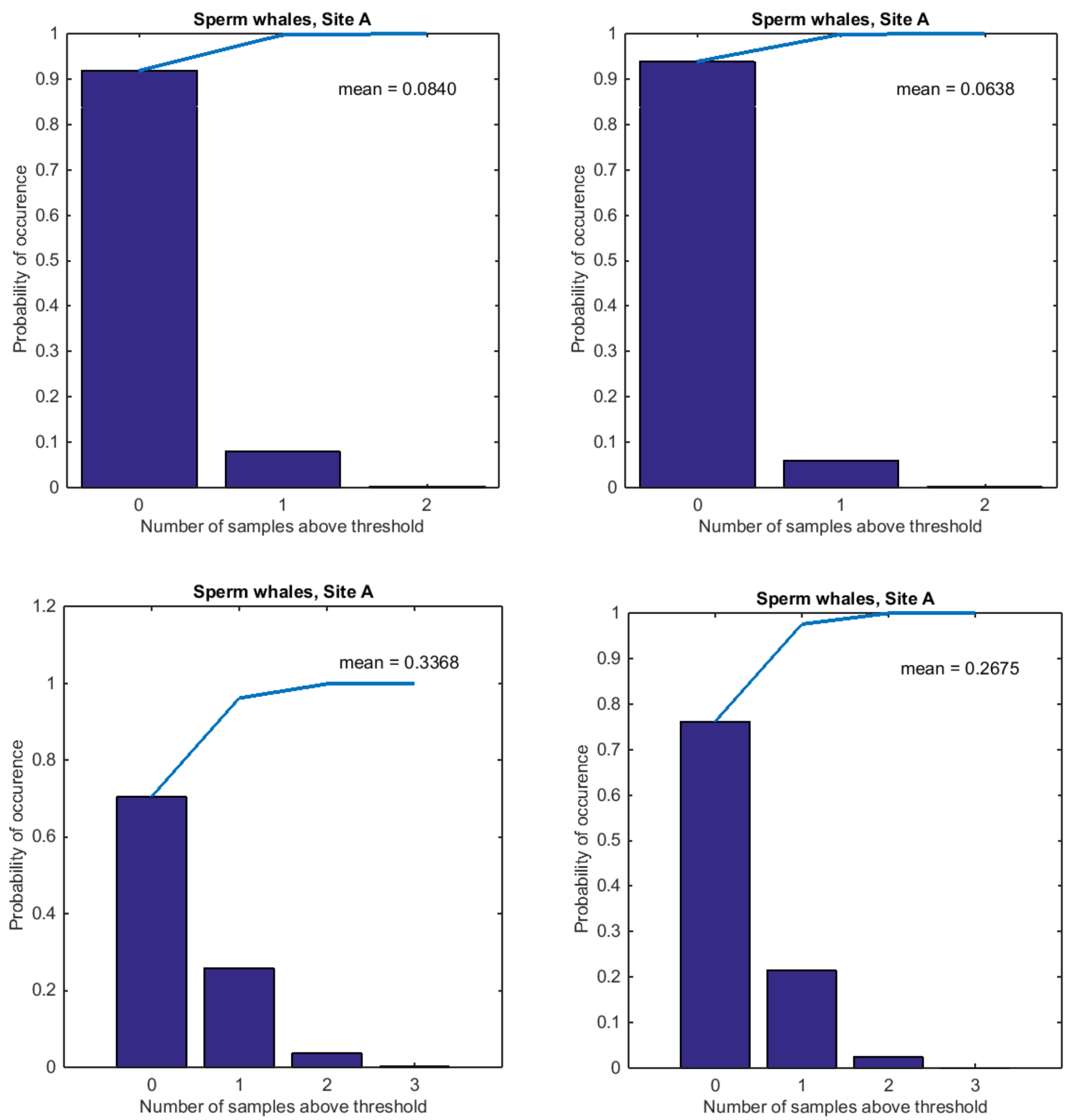


Figure 93. Sperm whales: Probability of exposure at or above injury thresholds at Survey site A without (left panels) and with mitigation (right panels) for peak SPL (top panels) and rms SPL (bottom panels). Detection probability is 0.7. The blue line is the cumulative distribution.

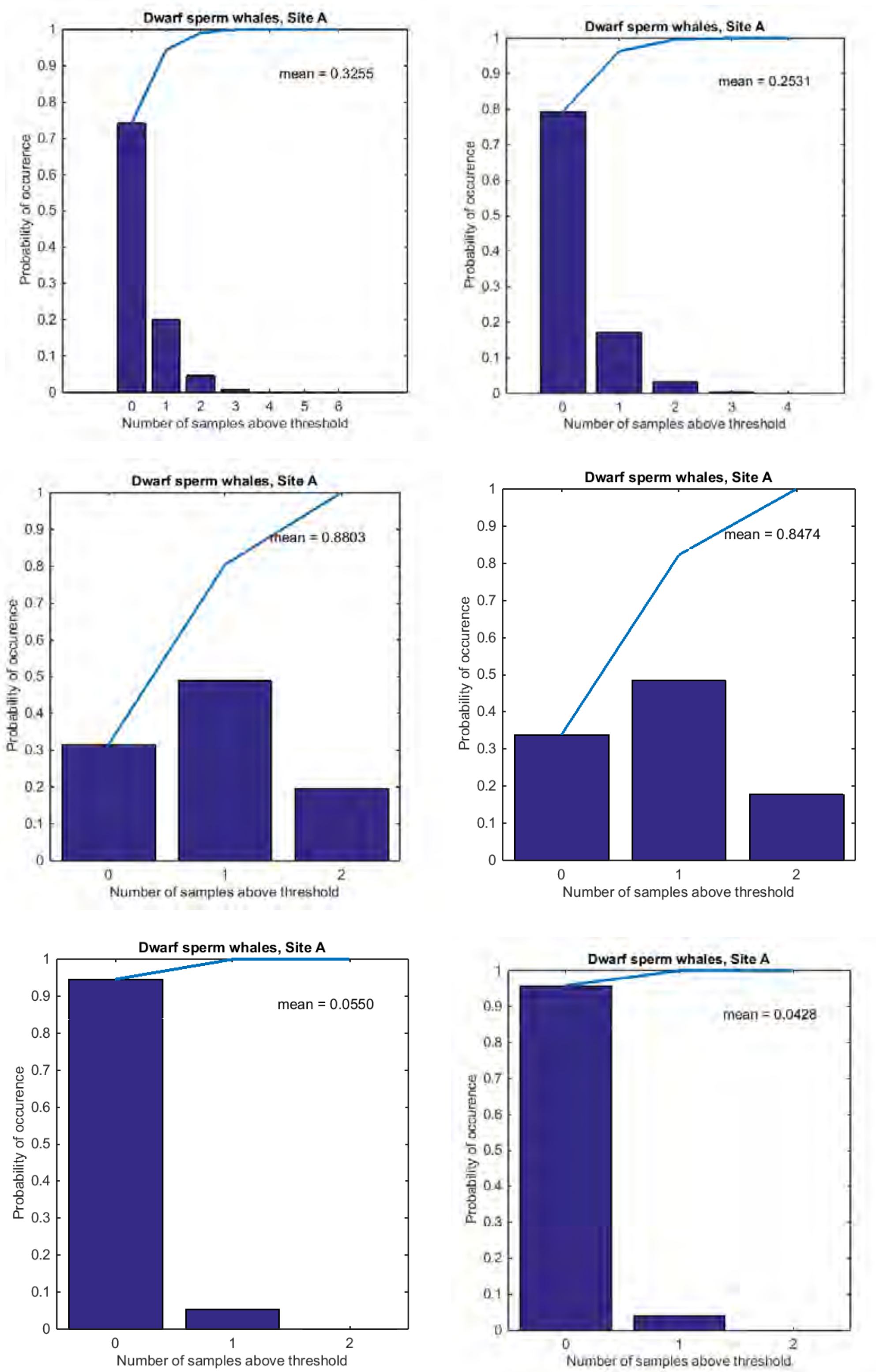


Figure 94. Dwarf sperm whales: Probability of exposure at or above injury thresholds at Survey site A without (left panels) and with mitigation (right panels) for SEL (top panels), peak SPL (middle panels), and rms SPL (bottom panels). Detection probability is 0.25. The blue line is the cumulative distribution.

6.5.3.3. Summary of Mitigation Effectiveness

The inclusion of mitigation procedures in the simulations reduced the numbers of exposures based on peak SPL and rms SPL criteria for five out of six species and detection probabilities considered, even though an extension in the survey period due to line re-shoot was taken into account. The exception was Bryde's whales, for which real-world densities were so low that no exposures were modeled even in the absence of mitigation. The numbers of exposures based on the SEL criteria were zero for most species (even without mitigation), except for dwarf sperm whales. For dwarf sperm whales, there was a reduction in SEL exposures with mitigation, but, as with the peak SPL criteria, the reduction amounted to fractions of an animal. Mitigation effectiveness, expressed as the reduction in the number of individual animals exposed, was generally related to animal densities; species with higher densities were more often exposed and the reduction in the number of exposures from mitigation was greater.

Mitigation effectiveness, as measured by the percentage reduction in the exposure estimates, is predominantly a function of animal detection probability during a seismic survey. The greater the detection probability, the greater the effectiveness of shutdown mitigation. The percentage reduction in exposures for species with relatively high detection probability (common bottlenose dolphins, short-finned pilot whales, and sperm whales) was higher than the percentage reduction for species with relatively low detection probability (Cuvier's beaked whales and dwarf sperm whales). Bryde's whales had no exposures with or without mitigation. In addition, the detection probability of beaked and dwarf sperm whales is potentially lower than reported from surveys due to uncertainty of detection availability. This also lead to a higher uncertainty in measuring mitigation effectiveness for these species using detection probability metrics. For deep diving species with unreliable vocal rates, a very conservative estimate of mitigation effectiveness should be used.

To summarize, the usefulness of mitigation depends on species characteristics and environmental conditions. Mitigation effectiveness, measured as percent reduction in exposures relative to no mitigation, tracks with detection probability and animal density. The absolute number of exposed animals reduced by mitigation is mainly dependent on how many animals were originally affected by the survey. The reduction due to mitigation for easily-detected, species with large populations, e.g., a large group of dolphins, may be high in terms of percentage decrease (perhaps ~ 70%) and absolute number of animals. For low-density species that are difficult to detect in rough seas (e.g., cryptic, deep-diving species like beaked whales), the efforts of mitigation may produce little mitigating effect.

6.5.4. Test Scenario 4: Effects of Aversion on Acoustic Exposure Estimates

Animals can display a range of behaviors in response to anthropogenic sounds, including increased respiration rates, increased or decreased vocalization rates, and changes in swimming speed (Nowacek et al. 2007). There can be substantial variation in individuals' responses to acoustic exposures; there are many examples where individuals of the same species exposed to the same sound reacted differently (Nowacek et al. 2004). If sounds are perceived as a threat or an annoyance, animals might temporarily or permanently avoid the area near the source (Stansfield and Matheson 2003, Southall et al. 2007, Ellison et al. 2012). Animals moving to avoid sound is called aversion.

Aversive responses to sounds are of particular interest because such behavior could decrease the number of injuries that result from acoustic exposure. If aversion occurs at a level less than that considered an exposure, a decrease in the corresponding exposure estimates can be assumed. The degree of aversion and level of onset for aversion, however, are poorly understood.

This Test Scenario uses a modeling approach to quantify the potential reduction in injury exposure estimates. Aversion is simulated as a reduction in received levels and, because little is known about the received levels at which animals begin to avert, the sound levels and probabilities used to evaluate potential behavioral disruption are used to implement aversion. This report only addresses the effects of aversion on potential injury exposures; disturbance or behavioral exposures are not considered because the aversive thresholds used are the same as the current behavioral disruption exposure thresholds. Consequently, based on these thresholds, aversion itself represents a behavioral disruption exposure. It is important to note that, if aversion thresholds were lower than behavioral disruption exposure thresholds, then aversion could also reduce behavioral exposures.

6.5.4.1. Effects of Aversion on Acoustic Exposure Estimates Methods

Injury exposure estimates associated with the 5-day WAZ simulation (Section 6.3.2) were determined with and without aversion. For each site and species, distributions of expected exposures were calculated using bootstrap resampling (Section 6.5.3.1.1) of the animats' acoustic exposure histories generated in the course of the Test Case simulations. For computational efficiency, the number of animats per bootstrap replicate was scaled by the ratio of the real-word animal densities to the modeling density. To simulate aversion, a modified exposure history was generated as outlined in Section 6.5.4.2, and injury exposure estimates were computed relative to SEL, peak SPL, and rms SPL (180 dB re 1 µPa) exposure criteria (Sections 5.4.2 and 5.4.3). The difference in the mean value of the exposure estimate distributions with and without aversion indicates the effect of aversion on the injury exposure estimates.

6.5.4.2. Exposure History with Aversion

Each animat sampled during the bootstrap process (Section 6.5.3.1.1) has an associated exposure history, i.e., a time series of received sound levels arising from relative motion of the source and animat. These exposure histories were computed assuming the animats' behaviors were otherwise unaffected by their received sound levels. Each exposure history was then modified based on received-level dependent probabilities of averting:

1. For each bootstrap sample, the occurrence of aversion was determined probabilistically based on the exposure level and the probability of aversion using the step function defined in Section 5.4.3 for SEL and peak SPL, and 50% probability at 160 dB rms SPL for 180 dB rms SPL. An iteration-specific aversion efficacy was also chosen randomly from a uniform distribution in the range of 2–10 dB.
2. Animats for which aversion occurred in Step 1 had their received levels adjusted as described in the following steps. The received levels were unchanged for animats that did not avert.
3. For an animat entering an averted state, the aversion level excesses (the levels above the threshold that prompted aversion) until the end of the aversion episode were calculated from the difference between the received level at the start of aversion and the threshold level at which aversion began up to a maximum of 5 dB.
4. The adjusted received level during aversion was set to the greater of two quantities:
    - The received level minus the aversion efficacy (from Step 1), or
    - The threshold level plus the aversion level excess at the start of aversion (from Step 3)

Adjusted exposure histories were computed separately for each source, animat, and episode of aversion; each occurrence of aversive behavior was thus independent.

Although the probability of aversion was defined in terms of the rms SPL, exposure histories were recorded in terms of the per-pulse SEL. A nominal conversion offset of +10 dB from SEL to rms SPL, corresponding to a pulse arrival duration of ~ 100 ms (Section 5.2.4), was used so the two metrics could be compared. Additionally, 5-day SELs, used to compute injury exposure estimates, were weighted using Type I M-weighting for low-frequency cetaceans (Bryde's whales) and Type II M-weighting for mid- and high-frequency cetaceans, but behavioral effects were estimated using Type I M-weighting for all species considered (Section 5.4.1). As such, the 5-day SEL exposure histories for mid- and high-frequency cetaceans were adjusted upward by an amount corresponding to the K_1 value of the Type II M-weighting functions (i.e., 16.5 dB for mid-frequency cetaceans and 19.4 dB for high-frequency cetaceans; Section 5.4.1) before they were compared to the aversion threshold levels (see Section 5.4 for exposure criteria levels developed for this study).

6.5.4.3. Effects of Aversion on Acoustic Exposure Estimates: Results

The average number of cetaceans exposed to sounds above the potential injury threshold was computed for Survey sites A (shallower water) and B (deeper water) for the six sample species. Exposure estimates were computed with and without aversion, producing an estimate of the aversion effectiveness for each site and species modeled (Table 45). For all species except the high-frequency dwarf sperm whales, no or a vanishingly small number of SEL exposures were registered with and without aversion. In the case of Bryde's whales, their very low real-world density led to a small number of bootstrap samples in each replicate and animats exposed to sound levels above SEL threshold were very rarely chosen during bootstrap resampling. Because the probability of exposure cannot truly be zero, and to keep our reporting convention consistent, the exposure estimates are listed as < 0.01 for these cases.

Sample plots of the probability distribution of injury exposure estimates, with and without aversion, are shown in Figures 95–100. In each case, the cumulative probability is shown as a blue line and the mean value (i.e., the expected number of exposures) is labeled. When the step function was used to determine aversion, the median amount of time common bottlenose dolphin, dwarf sperm whale, short-finned pilot whale, and sperm whale animats spent in an averted state was approximately 7 min at Survey site A and 2 min at Survey site B. The corresponding mean times were approximately 18 and 4 min, respectively. For beaked whales, the median was 45 min at Survey site A and 5 min at Survey site B and the corresponding means were 41 and 19 min. Too few Bryde's whale animats exceeded threshold to obtain a reliable statistical measure.

Table 45. Modeled Level A exposures, with and without aversion.

Species	Metric	Average number of cetaceans above exposure criteria					
		Survey site A			Survey site B		
		Without aversion	With aversion	Aversion effectiveness	Without aversion	With aversion	Aversion effectiveness
Bryde’s whales	5-day SEL	< 0.01	< 0.01	N/A	< 0.01	< 0.01	N/A
	peak SPL	< 0.01	< 0.01	N/A	< 0.01	< 0.01	N/A
	rms SPL	0.341	0.299	0.043 (12%)	0.390	0.336	0.054 (14%)
Cuvier’s beaked whales	5-day SEL	< 0.01	< 0.01	N/A	< 0.01	< 0.01	N/A
	peak SPL	0.033	0.006	0.028 (83%)	0.038	0.004	0.034 (89%)
	rms SPL	1.930	1.604	0.326 (17%)	2.662	2.237	0.425 (16%)
Common bottlenose dolphins	5-day SEL	< 0.01	< 0.01	N/A	< 0.01	< 0.01	N/A
	peak SPL	1.357	0.219	1.139 (84%)	0.191	0.033	0.159 (83%)
	rms SPL	68.701	57.940	0.761 (16%)	9.798	8.043	1.756 (18%)
Short-finned pilot whales	5-day SEL	< 0.01	< 0.01	N/A	< 0.01	< 0.01	N/A
	peak SPL	0.279	0.040	0.239 (86%)	0.346	0.052	0.294 (85%)
	rms SPL	13.287	11.410	1.877 (14%)	18.311	15.521	2.790 (15%)
Sperm whales	5-day SEL	< 0.01	< 0.01	N/A	< 0.01	< 0.01	N/A
	peak SPL	0.082	0.013	0.069 (84%)	0.126	0.020	0.106 (84%)
	rms SPL	4.744	3.819	0.925 (20%)	8.969	7.555	1.414 (16%)
Dwarf sperm whales	5-day SEL	0.318	0.191	0.127 (40%)	0.647	0.399	0.248 (38%)
	peak SPL	0.859	0.774	0.086 (10%)	1.958	1.756	0.202 (10%)
	rms SPL	1.756	1.421	0.335 (19%)	4.708	3.795	0.912 (19%)

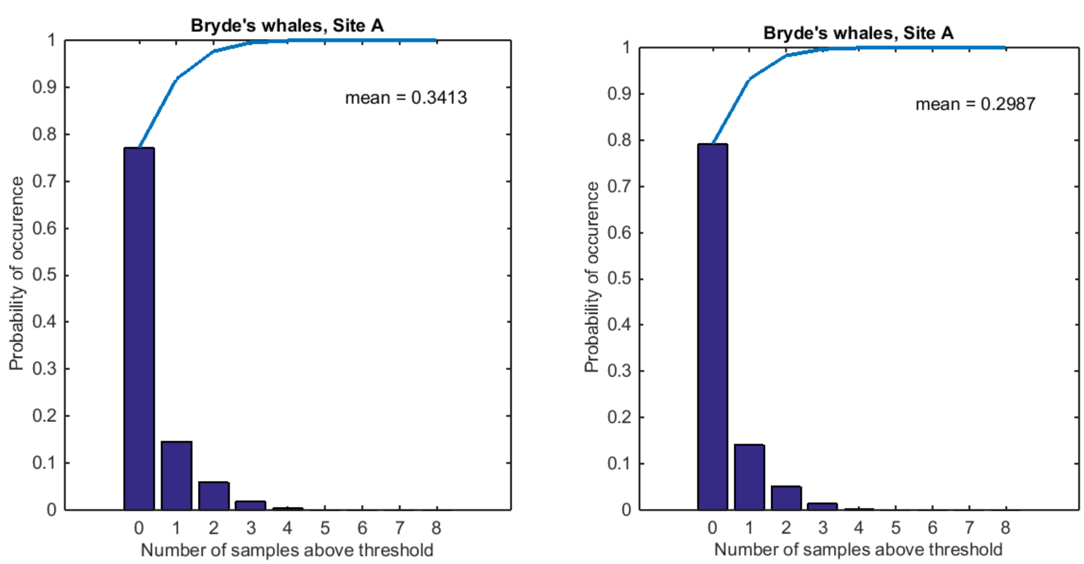


Figure 95. Probability of exposure at or above rms SPL injury thresholds for Bryde’s whales at Survey site A, (left) without and (right) with aversion. The blue line is the cumulative distribution.

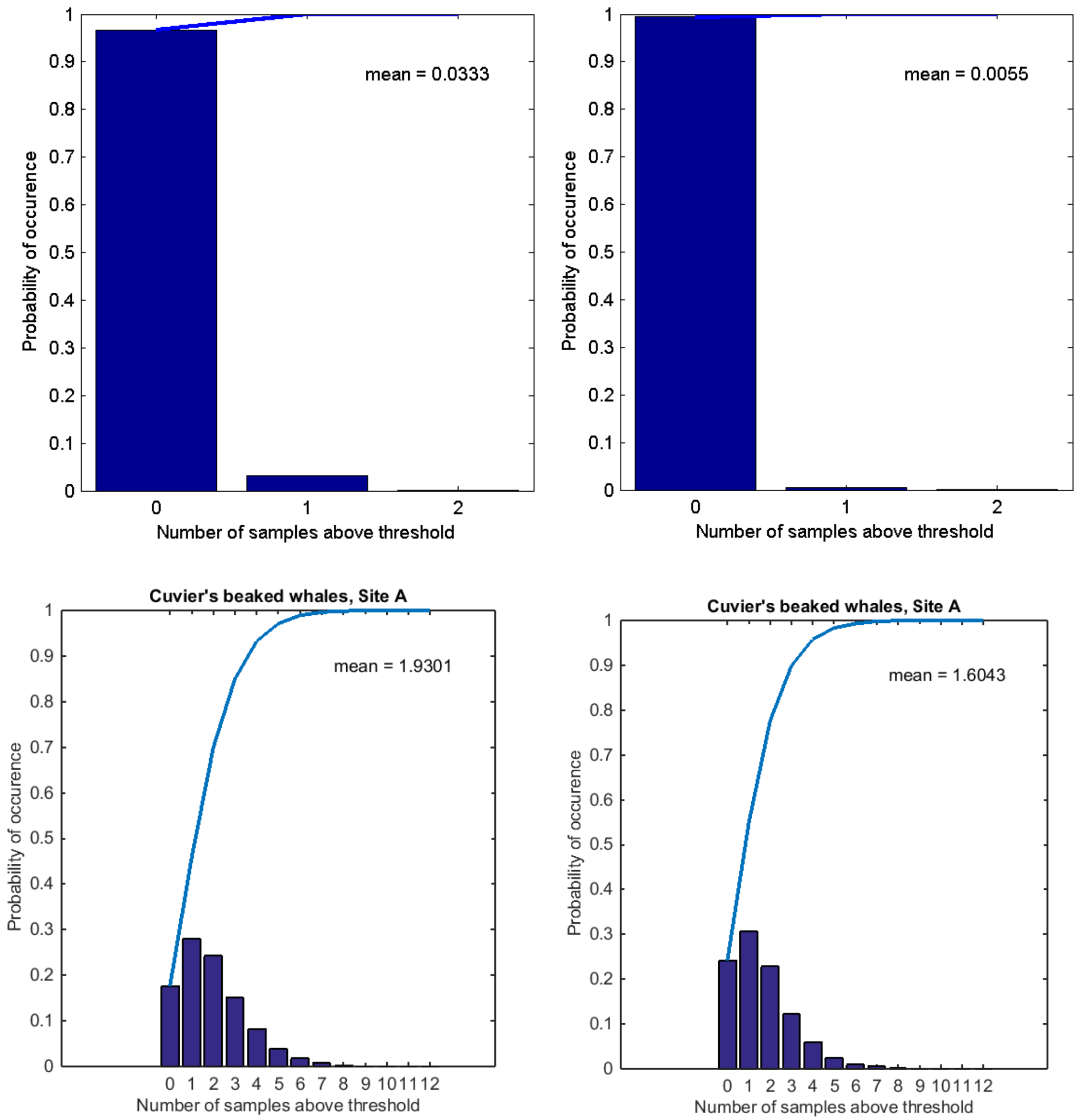


Figure 96. Probability of exposure at or above peak SPL (top panels) and rms SPL (bottom panels) injury thresholds for Cuvier's beaked whales at Survey site A, without (left panels) and with aversion (right panels). The blue line is the cumulative distribution.

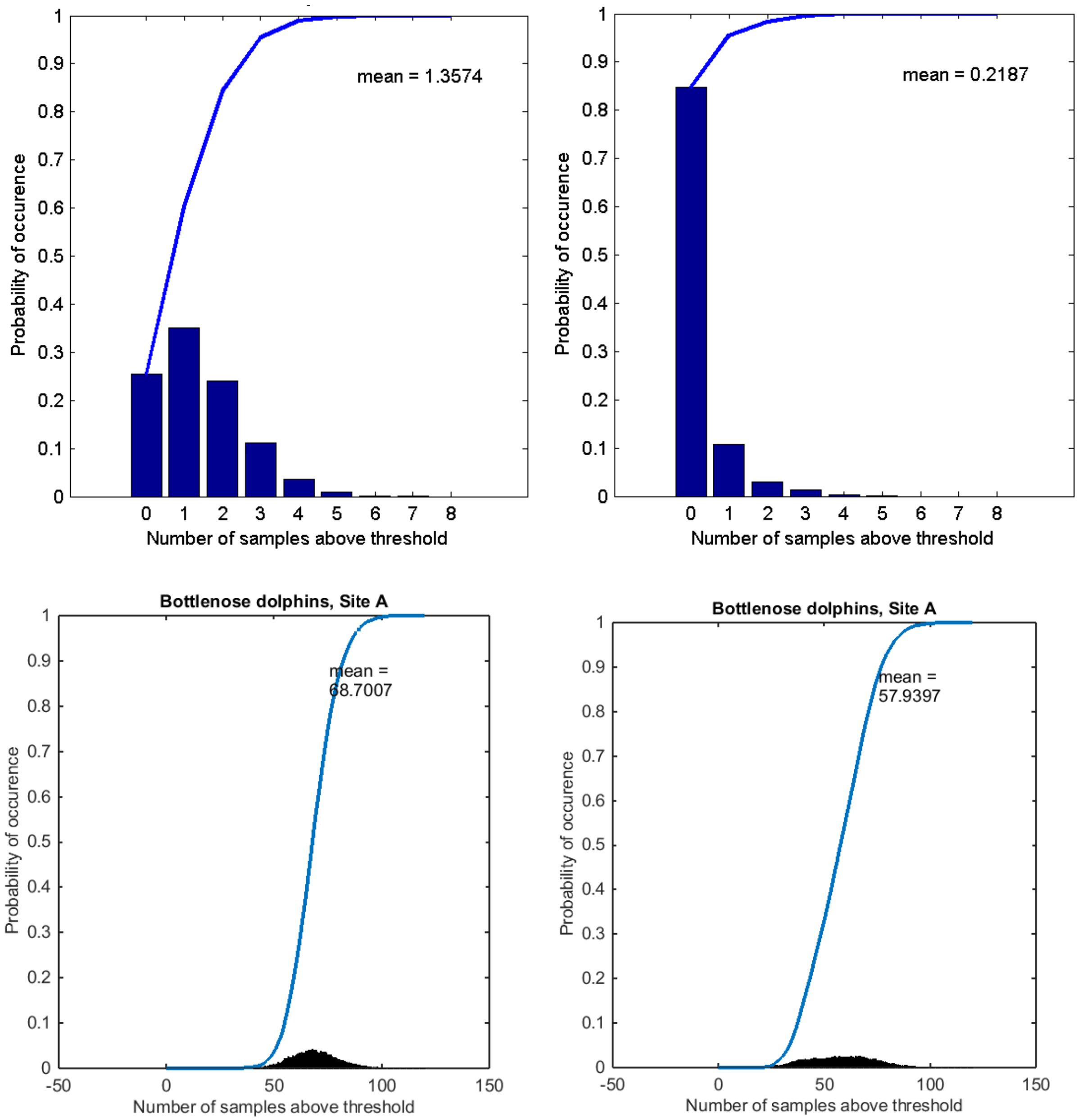


Figure 97. Probability of exposure at or above peak SPL (top panels) and rms SPL (bottom panels) injury thresholds for common bottlenose dolphins at Survey site A, without (left panels) and with (right panels) aversion. The blue line is the cumulative distribution.

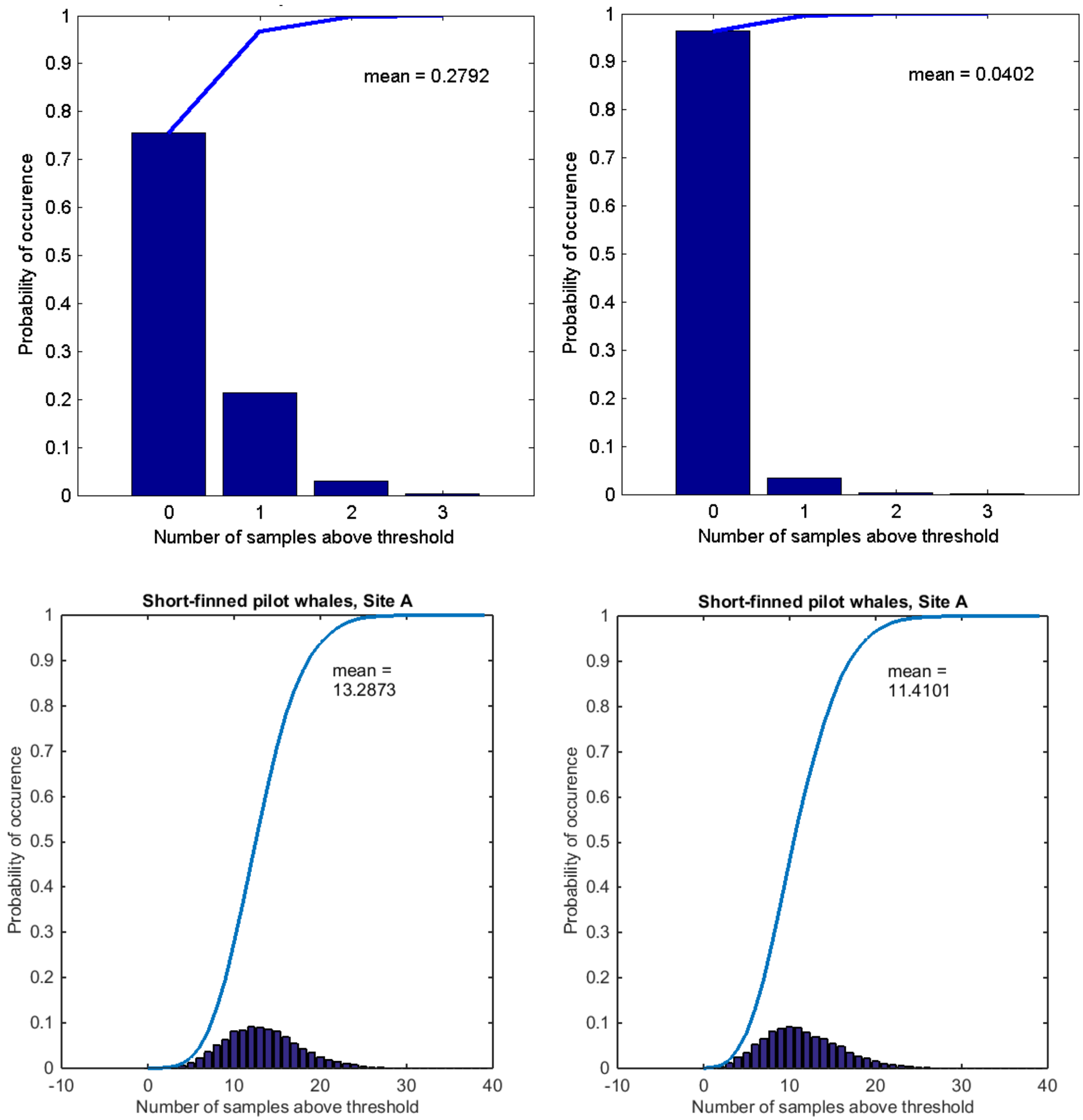


Figure 98. Probability of exposure at or above peak SPL (top panels) and rms SPL (bottom panels) injury thresholds for short-finned pilot whales at Survey site A, without (left panels) and with (right panels) aversion. The blue line is the cumulative distribution.

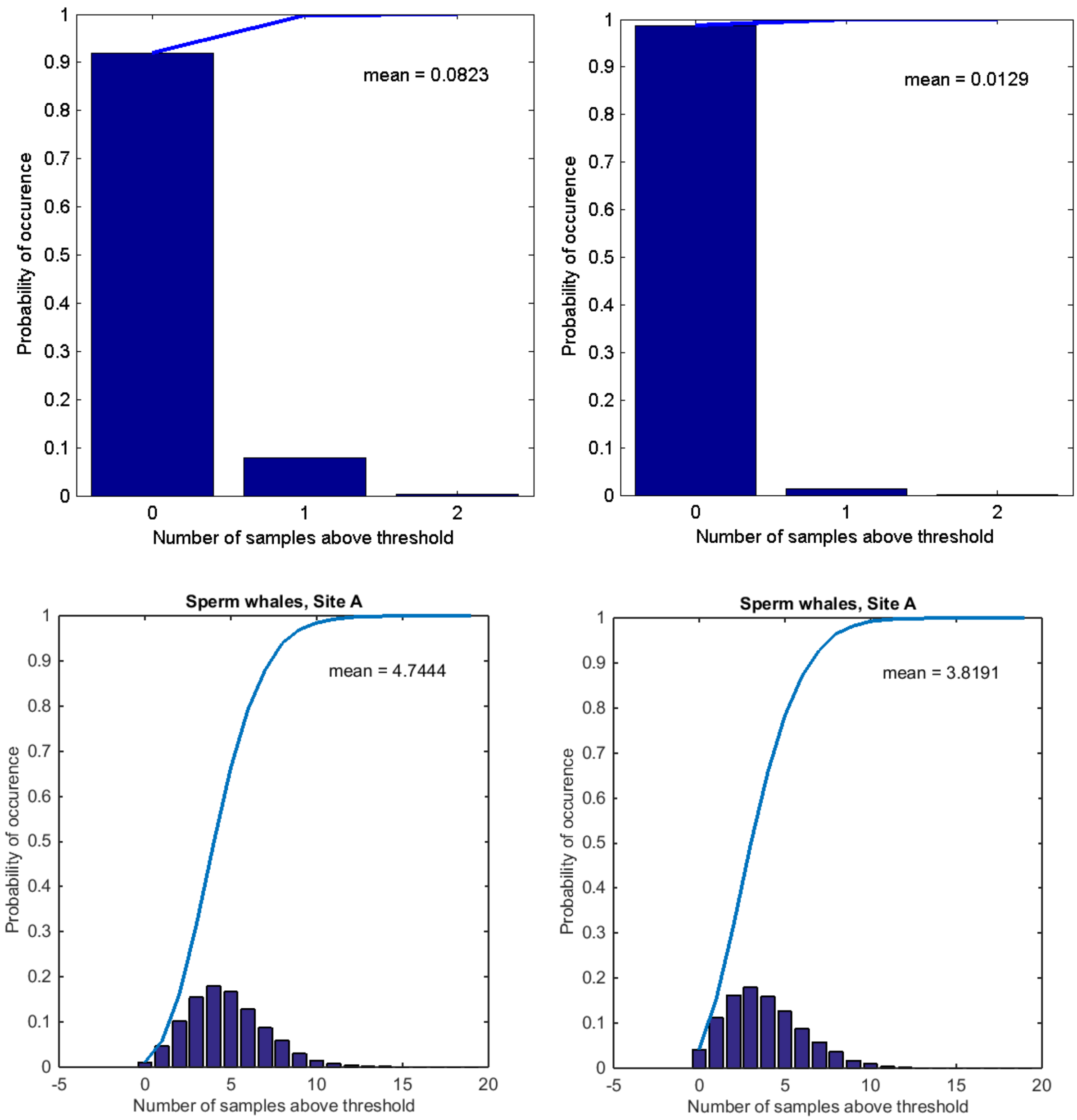


Figure 99. Probability of exposure at or above peak SPL (top panels) and rms SPL (bottom panels) thresholds for sperm whales at Survey site A, without (left panels) and with (right panels) aversion. The blue line is the cumulative distribution.

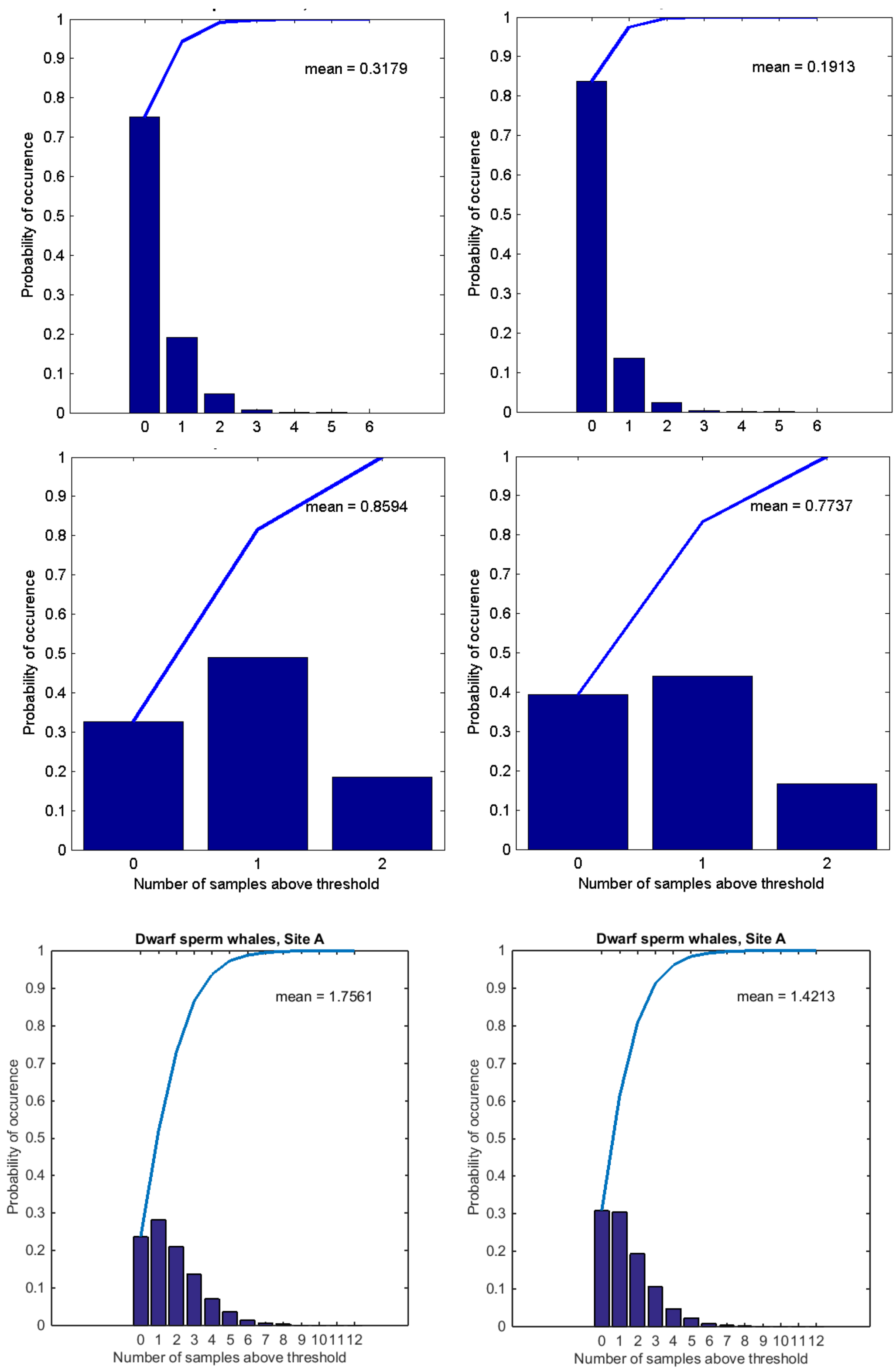


Figure 100. Probability of exposure at or above (top panels) SEL, (middle panels) peak SPL, rms SPL (bottom panels) injury thresholds for dwarf sperm whales at Survey site A, without (left panels) and with (right panels) aversion. The blue line in each plot is the cumulative distribution.

6.5.4.4. Summary of Effects of Aversion on Acoustic Exposure Estimates

Responses to sound carry potential health costs to animals. Hiding or retreating from an ensonified area could decrease their foraging time and/or increase the energy they spend searching for food (Bateson 2007). In most cases, animals likely expend less energy temporarily avoiding or averting noise by changing their travel or migratory routes, than they would if their foraging was interrupted. The circumstances under which aversion occurs depends on the context in which the animals receive sounds and on the animals' motivation. The decision to deviate from a path or avoid an ensonified area is likely driven by energetic and reproductive requirements (Croll et al. 2001). For example, bowhead whales who avoided distant seismic airguns at received levels of rms SPL of 120–130 dB re 1 µPa during fall migration (Richardson et al. 1999) were more tolerant of airgun sounds while feeding in the summer. The feeding whales avoided airguns only when received levels reached 152–178 dB re 1 µPa, roughly 30–50 dB higher than migrating avoidance levels (Richardson et al. 1995).

Stone and Tasker (2006) reported that small odontocetes showed the strongest reaction to airgun sounds by moving away from or avoiding an ensonified area. Mysticetes and killer whales showed more localized avoidance, with fewer sightings when the source was active; long-finned pilot whales only changed their orientation; and sperm whales showed no significant avoidance response (Stone and Tasker 2006). Others (e.g., Rankin and Evans 1998) also noted sperm whales' apparent lack of response to seismic operations. In controlled exposure experiments, eight tagged sperm whales over a series of 120 min intervals during pre-exposure, ramp-up, and full-array airgun firing did not avoid airgun sounds by adjusting their position horizontally; only one individual adjusted its diving and foraging rate by resting longer at the surface and diving immediately following the final airgun pulse (Miller et al. 2009). In contrast, during the first 72 h of a 10-day seismic survey, fin whales moved away from the airgun array. This displacement persisted well beyond the 10-day duration of seismic airgun activity (Castellote et al. 2012). Though consistent with aversion to airgun sounds, another possibility is that the animals were following a food source that was not tracked during the observations. Gender-specific responses were also observed. Resting female humpback whales avoided seismic surveys by distancing themselves from the source by 7–12 km, whereas males were occasionally attracted to the sounds (McCauley et al. 2000a).

To assess how aversion could reduce injury exposure estimates, a simple model was created that allowed for lower exposure levels for animats in the simulation, based probabilistically on their received level. Any animat that averted was considered to have a behavioral response so only the effects of aversion on injury exposures were considered.

Aversion in the simulations reduced the numbers of exposures based on peak SPL criteria for most species. Aversion effectiveness, as measured by the percentage reduction in the exposure estimates, could be high: ~ 85% for common bottlenose dolphins, Cuvier's beaked whales, short-finned pilot whales, and sperm whales, and ~ 40% for dwarf sperm whales. Bryde's whales, whose real-world densities were so low that no exposures were modeled even in the absence of aversion, were the exception. The numbers of exposures based on SEL criteria were near zero for most species even without aversion. For dwarf sperm whales, there was a reduction in SEL exposures with aversion, but as with the peak SPL criteria, the reduction amounted to a fraction of an animal. There was a consistent reduction of 14–20% in exposures above rms SPL 180 dB re µPa based on aversion starting at rms SPL 160 dB re µPa for all species. The reduction in the number of individuals above rms SPL 180 dB re µPa ranged from a fraction of an animal to more than ten individuals. Aversion effectiveness, expressed as the reduction in the number of exposures, was generally related to animal densities: species with higher densities were more often exposed, and the reduction in the number of exposures from aversion was greater. This reduction in exposures was also influenced by the criteria used to estimate exposures and by the assumptions made with respect to aversion probability. For example, although the real-world densities of dwarf sperm whales (a high-frequency cetacean) are similar to those for Cuvier's beaked whales (a mid-frequency cetacean), exposure estimates and the decrease in number of exposure estimates arising from aversion were different. The differences in aversion effectiveness reflect differences in injury threshold criteria and aversion probability. The Cuvier's beaked whales' behavioral response thresholds are lower than other species, leading to potential aversion at lower received levels and greater reduction in injury exposures based on the SPL metric. Dwarf sperm whales had more absolute exposures and less reduction because of their lower behavioral response thresholds and larger ensonified area in which injury could occur.

6.5.5. Test Scenarios 5 and 6: Stand-off Distance and Simultaneous Firing

Modern geophysical seismic surveys employ a variety of seismic sources, including airgun arrays. Recent survey practices have included survey geometries that with multiple airgun arrays, separated by tens of meters to several kilometers, in a single survey. New technologies for analyzing seismic data are less sensitive to interference of noise between multiple surveys, and this has allowed for different surveys to be performed closer together than previously. There is concern that the combined sound pressure levels of multiple sources operated close-by can lead to increased noise effects than would occur with a single source. This Test Scenario report addresses the issue of the aggregate noise produced by multiple airgun arrays and the potential for those signals to combine and lead to larger effects.

Airgun arrays consist of multiple airguns that are fired almost simultaneously to increase the amplitude of the overall source pressure signal. The combined sound emission amplitude and directivity of an airgun array is dependent on the number and sizes of individual airguns and their geometric positions within the array. Airgun arrays are typically operated repetitively as the arrays are towed over a survey grid pattern. The time intervals between airgun shots are optimized for water depth and the distance of important geological features below seafloor; there must be enough time between shots for the sound signals to propagate down to and reflect from the feature of interest, and then to propagate upward to be received on hydrophones. Reverberation of sound from previous shots must also be given time to dissipate. The receiving hydrophones can be towed behind or in-front of the airgun array, or deployed on the seabed. These can be displaced several kilometers horizontally away from the source, so horizontal propagation time is also considered in setting the interval between shots.

Many 3-D surveys now use two or more airgun array sources to get different 'views' of geological features. A common approach for these surveys has been to tow two arrays spaced horizontally a few tens of meters away from each other, and to fire them alternately. This alternate firing of pairs of arrays is referred to as 'flip-flop' mode. More recently, wider offsets of the airgun arrays are achieved by towing the arrays from different vessels. Surveys of this type are referred to as wide azimuth, and they are be performed with multiple vessels spaced from hundreds or thousands of meters apart, with each vessel towing its own airgun array or arrays.

In these cases, a stand-off distance may be required for operational and data quality purposes. A minimum standoff distance may be desired, or required for permitting, to allow a corridor for animals to pass between adjacent work zones. Determining the underwater sound field of surveys involving multiple arrays with potential overlap is more complex than evaluating the impacts due to a single-array survey because relative locations and relative shot timing might have to be taken into account. The influence of stand-off distance and simultaneous firing on acoustic exposure estimates is explored here.

6.5.5.1. Stand-off Distance

Multiple seismic surveys may be conducted nearby one another at the same time. The sound emissions of the multiple sources from these surveys, operating in close proximity, can lead to increased received sound levels for nearby marine mammals. A minimum separation distance between the surveys, referred to as a stand-off distance, may be mandated to keep the noise exposures lower. If the stand-off distance keeps the surveys sufficiently separated, the estimates of marine mammal exposures for either survey, i.e., the number of animals exposed to sound levels above exposure thresholds, is largely independent of the presence of the other survey. If the surveys move closer together, nearby marine mammals can experience sound exposure contributions from both surveys, potentially increasing their total exposures above effects thresholds and consequently causing additional exposures. In the case where a marine mammal approaches two surveys close enough to exceed the exposure threshold of both independently, it is only considered to have been exposed once (if the exposures occur within the reset period). In those cases, the number of exposures might actually be reduced by smaller stand-off distances. The issue of value of stand-off distance is therefore not straightforward. It is further complicated by the fact that the SPL and SEL sound metrics, all used for exposure assessments, vary differently in the presence of sound contributions from two or more surveys.

SPL is a metric used for both injurious and behavioral exposure assessments. SPL of impulsive airgun sounds is calculated over relatively short time windows, almost always less than 1 s and commonly approximately 100 ms, during which the highest amplitude parts of the pulse-like sounds occur (see Figure 15a, which shows the pressure waveform of the 8000 in^3 array from the Test Case). When two seismic surveys are operating nearby, marine mammal receivers can experience pulses from both surveys. However, unless those pulses happen to arrive near-simultaneously at the receiver, the SPLs do not sum and the SPL exposure will be that only of the louder survey (at the receiver position). Interpulse time intervals typically are 10 to 20 s, with 15 s being quite common. Using that as an example, with a SPL time window of 100 ms, only one in 75 pulses will have some degree of important overlap for a given receiver, and that will usually only be partial. This example neglects that signals in deep waters can have several discrete arrivals associated with multipaths (e.g., Figure 101, which shows pressure waveform shapes at several distances from the 8000 in^3 array source at Survey site A, from the Test Case, in 500 m water depth), but typically just one of those paths dominates. In the maximum-propagation scenario of full overlap and signals from both arrays having the same SPLs, the SPL increase would be about 3 dB. Generally, one signal will have higher amplitude than the other and the potential increase will be less. For example, if the received SPL from one survey is 158 dB re 1 µPa, and the other is 155 dB re 1 µPa, the fully overlapped pulses would have a combined SPL of 159.8 dB re 1 µPa, an increase of less than 2 dB over the higher-amplitude pulse, assuming they have the same pulse duration.

While the expected SPL increases from multiple surveys are relatively small, and occur infrequently, SPL-based exposures occur on a single instance of an exposure above the threshold. The behavior-based threshold may be exceeded several kilometers from either source, so there is a chance an animal mid-way between two surveys, and receiving similar SPL levels from both, could experience an increase by up to 3 dB when exposed to overlapping sounds from both surveys. To avoid this effect entirely would require stand-off distances of twice the distance to the exposure threshold minus 3 dB. Under the assumption of 20 log R (spherical spreading) transmission loss, the stand-off distance would have to be more than 3 times the distance to the exposure threshold to ensure that summed levels always fall off to the exposure threshold mid-way between the two sources. This geometry, however, leads to the largest combined exposure zone because the exposure zones of the individual surveys meet at the mid-point. In fact, much smaller stand-off distances reduce the size of the combined exposure zone.

The peak SPL metric is used to assess potential injury exposures close to a source. Peak SPLs occur over very short times, and the argument for rare overlaps of pulses, provided above for SPL, is even more pronounced for peak pressure. The likelihood of temporal overlaps of pressure peaks is very limited. Further, the peak pressure injury threshold exceedance zones are so small (typically a few hundred meters) that marine mammals would be extremely unlikely to experience an overlap that would lead to a peak pressure acoustic exposure that did not occur from a single survey source.

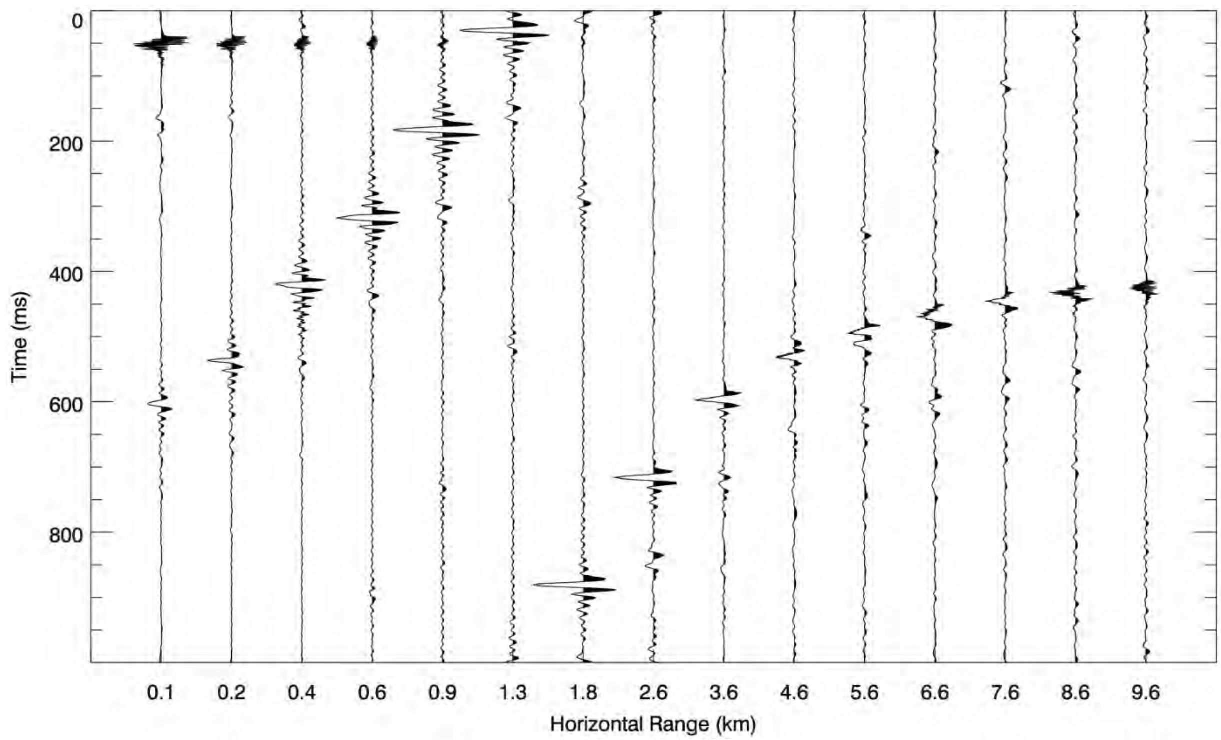


Figure 101. Waveforms predicted by FWRAM for the 8000 in^3 array at Survey site A, for a 10 m receiver depth. Waveforms are shown as a function of horizontal range from the receiver. Positive pressures are filled in black. The key feature is that pressure signals for individual multipaths are short in duration, here generally 50–100 ms.

SEL is a measure of accumulated sound energy. Unlike the previously described metrics of SPL and peak pressure, it does not depend on the structure (time and phase) of the received sound, and it increases throughout the reset period with each received pulse. For example, Figure 102 shows the unweighted SEL field for the start of a 3-D WAZ survey, assuming stationary receivers (as opposed to the moving animats used to compute exposure estimates). When surveys are close enough for animals to receive energy from two or more surveys, some animals that would have been below threshold in one survey could accumulate sufficient additional energy to exceed threshold in the aggregate of the surveys. In this case, an exposure would occur when no exposure would have been registered if the surveys did not overlap. For the current SEL criteria (Section 5.4.2), which apply only to potential injury, ranges for which injury may occur are on the order of a few hundred meters from the source. As such, overlap must occur over similarly short ranges to affect exposures. For example, even in high-density simulations (2 animats/km^2) of the 3-D WAZ surveys, no animats were exposed to levels exceeding the SEL threshold for mid-frequency species at Survey site B (deep) and only common bottlenose dolphin and Cuvier's beaked whale animats were exposed to levels exceeding the threshold at Survey site A. For Bryde's whales (low frequency) and dwarf sperm whales (high frequency), the number of acoustic exposures was much higher, but when real-world animal densities are considered, SEL exceedance is still rare and resulted from being near an individual source once rather than accumulating energy from multiple sources. Overall, exceeding the SEL threshold is a rare event and having four vessels close to each other (350 m between tracks) did not cause appreciable accumulation of energy at the ranges relevant for injury exposures, thus accumulation of energy from independent surveys is expected to be negligible.

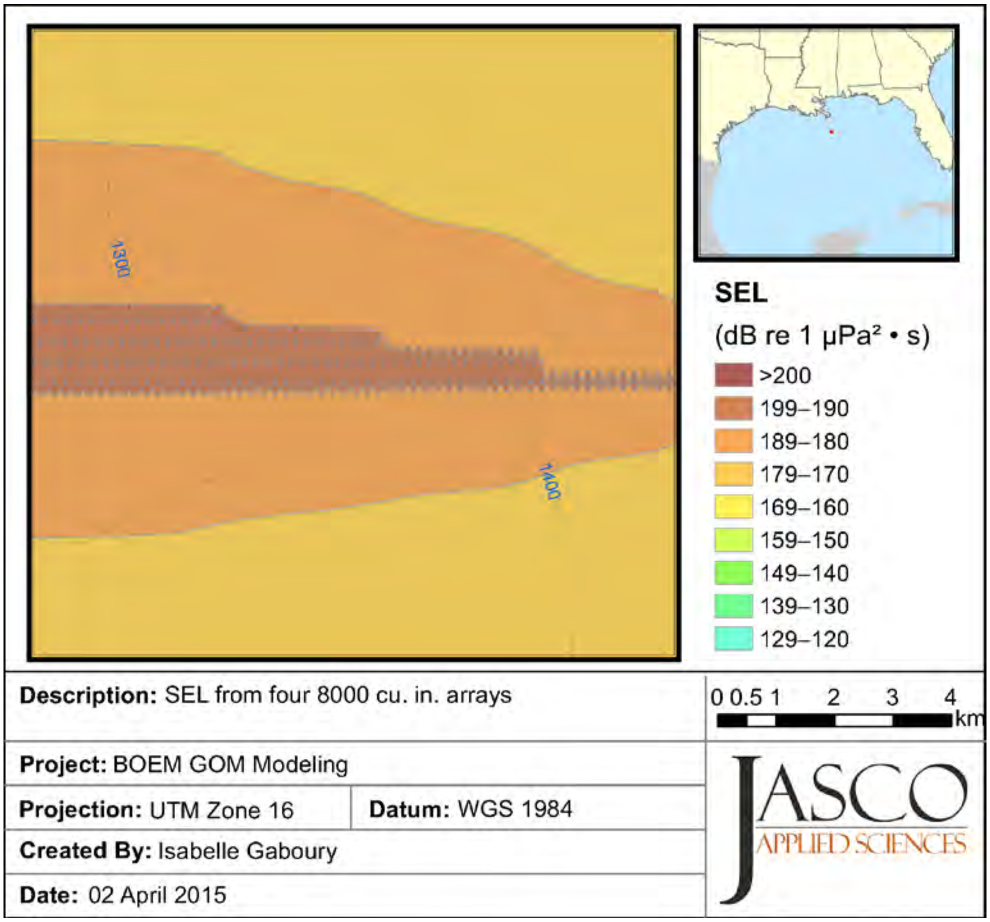


Figure 102. Sound exposure level for four 8000 in^3 arrays at the start of a 3-D wide azimuth seismic survey at Survey site A, S01 modeling province. Arrays are offset by an across-track distance of 350 m and an along-track distance of 2.7 km. Tow speed is 2.3 m/s, and shot interval for each vessel is 86.4 s.

6.5.5.2. Simultaneous Firing

Traditional large-scale surveys involving multiple airgun arrays towed from multiple vessels alternate, or distribute, the shots fired among the arrays. Some modern surveys now fire multiple arrays simultaneously. This simultaneous firing warrants special consideration for its potential to affect estimated exposures.

Coincidence of pulse arrival is only of concern for metrics based on sound pressure (the energy-related metric, SEL, is simply summed and does not rely on signal timing). As discussed in Section 6.5.5.1, the sound pressure at a location with multiple impinging sources is a function of the arrival time, shape, and phase of each arriving pulse. The greatest pressure amplitude is when two identical pulses arrive at the same time and in the same phase. These pulses sum coherently, doubling the sound pressure or, equivalently, increasing the SPL by 6 dB. Because phase varies with time, location, and frequency as sound propagates away from a source, coherent summing occurs only with nearly-coincident synchronized sources such as those within a single array. For separate arrays the pressure signals combine incoherently, with a maximum SPL increase of 3 dB, as described previously. More precisely, the incoherent sum of the rms SPLs from two arriving pulses in regions of overlap may be estimated as follows:

$$L_p = 10\log\left(\frac{T_1 \times \log^{-1}(L_{p1}/10) + T_2 \times \log^{-1}(L_{p2}/10)}{T_2 + \Delta t}\right), \qquad \Delta t < T_1 \qquad (20)$$

where L_{p1} and L_{p2} are the rms SPLs of the two pulses (dB re 1 μPa), T_1 and T_2 are time windows for computation of rms SPL (s), $\log^{-1}$ is the antilog function, and Δt is the difference in arrival time of the two pulses. The sum of more than two pulses is computed similarly. Where pulses do not overlap, the received SPL is taken to be the maximum SPL of the two individual pulses. For example, Figure 103 shows the maximum-over-depth rms SPL sound fields for one 8000 in^3 array and for two identical arrays fired simultaneously with an across-track separation of 350 m and an along-track separation of 2700 m (as in Figure 102 showing SEL). While there are some regions where the combined sound field is louder than the individual sound fields (e.g., the small extensions to the isopleths visible in the across-track direction in the bottom panel of Figure 103), the individual and combined sound fields are nearly identical. Similar results would be expected for simultaneous firing of three or four arrays.

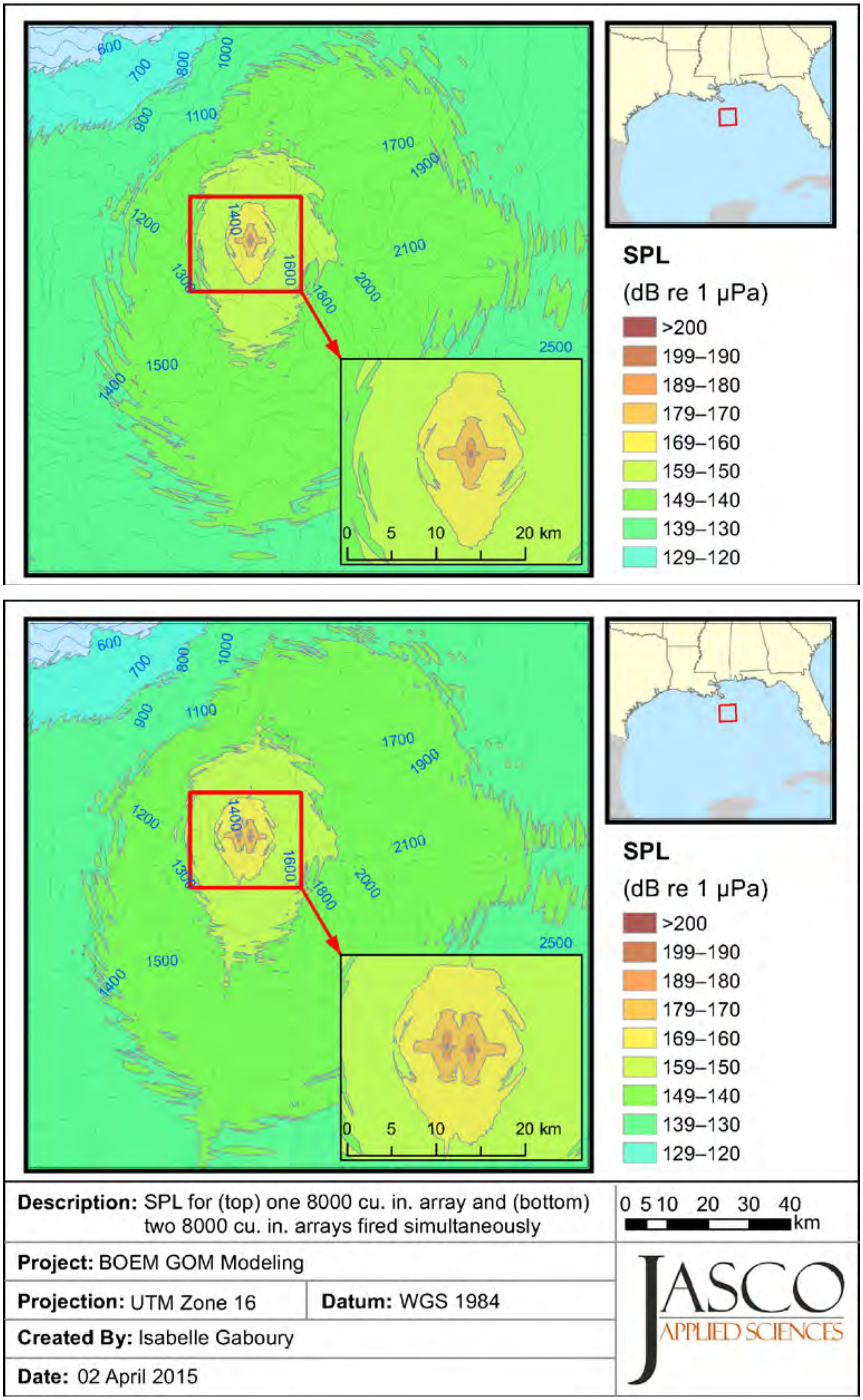


Figure 103. SPL for (top) one 8000 in^3 array and (bottom) two 8000 in^3 arrays fired simultaneously with an across-track separation of 350 m and an along-track separation of 2700 m.

6.5.5.3. Summary of Stand-off Distance and Simultaneous Firing

It was found that while SEL increases for overlapping surveys, injury due to accumulated energy is a rare event, and exceeding threshold resulted from a few high-level exposures near a source, not an accumulation of many lower-level exposures. The range to injury assessed by peak SPL is up to a few hundred meters and does not accumulate. Injury in typical seismic surveys, therefore, occurs mainly because of a close encounter with a single airgun array. There are practical limits to how close two acquisition lines can be without one survey source interfering with the other survey's recordings. Depending on the survey type and the propagation environment of the area, the stand-off distance between fully concurrent surveys operating independently may be several tens of kilometers. If two surveys are conducted in closer proximity, then the operators will generally agree to "time-sharing" strategies whereby, for example, one survey acquires a line while the other completes a line turn with the source inactive, or similar ways of minimizing the amount of missed effort. Effects of overlapping surveys on injury exposure estimates are unlikely.

For potential behavioral disruption, overlapping surveys may affect exposure estimates, but the effect is either small or potentially negative (reducing the overall number of estimated exposures). Because coincident reception in which the sound level increases appreciably only occurs in small portions of the ensonified volume, overlapping survey sound fields do not generally result in higher maximum received sound pressure levels. And, because animals may only be exposed once, animals exposed in more than one survey are only counted once in the aggregate of the surveys. This does not preclude possible behavioral effects of animals spending more time above threshold, but such effects are not addressed by existing criteria.

From an energetic perspective, the relative firing pattern of different arrays does not matter. The same SEL will be registered when two arrays are alternated or fired simultaneously. For the pressure-based metrics, peak SPL and rms SPL, simultaneous firing can increase the received levels, but in only a small portion the ensonified volume. Because the maximum received levels are rarely increased, the exposure estimates based on SPL are rarely increased. The most likely place for meaningful summation to occur is very near the source, and in that case the firing pattern would be included in the simulation and therefore in the exposure estimates.

In sum, neither stand-off distance nor simultaneous firing are of significant concern when estimating exposures using the current criteria.

6.6. Cumulative and Chronic Effects Assessment Framework

6.6.1. Overview

A cumulative sound exposure calculation framework was developed to assist with assessing chronic seismic exploration noise received by marine mammals at a set of ten pre-defined receiver locations (Table 46) in the Gulf of Mexico. This framework is implemented as Excel spreadsheets with scripting to provide a flexible tool for evaluating potential effects of scenarios representing different levels of seismic exploration activity over wide areas of the Gulf of Mexico. The spreadsheets incorporate the results of acoustic modeling of the same 8000 in^3 seismic array and single 90 in^3 airgun that were considered in the broader environmental assessment. Source directivity is accounted for with an azimuthal resolution of 22.5°. Model results are currently available for winter and summer seasons and at three possible receiver depths: 5 m, 30 m and 500 m.

Table 46. Receiver site locations and water depths.

Site #	Receiver Site Name	Latitude	Longitude	Water Depth
1	Western Gulf	27.01606	-95.7405	842
2	Florid Escarpment	25.95807	-84.6956	693
3	Midwestern Gulf	27.43300	-92.1200	830
4	Sperm Whale site	24.34771	-83.7727	1053
5	Deep offshore	27.64026	-87.0285	3050
6	Mississippi Canyon	28.15455	-89.3971	1106
7	Bryde’s Whale site	28.74043	-85.7302	212
8	De Soto Canyon	29.14145	-87.1762	919
9	FGBNMS*	27.86713	-93.8259	88
10	Bottlenose Dolphin Site	29.40526	-93.3247	12

*Flower Garden Banks National Marine Sanctuary

Spreadsheets store the acoustic transmission loss results generated by the parabolic equation model (MONM) used in the broader assessment. The model was used to generate range and direction-dependent transmission loss along radials 150 km long that converge on the receiver sites. The radials are in azimuthal steps of 22.5° and the transmission loss results along each were modeled at the center frequencies of all consecutive 1/3-octave-bands from 10 Hz to 5 kHz. The modeling geometry was implemented using acoustic reciprocity, whereby the model was run with the source and receiver positions interchanged—an efficient approach when there are more potential source sites than receiver sites.

The spreadsheets also contain several sets of frequency weighting coefficients that can be applied to the received levels. Currently the framework supports the Low-Frequency Cetacean (LF1), Mid-Frequency Cetacean (MF1), and High-Frequency Cetacean (HF1) filters as defined by Southall et al. (2007), and the equal-loudness weightings for Low-Frequency Cetaceans (LF2), Mid-Frequency Cetaceans (MF2), and High-Frequency Cetaceans (HF2) as defined by Finneran and Jenkins (2012). It is straightforward to add other weightings by including them in the weighting table spreadsheet.

6.6.2. Method of Use

The spreadsheet scripting initially displays a data entry screen with two panes to the user: one for entering receiver-based and general information, and the other for entering information related to multiple seismic surveys.

The general information pane has four fields:

- Select Frequency Filter: displays a drop-down list of filter types that include unweighted, LFC1, MFC1, HFC1, LFC2, MFC2, HFC2 as described above.
- Select Site: displays a drop-down list of the ten receiver sites (Table 46).
- Receiver Depth: displays a list of the possible depths: 5 m, 30 m, and 500 m. If water depth is less than 30 m or 500 m then those options are listed as n/a.
- Month: current choices are July or December.

The spreadsheet displays information based on the choices made, as shown in this example of the general information pane:

Select Frequency Filter:	**LFC1**	N 28.155	East: 853873	Water depth	Description
Select site:	**Site 6**	W 89.397	North: 3119577	1100 m	Mississippi Canyon - Sperm whales, cryptic deep divers
Receiver depth:	**5 m**				
Month:	**July**	Season:	S3		

The seismic survey entry pane is a multi-line data entry area in which the user can enter information associated with each of the surveys considered. These are the primary inputs for each seismic survey:

- Location: Entered in latitude and longitude in WGS-83 coordinates. The current version of the framework assumes the source is fixed at this location for the duration of the survey, although a single survey can be divided into multiple sub-parts at different locations.
- Array type and operating depth: Selected from a drop-down list. Currently the framework includes an 8000 in^3 airgun array operating at 8 m depth and a 90 in^3 single airgun operating at 4 m depth.
- Duration: The total operating time in seconds. The total cumulative operating time does not include break times. It is used with shot interval to calculate the total number of seismic shots or pulses.
- Shot interval: The time in seconds between each seismic shot or pulse. That typically ranges from 10-20 seconds, but can be shorter in shallow waters. This value is used with survey duration to calculate the number of pulses accounted for in the cumulative sound exposure level calculation.
- Azimuth: The direction, in degrees, relative to true North that the seismic array is towed. 90° is due east. The value is used to select the appropriate direction-dependent source levels.

Up to 50 separate seismic surveys can be entered in the survey entry pane. The spreadsheet automatically computes and displays several other fields in the greyed-out “control numbers” section:

Surveys						Source:		Control numbers:				
#	Active	Lat	Lon	Duration (seconds)	Shot interval (seconds)	Type	Tow azimuth	Number of shots	East	North	Range	Azimuth
1	**yes**	**29.000**	**-89.500**	**864000**	**30.00**	**8000 in³ at 8 m**	**90**	**28800**	841013	3213039	94343	352.2
2	**yes**	**28.000**	**-89.600**	**864000**	**10.00**	**90 in³ at 4 m**	**90**	**86400**	834407	3101864	26318	227.7
3	**yes**	**29.000**	**-91.000**	**864000**	**30.00**	**8000 in³ at 8 m**	**10**	**28800**	694821	3209635	182778	109.5
4	**yes**	**29.000**	**-91.500**	**864000**	**15.00**	**90 in³ at 4 m**	**350**	**57600**	646109	3208913	226156	123.3
5	**yes**	**27.000**	**-89.700**	**864000**	**10.00**	**90 in³ at 4 m**	**350**	**86400**	827517	2990720	131524	21.6
6	**yes**	**27.000**	**-89.800**	**864000**	**30.00**	**8000 in³ at 8 m**	**350**	**28800**	817586	2990464	134115	25.7

The framework contains a separate sheet that displays a map of the first ten survey locations with the receiver locations. The map also shows the currently-selected receiver position, which is displayed using a different symbol than the other receiver positions. This map is help for reviewing survey location values relative to a chosen receiver. An example map is shown in Figure 104.

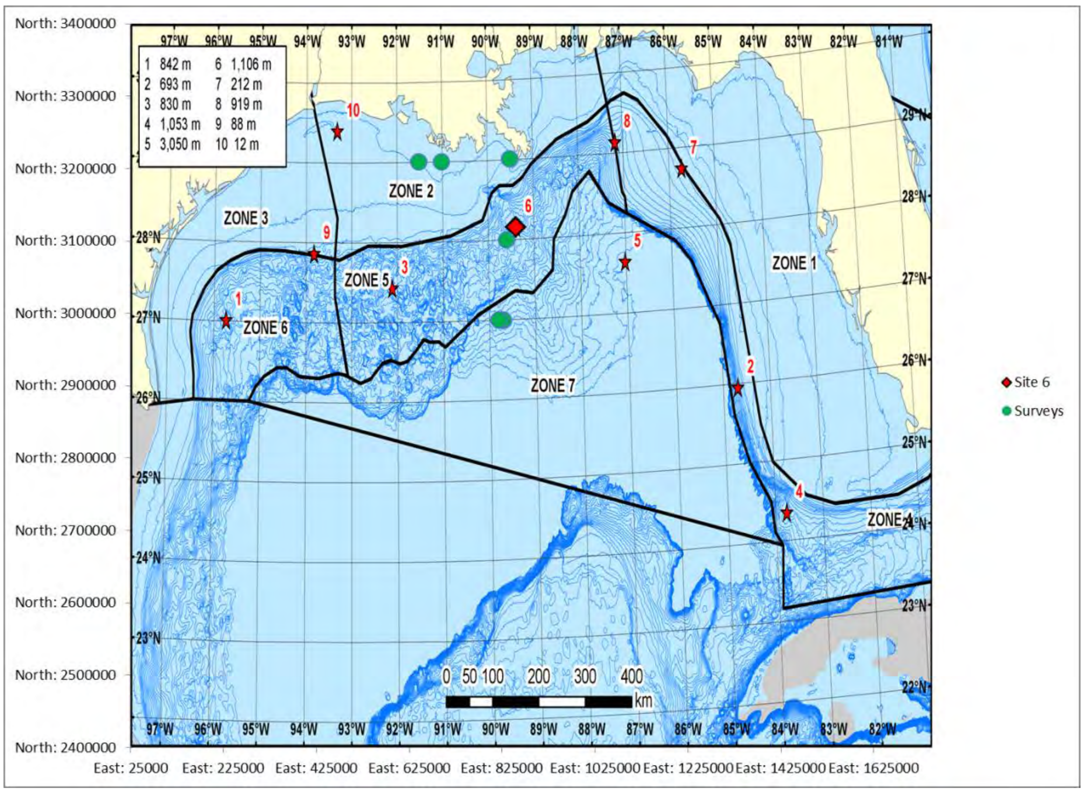


Figure 104. Map automatically produced by the cumulative and chronic effects calculator, showing seismic survey positions and receiver locations. The seismic survey locations are shown as green dots. Receiver stations are shown as red stars, except for the selected receiver which is shown as a red diamond.

6.6.3. Calculator Output

The calculator computes cumulative frequency-weighted sound exposure level (SEL) at a selected receiver location and depth from all shots from all seismic surveys specified. The modeled radial lengths are 150 km, so surveys more distant than that from a receiver will not contribute to the calculated received SEL. The calculator computes the SEL contribution of each survey separately as follows:

5. Looks up the 1/3-octave band per-pulse SEL source levels based on the selected source type and depth, and the calculated direction to the receiver that depends on source and receiver locations and source tow direction.
6. Extracts the appropriate 1/3-octave band transmission loss levels based on the selected source depth and receiver depth and closest modeled radial passing by the source position.
7. Subtracts the transmission losses from the source levels in each frequency band to compute unweighted received per-pulse band levels.
8. Calculates the number of pulses in the survey based on the survey duration and pulse interval, and sums this number of received per-pulse SELs to calculate the unweighted band SEL for the entire survey.
9. Applies the 1/3-octave filter coefficients for the selected filter to the corresponding received band levels for the entire survey.
10. Sums the filtered 1/3-octave band received levels to compute a broadband filtered SEL for the survey as a single number.

The final cumulative frequency-weighted SEL at the receiver from all surveys is the sum of the results of individual surveys. The calculator displays the individual survey SELs and the total exposure. An example of this output is given in the screen capture below (note only the first 13 of 50 surveys is captured in the figure so the total exposure doesn’t match the sum of those displayed):

Total exposure: 161.0 dB re 1 µPa·s²		
Individual survey Exposures		
	Per-pulse	Per-survey
1	81.6	126.2
2	103.7	153.1
3	100.8	145.3
4	63.7	111.3
5	75.5	124.9
6	100.2	144.8
7	99.6	147.2
8	100.8	148.4
9	100.8	150.1
10	100.8	148.4
11	100.8	148.4
12	100.8	148.4
13	100.8	148.4

6.6.4. Discussion

Few studies of cumulative and chronic effects have involved quantitative assessments of the type this framework provides. There are no generally accepted methods for interpreting cumulative SEL in terms of chronic effects, and there are no thresholds defined for this use. In the Gulf of Mexico, seismic surveys continue year-round and, at least in deeper locations, the sounds from distant surveys contribute to a relatively continuous background noise field that is above natural ambient. Superimposed on this background field are the contributions of closer-range seismic surveys that have shorter durations, typically of a few weeks, but those surveys lead to substantially higher sound levels. Initial tests with the framework have shown that seismic surveys close to receivers dominate the received cumulative SEL, which raises questions about how to interpret the results, such as:

- Should chronic effects assessments neglect close-range surveys that produce higher received sound levels, but occur for limited periods, and if so, which surveys should be excluded?
- What errors are introduced by assuming fixed seismic survey locations for surveys that in reality can have large spatial extents that lead to significant received sound level variations?

The cumulative and chronic effects calculator framework developed here is being used to investigate such questions with a goal of developing systematic methods to deal with the issues. The framework will then be applied to assess potential chronic effects from seismic survey noise in the Gulf of Mexico.

7. Phase II: Marine Mammal Exposure Estimates

The goal of Phase II of this study was to estimate the yearly acoustic exposures received by marine mammals to geological and geophysical survey activities in the Gulf of Mexico for the coming decade. Phase I demonstrated and explored the basic methodological approach using agent-based animal movement in simulated sound fields as a Monte Carlo simulation to determine the probability of exposure. The results are specific to the survey simulated. The exact number, location, and configuration of future surveys are unknown, but yearly level-of-effort projections within planning areas for several survey types (including different sources) were provided by BOEM (Table 75). To evaluate the impact of exposure, a 24 h resetting time was chosen such that the received level of each animat was reset to zero after each 24 h evaluation period. In Test Scenario 1, it was found that location-specific characteristics of a survey, such as the acoustic propagation regime (e.g., shelf versus slope) or depth restrictions of animals had the greatest influence on the 24 h exposure estimates (as opposed to inherent modeling constraints, such as replacing animats as they move across the boundaries of the simulation). In Test Scenario 1, a method for scaling up simulation results to account for long-duration surveys was suggested. When using a resetting period (e.g., 24 h) the primary objective was to accurately estimate the average exposure within the reset period by ensuring that the simulation covered the various location-specific environments. The surveys may be conducted at any location within the planning area and occur at any time of the year, so the requirement was to adequately cover each area during the simulations. All survey simulations in Phase II are for 7 days and a sliding window approach was used to get the average 24 h exposure. The 24 h exposure levels were then be scaled by the level of effort for each survey type to calculate the yearly exposure levels.

7.1. Assumptions

In Phase II, the annual marine mammal acoustic exposure associated with geological and geophysical activity in the Gulf for the upcoming decade (2016–2025) used agent-based animal movement in simulated sound fields as Monte Carlo simulations to estimate the probability of exposure. The average number of animals exposed to levels exceeding threshold criteria in 24 h periods was scaled by the level of survey effort to determine the yearly number of potential individuals exceeding threshold for each species. The threshold criteria included the current NMFS criteria for potential injury (Level A harassment) and potential behavioral disruption (Level B harassment), and criteria for potentially injurious exposure based on Southall et al. (2007) and step-function criteria based on Wood et al. (2012) to evaluate potential behavioral disruption.

The situations simulated are complex and evolving. The time period evaluated was 10 years of future survey efforts using representative surveys whose precise design, location, and time of performance are not known. There is presently a great of variety in survey and source configurations, and new configurations, sources, or use of sources are likely to be developed. The details of marine mammal density, distributions, and behavior patterns are imprecisely known and change as animal populations vary from year to year and location to location.

When modeling complex situations with imperfect and incomplete data, assumptions must be made. When possible, the most representative data or methods were used. When necessary, the choices were made to be conservative, i.e., were expected to produce an overestimate. Conservative assumptions in the Phase II modeling procedures include:

- Environment parameters for acoustic propagation modeling: The environmental input parameters used for transmission loss modeling were from databases that provide averaged values with limited spatial and temporal resolution. Sound speed profiles are averaged seasonal values taken from many sample locations. Geoacoustic parameters (including sediment type, thickness, and reflectivity coefficients) and bathymetric grids are smoothed and averaged to characterize large regions of the seafloor. Local variability, which can be effected by weather, daily temperature cycles, and small-scale surface and sediment details, generally increases signal transmission loss, but was removed by these averaging processes. As a result, the transmission loss could in some cases be underestimated and, therefore, the received levels would be overestimated.

- Acoustic propagation modeling: The acoustic propagation model, MONM, used the horizontal-direction source level for all vertical angles. This may slightly underestimate the true sound levels in the vertical directional beam of the array that ensonifies a zone directly under the array. This is expected to be a minor effect given the small volume over which the reduction occurs. Additionally, there is a steep angle limitation in the parabolic equation (PE) model used in MONM that also leads to slightly reduced levels directly under the array. The wide-angle PE that is used in MONMN is accurate to at least 70 degrees. The reduced-level zone is a cone within a cone few degrees of vertical, which represents a relatively small water volume that should not significantly affect results.
- Acoustic filtering: Auditory weighting functions were used to filter the SEL and rms SPL sound fields. Type II M-weighting based on equal loudness perception (Finneran and Jenkins 2012) was used to filter the SEL sound field used to evaluate potential injury. Type I M-weighting (Southall et al. 2007) was used to filter the rms SPL sound fields that, primarily, were used to evaluate behavior. Type I and Type II M-weighting are approximations of the hearing ability of different species groups. As approximations, they do not necessarily represent any one individual animal. Type I M-weighting was meant as a conservative filter to account for the expected hearing range of the species groups (Southall et al. 2007). The use of Type I filtering is a conservative choice because these filter roll-off at high and low frequencies admit more sound energy than the corresponding audiograms would suggest.
- Seasons modeled: To account for seasonal variation in propagation, winter (most conservative) and summer (least conservative) were both used to calculate exposure estimates. Propagation during spring and fall was found to be almost identical to the results for summer, so those seasons were represented with the summer results.
- Social grouping: Marine mammals often form social groups, or pods, that may number in the hundreds of animals. Although it was found that group size effects the distribution of the exposure estimates, the mean value of the exposure estimate was, generally, unchanged. Because the annual exposure estimates are meant to represent the aggregate of many surveys conducted in many locations at various times throughout the year, it is the mean exposure estimates that are most relevant. For this reason, social group size was not included in the exposure estimates.
- Mitigation: Mitigation procedures, such as shutting down an airgun array when animals are detected within an established exclusion zone, can reduce the injury exposure estimates. Mitigation effectiveness was found to be influenced by several factors, most importantly the ability to detect the animals within the exclusion zone. Some species are more easily detected than others, and detection probability varies with weather and observational set up. Weather during any seismic survey is unknown beforehand and detection probabilities are difficult to predict, so the effects of mitigation were not included in the exposure estimates.
- Aversion: Aversion is a context-dependent behavioral response affected by biological factors, including energetic and reproductive state, sociality, and health status of individual animals. Animals may avoid loud or annoying sounds, which could reduce exposure levels. Currently, too little is known about the factors that lead to avoidance (or attraction) of sounds to include aversive behavior in the exposure estimates.

7.2. Phase II Modeling Methods

7.2.1. Acoustic Source Parameters

7.2.1.1. Airgun Array—8000 in^3

The airgun array parameters Phase II were the same as those used in the Test Case (Section 6.1).

7.2.1.2. Single Airgun—90 in^3

This acoustic source consists of a single Sercel airgun with a working firing volume of 90 in^3. This source was used in a high-resolution geotechnical survey. The modeling assumed a tow depth of 4 m for the airgun, which was typical for this source type. The model assumed an operating pressure of 2000 psi.

7.2.1.3. Boomer

The representative boomer system for geotechnical survey operations was the Applied Acoustics AA301, based on a single plate with ~ 40 cm baffle diameter. Since the boomer plate has a circular piston surrounded by a rigid baffle, it has acoustic directivity and cannot be considered a point-like source (Verbeek and McGee 1995). The beam pattern of a boomer plate shows directivity for frequencies above 1 kHz. The input energy for the AA301 boomer plate was up to 350 J per pulse or 1,000 J per second. The width of the pulse was 0.15–0.4 ms.

Source: Applied Acoustic Engineering Limited. Accessed January 2015

A source verification study was performed on a system similar to the AA301, the AP3000 system (Martin et al. 2012), which has a double-plate configuration operating at maximum input energy of 1,000 J. During the Martin et al. (2012) study, acoustic data were collected as close as 8 m to the source and directly below it. The data showed that the broadband source level for the system was 203.3 dB 1 μPa @ 1 m rms SPL over a 0.2 ms window length and 172.6 dB re 1 $\mu Pa^2 \cdot s$ @ 1 m SEL. Data from the AP3000 were used in this study for modeling the boomer source.

7.2.1.4. High Resolution Survey Sources

An autonomous underwater vehicle (AUV) may be used when performing high-resolution geotechnical surveys. Three types of survey equipment may be installed on the AUV:

- Multibeam echosounder
- Side-scan sonar
- Sub-bottom profiler

All three sources can operate concurrently, and typically do, although there may be times when one or two of the three is off. In our modeling, we assume that all three were operated concurrently. When sources were towed, the towing depth of the AUV was 4 m below the sea surface when the water depth was less than 100 m, and 40 m above the seafloor where water depth was more than 100 m. High resolution geophysical surveys are not always towed by an AUV, but in this modeling effort, the sources were assumed to be towed by an AUV.

7.2.1.4.1. Multibeam Echosounder—Simrad EM2000

The representative multibeam echosounder system for geotechnical survey operations was the Simrad EM2000 (manufactured by Kongsberg Maritime AS). This device operates at 200 kHz (Kongsberg 2004). The system is equipped with an SM2000 transducer head that produces a single beam 17°× 88° wide. The multibeam forming occurs through receiving head and processing software. The nominal source level was 204 dB re 1 μPa @ 1 m. The per-pulse SEL depends on the pulse length.

Operational parameters of the Simrad EM2000 multibeam echosounder system (Kongsberg 2004) are:

- Operating frequency: 200 kHz
- Beam width: 17°× 88°
- Beam: 1 (straight down)
- rms SPL: 203 dB re 1 μPa @ 1 m
- Pulse length: 0.04–1.3 ms
- Per pulse SEL: 160–175 dB re 1 $\mu Pa^2 \cdot s$ @ 1 m

7.2.1.4.2. Side-scan Sonar—EdgeTech 2200 IM

EdgeTech 2200 IM was a representative modular system designed for installation on an AUV. The system features full spectrum chirp side-scan capabilities that work at two frequencies concurrently, 120 and 410 kHz. The side-scan sonar uses two side-mounted rectangular transducers, whose declination angle can be adjusted from 10° to 20° below the horizontal plain. The produced beam angle was 70° × 0.8° at 120 kHz and 70° × 0.5° at 410 kHz. At 120 kHz, we estimated the peak level at 210 dB re 1 μPa @ 1 m; at 410 kHz, we estimated the peak level at 216 dB re 1 μPa @ 1 m (EdgeTech 2007). The pulse length was 8.3 ms at 120 kHz and 2.4 ms at 410 kHz.

7.2.1.4.3. Sub-bottom Profiler—EdgeTech 2200 IM with DW−424

EdgeTech 2200 IM was a representative modular system designed for installation on an AUV. The system features DW−424, a full spectrum chirp sub-bottom profiler that produces a sweep signal in the frequency range from 4 to 24 kHz. The transmitter is a circular transducer directed straight down. The projected beamwidth varies from 15° to 25° depending on the emitted frequency. The source level was 200 dB re 1 μPa @ 1 m (EdgeTech 2007). The pulse length was 10 ms.

7.2.2. Survey Patterns

To estimate exposures, we considered two major survey types:

- Large area seismic
- Small-area, high-resolution geotechnical study

The primary differences between each survey were the energy of the sources, the size of the areas, and the density of the tracks.

Large area seismic surveys cover more than 1,000 square miles and include 2-D, 3-D NAZ, 3-D WAZ, and Coil types. An 8000 in^3 airgun array was the primary source for the large area seismic surveys. The large surveys use a survey vessel with an average speed of 4.5–5 knots; it travels 200–220 linear km per day. No mitigation airguns were modeled, and airgun arrays were off during turns.

Geotechnical study surveys cover an area less than 100 mi^2 and use small airgun arrays (20–90 in^3) and/or high-frequency electromechanical sources (sonars) installed on an AUV. The high resolution sources included a side-scan sonar, a sub-bottom profiler, and a multibeam echosounder. The survey vessel used in the large surveys travels at an average speed of 4 kts; it transits 180 km per day.

Although parameters of the actual surveys could vary from one survey to the other, we selected specific parameters to model based on specifications provided by BOEM. The subsections herein describe the parameters of each survey type as they were modeled for Phase II.

Table 47. Summary of the Phase II surveys considered to determine the exposure estimates. The high resolution sources were modeled independently.

Survey type	Area	Source	Production lines lateral offset (km)
2-D	10 × 30 blocks 48 × 145 km 2700 mi^2	1 × 8000 in^3	4.8
3-D NAZ		2 × 8000 in^3	1
3-D WAZ		4 × 8000 in^3	1.2
Coil	12 × 12 blocks 58 × 58 km 1300 mi^2	4 × 8000 in^3	not applicable
Geotechnical	1 × 3 blocks 5 × 14.5 km 27 mi^2	1 × 90 in^3 high resolution sources	0.03

The survey schematics indicate the survey area (black rectangle) and vessel tracks. The tracks for different vessel are shown with different colors. To simplify the track design for the surveys using a racetrack fill-in method, the actual circular turn track was substituted with three straight legs: run-out, offset, and run-in sections. The run-in and run-out sections were 1 km long and extend beyond the survey area.

7.2.2.1. 2-D Seismic Survey

The 2-D seismic survey was performed with a single vessel towing a single large seismic array. The lateral spacing of the production lines was 4.8 km (Figure 105). The production lines were filled in with a racetrack fill-in method, skipping two tracks on the left side turn (15 km wide turn) and transitioning on to the adjacent line on the right side turn (5 km wide turn). Seven days of survey were simulated. The vessel speed was 4.5 kts (2.3 m/s). The shot interval was 21.6 s (50 m). The total length of the simulated track was ~ 1400 km. The number of simulated pulses was ~ 28,000. Constant towing azimuth, parallel to the long side of the survey box, was modeled for all shots.

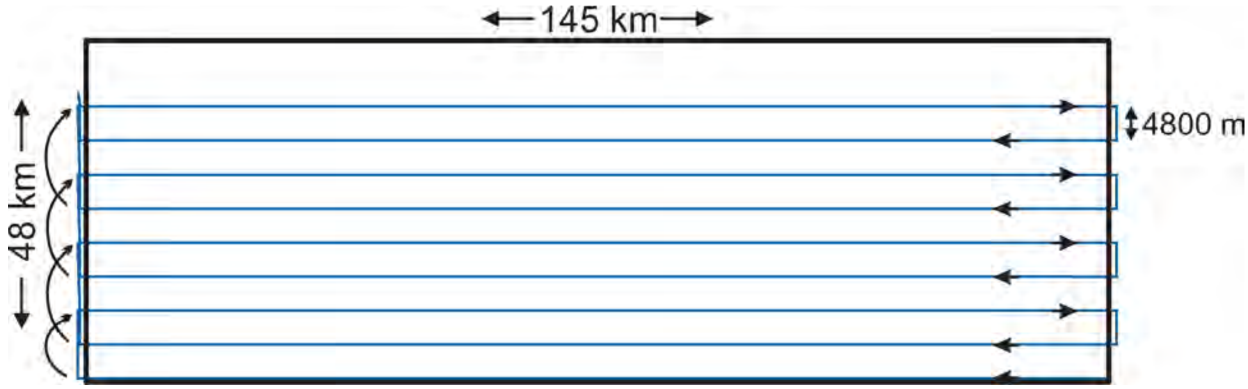


Figure 105. Simulated portion of the track for the 2-D seismic survey.

7.2.2.2. 3-D Narrow Azimuth Seismic Survey

The 3-D NAZ seismic survey was performed with one or two vessels towing two identical large seismic arrays. The sources towed by the same vessel were operated in a flip-flop mode, i.e., for each shot position only one of the two produces a seismic pulse. In the two-vessel option, sources at each vessel produce seismic pulses simultaneously. The two-vessel option was simulated. Both vessels follow the same track, but were separated along the track by 6,000 m. The production lines were laterally spaced by 1 km (Figure 106). The production lines were filled via a racetrack fill-in method with eight loops in each racetrack (7–8 km wide turn). Forty-nine lines were required to fully cover the survey area. The 7-day simulation covered ~ 20% of the complete survey. The vessel speed was 4.9 kts (2.5 m/s). The shot interval was 15 s (37.5 m) for each vessel. The total length of the simulated track was ~ 1500 km. The number of simulated pulses was ~ 80,000.

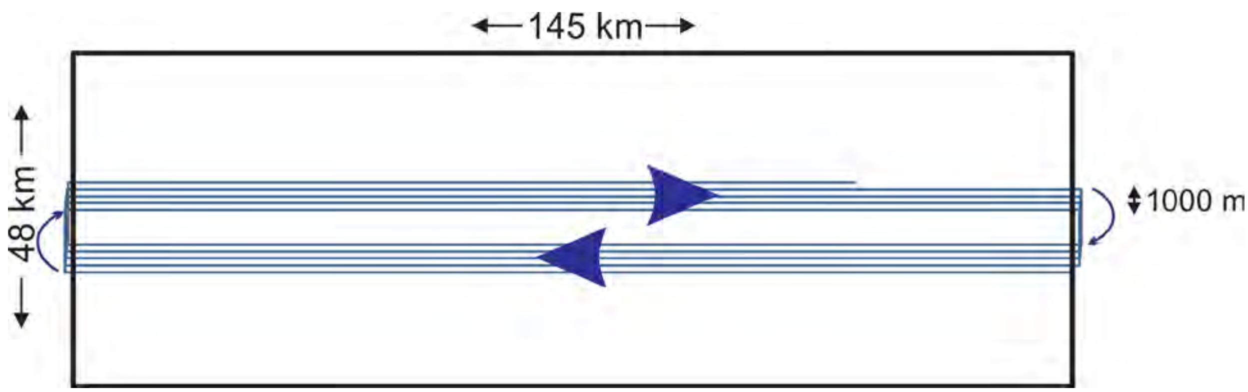


Figure 106. Simulated portion of the track for the 3-D NAZ seismic survey.

7.2.2.3. 3-D Wide Azimuth Seismic Survey

The3-D WAZ seismic survey was performed with multiple vessels traveling along parallel tracks with some lateral and along the track offsets. The four-vessel option with seismic sources firing sequentially was simulated. The tracks of each vessel had the same geometry and had 1,200 m lateral offset. The vessels also had 500 m offset along the track. The lateral spacing of the same vessel's production lines was 4.8 km and 1.2 km for the group (Figure 107). The production lines were filled in with a racetrack fill-in method with two loops in each racetrack (9.6 km wide turn). Forty lines were required to fully cover the survey area. The 7-day simulation covered ~ 85% of the complete survey. The vessel speed was

4.5 kts (2.3 m/s). The shot interval was 86.4 s (200 m) for each vessel or 21.6 for the group. The total length of the simulated track was ~ 1400 km. The number of simulated pulses was ~ 28,000.

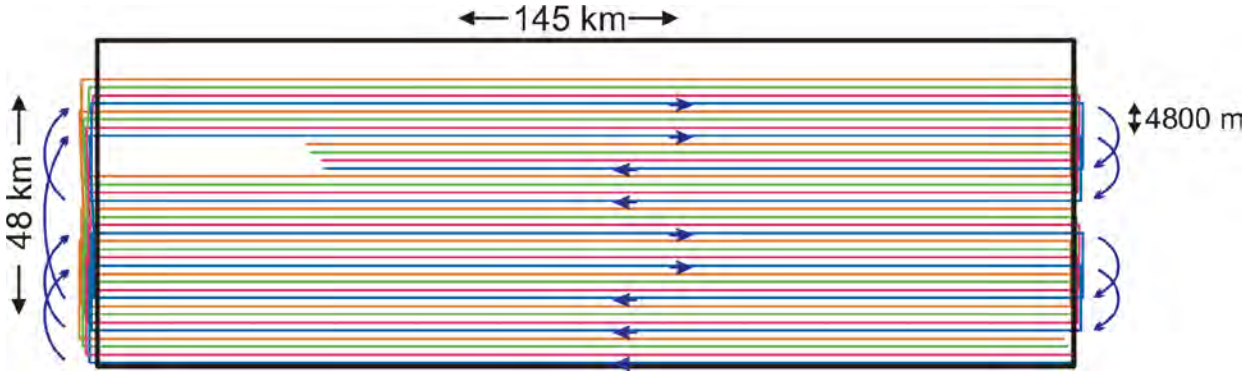


Figure 107. Simulated portion of the track for the 3-D WAZ seismic survey.

7.2.2.4. Coil Seismic Survey

The Coil seismic survey was performed by multiple vessels that sailed a series of circular tracks with some angular separation while towing sources. The four-vessel option was simulated assuming simultaneous firing, and the track consisted of a series of circles with 12.5 km diameter (Figure 108). Once the vessel completes a full circle, it advanced to the next one along a tangential connection segment. The offset between the center of one circle and the next, either along-swath or between swaths, was 5 km. The full survey geometry consisted of two tracks with identical configuration with 1,200 m and 600 m offsets along X and Y directions, respectively. Two of the four vessels followed the first track with 180° separation; the other two vessels followed the second track with 180° separation relative to each other and 90° separation relative to the first pair. One hundred circles per vessel pair were required to fully cover the survey area. The 7-day simulation covered ~ 30% of the complete survey. The vessel speed was 4.9 kts (2.5 m/s). The shot interval was 20 s (50 m) for each vessel. The total length of the simulated track was ~ 1,500 km. The number of simulated pulses was ~ 120,000.

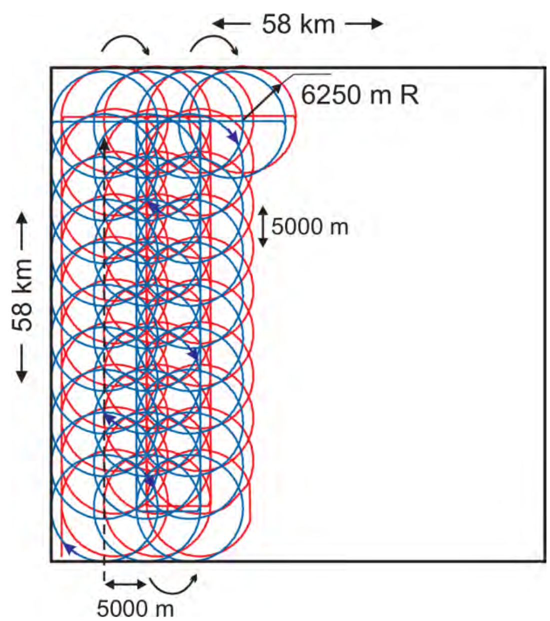


Figure 108. Simulated portion of the track for the Coil seismic survey.

7.2.2.5. High Resolution Geotechnical Survey

The geotechnical survey was performed in a similar fashion as the 2-D and 3-D surveys, only on significantly smaller survey areas and with denser production lines.

A single vessel survey was considered for the simulation, towing either a 90 in³ airgun or a high resolution source equipped with a side-scan sonar, a sub-bottom profiler, and a multibeam echosounder. Production lines were laterally spaced 30 m (Figure 109) then filled in with a racetrack fill-in method where each racetrack has 20 loops (1.2 km wide turn). One hundred and sixty lines were required to fully cover the survey area. The 7-day simulation covered ~ 50% of the complete survey. The vessel speed was 4 kts (2 m/s). The shot interval was 10 s (20 m). The total length of the simulated track was ~ 1260 km. The number of simulated pulses was ~ 60,000.

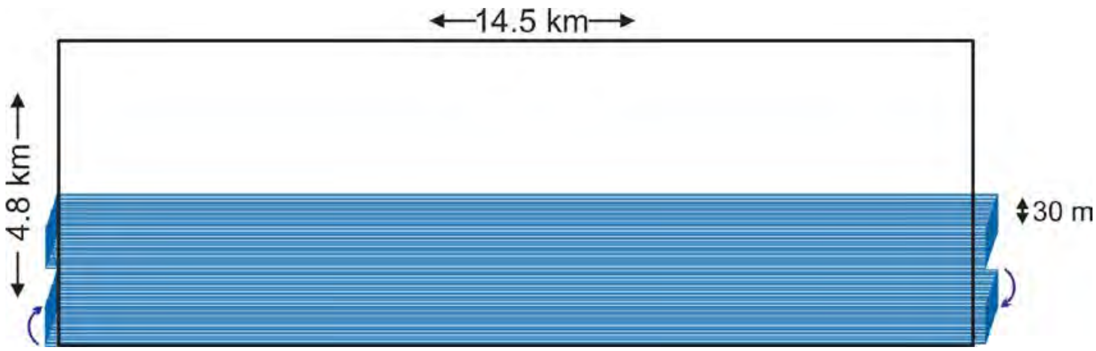


Figure 109. Simulated portion of the track for the geotechnical survey.

7.2.3. Choice of Zone Boundaries

The size and shape of acoustic footprints from exploration surveys in the Gulf of Mexico are influenced by many parameters, but the strongest influencers are water depth and seabed slope. We divided the project area into three main bathymetric areas Shelf, Slope, and Deep. The Shelf extend from shore to 100–200 m depths, where bathymetric relief is gradual; water depths on the continental shelf off Florida's eastern coast are less than 200 m deep out to ~ 150 km from shore. The Slope starts at the Shelf's outer boundary and extends into deeper water where the seabed relief is steeper and water deepens from 100–200 m to 1500–2500 m over as little as a 50 km horizontal distance. The Slope ends at the Deep area, where, although water depths are more consistent than in the other areas, depths can vary from 2000–3300 m. The subdivision depth definitions are Shelf: 0–200 m, Slope 200–2000 m, and Deep: > 2000 m.

Water depth influences species distribution in that there are distinctions from Shelf to Slope and from Slope to Deep. The maps in Appendix A show marine mammal distribution information from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation; Section 7.2.6) and the subdivision depth boundary contours. The subdivision depths were chosen so that nominal marine mammal densities remain relatively constant over the resulting depth intervals. While different species prefer different depths, there are optimal depth breaks based on density distribution for the majority of species considered. The density of several species varies within the Shelf and Slope areas, but less so within the Deep area. Interestingly, the variation in animal density within the Shelf and Slope areas seems correlated with the orientation and differences in the widths of these areas over the east-west extent of the project area. The western region is characterized by a relatively narrow shelf and moderate-width slope. The central region has a moderate-width shelf and moderate-width slope, and the eastern region has a wide shelf and a very narrow slope. Because of these differences, areas were further division into lateral regions, which align with the previously defined BOEM Planning Area boundaries: West, Central, and East, was made in the Shelf and Slope areas.

Based on the physical properties of the project area and the distribution of its marine inhabitants, we divided the Gulf into 7 zones: 3 Shelf zones, 3 Slope zones, and 1 Deep zone. The southern edge of the Deep zone is defined by the U.S. Exclusive Economic Zone (EEZ) boundary. The zones boundaries were defined by the 200 and 2000 m depth contours and the east-west boundary lines of BOEM's Planning Areas (except for the Deep zone 7, which included portions of all three Planning Areas). The seven modeling zones, labelled "zones" are shown in Figure 110 along with the seven representative simulation locations—the numbered rectangles—which are discussed in the next section.

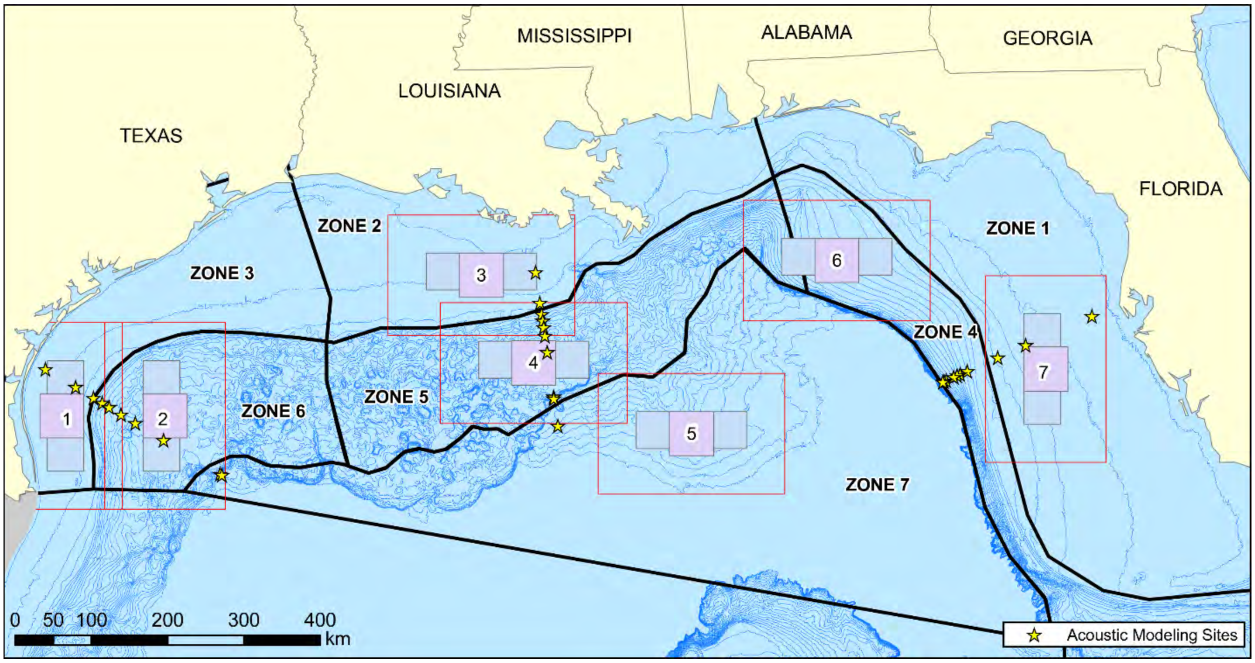


Figure 110. Gulf of Mexico project area. Black lines delineate the zones. Large, red rectangular boxes show the animal simulation extents for seismic surveys. Gray rectangles are the survey area extents for the 2-D and 3-D surveys. Pink squares are the survey extents of Coil surveys. Yellow stars show the acoustic modeling sites are along West, Central, and East transects.

7.2.3.1. Survey Extents

Within each of the seven zones, we defined a set of representative survey-simulation rectangles for each of the survey types discussed in Section 7.2.2. To avoid clutter in the diagram, Figure 110 shows the rectangles for the largest area surveys (2-D, 3-D, and Coil). Smaller area surveys (geotechnical surveys) were modeled near the center of the larger area surveys. During the seismic survey simulation, the source was moved within these rectangles. The sound produced, however, would ensonify an area larger than the rectangle. The corresponding animat simulation extents are shown as large, red boxes (Figure 110) and are discussed in more detail in Section 7.2.5.

7.2.3.2. Acoustic Modeling Sites

As the acoustic energy from a source propagates, it is subject to a number of marine acoustic effects that depend on the ocean and bottom environment (see Section 5.2). We selected a set of 30 sites to calculate acoustic propagation loss grids as functions of source, range from the source, azimuth from the source, and receiver depth. We then used these grids as inputs to the acoustic exposure model. The 30 modeling sites (yellow stars in Figure 110) were grouped into three transects—Western, Central, and Eastern. The detailed geographic coordinates and water column depth of each acoustic modeling site are listed in

Tables 48–51 for each transect. The coordinates of the center of survey locations are shown in Table 51. Even though these 30 modeling sites were not all located within the survey extents (boxes) discussed in the previous section, and Boxes 5 and 6 do not contain any individual modeling sites, the environmental parameters and acoustic propagation conditions represented by these 30 modeling sites were chosen to be representative of the prevalent acoustic propagation conditions within the survey extents (boxes).

Table 48. Modeling sites along the West transect.

Region	Site	Geographic coordinates	UTM Zone 15 coordinates		Water depth at source (m)
West-Shelf	WS1	27° 24.77′ N 97° 5.78′ W	3038833 N	94877 E	25
	WS2	27° 12.59′ N 96° 41.28′ W	3015053 N	134623 E	75
	WS3	27° 5.40′ N 96° 26.93′ W	3001087 N	157967 E	150
West-Slope	WM1	27° 1.94′ N 96° 20.06′ W	2994389 N	169162 E	300
	WM2	26° 59.07′ N 96° 14.39′ W	2988854 N	178414 E	500
	WM3	26° 54.23′ N 96° 4.82′ W	2979509 N	194032 E	750
	WM4	26° 48.37′ N 95° 53.29′ W	2968231 N	212884 E	1000
	WM5	26° 36.82′ N 95° 30.73′ W	2946105 N	249866 E	1500
West-Deep	WD1	26° 13.56′ N 94° 45.86′ W	2901905 N	323744 E	2000
	WD2	26° 12.73′ N 94° 44.29′ W	2900349 N	326344 E	2500

In the site names, S denotes a Shelf site, M a Slope (middle) site, and D a deep site.

Table 49. Modeling sites along Central transect.

Region	Site	Geographic coordinates	UTM Zone 15 coordinates		Water depth at source (m)
Central-Shelf	CS1	28° 35.84′ N 90° 34.27′ W	3165787 N	737510 E	25
	CS2	28° 14.08′ N 90° 31.20′ W	3125696 N	743350 E	75
	CS3	28° 6.06′ N 90° 30.07′ W	3110922 N	745502 E	150
Central-Slope	CM1	28° 1.19′ N 90° 29.39′ W	3101933 N	746812 E	300
	CM2	27° 56.60′ N 90° 28.74′ W	3093482 N	748043 E	500
	CM3	27° 50.68′ N 90° 27.91′ W	3082567 N	749633 E	750
	CM4	27° 39.14′ N 90° 26.30′ W	3061316 N	752729 E	1000
	CM5	27° 7.28′ N 90° 21.85′ W	3002614 N	761280 E	1500
Central-Deep	CD1	27° 5.87′ N 90° 21.66′ W	3000015 N	761658 E	2000
	CD2	26° 46.56′ N 90° 18.98′ W	2964438 N	766841 E	2500

In the site names, S denotes a Shelf site, M a Slope (middle) site, and D a deep site.

Table 50. Modeling sites along East transect.

Region	Site	Geographic coordinates	UTM Zone 15 coordinates		Water depth at source (m)
East-Shelf	ES1	27° 45.04′ N 83° 12.99′ W	3108253 N	1466813 E	25
	ES2	27° 28.13′ N 84° 6.79′ W	3070008 N	1380052 E	75
	ES3	27° 20.87′ N 84° 29.42′ W	3053885 N	1343477 E	150
East-Slope	EM1	27° 12.89′ N 84° 54.04′ W	3036311 N	1303609 E	300
	EM2	27° 10.97′ N 84° 59.89′ W	3032133 N	1294132 E	500
	EM3	27° 10.13′ N 85° 2.47′ W	3030284 N	1289936 E	750
	EM4	27° 9.30′ N 85° 5.00′ W	3028478 N	1285839 E	1000
	EM5	27° 7.24′ N 85° 11.27′ W	3023996 N	1275672 E	1500
East-Deep	ED1	27° 6.69′ N 85° 12.93′ W	3022805 N	1272969 E	2000
	ED2	27° 6.40′ N 85° 13.79′ W	3022193 N	1271580 E	2500

In the site names, S denotes a Shelf site, M a Slope (middle) site, and D a deep site.

Table 51. Center coordinates of survey boxes.

Box	Geographic coordinates	UTM Zone 15 coordinates		Water depth at source (m)
1	26° 51.96′ N 96° 47.61′ W	2977239 N	123022 E	70
2	26° 53.66′ N 95° 31.78′ W	2977239 N	248731 E	1400
3	28° 36.94′ N 91° 17.84′ W	3166579 N	666464 E	30
4	27° 34.03′ N 90° 37.10′ W	3051524 N	735128 E	1000
5	26° 40.82′ N 88° 33.67′ W	2958720 N	941905 E	2400
6	28° 38.72′ N 86° 32.18′ W	3185841 N	1132432 E	500
7	27° 10.49′ N 83° 54.20′ W	3038730 N	1403352 E	70

7.2.4. Environmental Parameters

7.2.4.1. Bathymetry

Water depths throughout the modeled area were obtained from the National Geophysical Data Center’s U.S. Coastal Relief Model l (NGDC 2014) that extends up to about 200 km from the U.S. coast. These bathymetry data have a resolution of 3 arc-seconds (~ 80 × 90 m at the studied latitude). Bathymetry data for an area were extracted and re-gridded, using the minimum curvature method, onto a Universal Transverse Mercator (UTM) Zone 15 coordinate projection with a horizontal resolution of 50 × 50 m.

Two bathymetry grids were used for modeling. The first covered the West region (Boxes 1 and 2 in Figure 110); the second covered Central and East regions (Boxes 3–7 in Figure 110).

7.2.4.2. Multi-Layer Geoacoustic Profile

The top sections of the sediment cover in the Gulf of Mexico are represented by layers of unconsolidated sediments at least several hundred meters thick. The grain size of the surficial sediments follows the general trend for the sedimentary basins: the grain size of the deposited sediments decreases with the distance from the shore. For the Shelf zone, the general surficial bottom type was assumed to be sand, for the Slope zone silt, and for the Deep zone clay. In constructing a geoacoustic model for input to MONM (see 6.5.2.1.5 for required input parameters), a median value of φ was selected for each sediment type with the exception of the geoacoustic profile for the East-Shelf area. Because the grain size of the surficial sediment offshore Florida is consistently larger than in other shelf areas (Figure 50), we assumed φ equal to 1 for the sand in this zone.

Four sets of geoacoustic parameters were used in the acoustic propagation modeling:

- Center-West Shelf (Table 52)
- East Shelf (Table 53)
- Slope (Table 54)
- Deep (Table 55)

Table 52. Shelf zone Center and West: Geoacoustic properties of the sub-bottom sediments as a function of depth, in meters below the seafloor (mbsf), for fine sand. Within each depth range, each parameter varies linearly within the stated range.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–20	Sand *φ=2*	1.61	1610	0.62	200	0.76
20–50		1.7	1900	1.44		
50–200		1.78	2090	1.77		
200–600		1.87	2500	2.31		
> 600		2.04	2500	2.67		

Table 53. Shelf zone East: Geoacoustic properties of the sub-bottom sediments as a function of depth, in meters below the seafloor (mbsf), for medium-sand. Within each depth range, each parameter varies linearly within the stated range.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–20	Sand *φ=1*	1.7	1660	0.76	200	1.13
20–50		1.78	2040	1.68		
50–200		1.87	2290	2.03		
200–600		1.96	2500	2.56		
> 600		2.04	2500	2.91		

Table 54. Slope zone: Geoacoustic properties of the sub-bottom sediments as a function of depth, in meters below the seafloor (mbsf), for medium silt. Within each depth range, each parameter varies linearly within the stated range.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–20	Silt *φ=6*	1.44	1515	0.33	150	0.22
20–50		1.7	1670	0.82		
50–200		1.7	1750	1.07		
200–600		1.87	1970	1.48		
> 600		2.04	2260	1.82		

Table 55. Deep zone: Geoacoustic properties of the sub-bottom sediments as a function of depth, in meters below the seafloor (mbsf), for medium clay. Within each depth range, each parameter varies linearly within the stated range.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0–20	Clay *φ=9*	1.52	1472	0.17	100	0.06
20–50		1.7	1560	0.43		
50–200		1.78	1610	0.56		
200–600		1.87	1720	0.83		
> 600		2.04	1890	1.05		

7.2.4.3. Sound Speed Profiles

The sound speed profiles for the modeled sites were derived using the same source and method as described in Section 6.2.4.

We investigated variation in the sound speed profile throughout the year and produced a set of 12 sound speed profiles, each representing one month, in the Shelf, Slope, and Deep zones (Figure 111). The set was divided into four seasons:

- Season 1: January, February, and March
- Season 2: April, May, and June
- Season 3: July, August, and September
- Season 4: October, November, and December

For each zone, a month was selected to represent the propagation conditions in the water column in each season (Table 56).

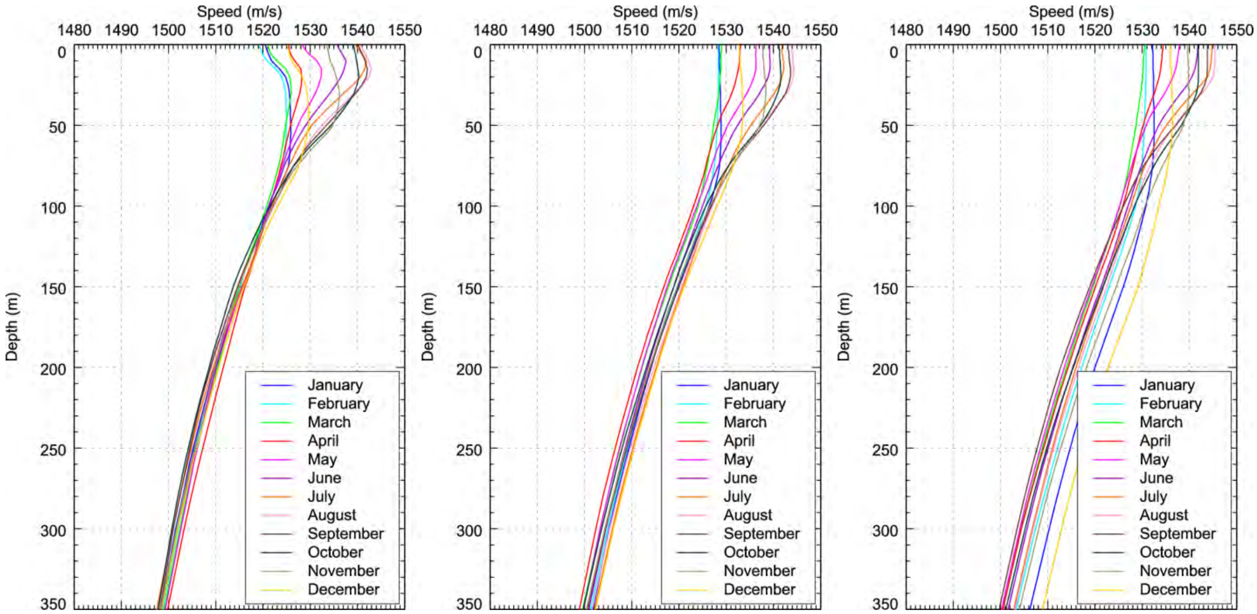


Figure 111. Sound speed profiles at the (left) Shelf, (center) Slope, and (right) Deep zones, derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

Table 56. Representative months for each season and modeling zone.

Zone	SSP GDEM location	Season 1 (Jan-Mar)	Season 2 (Apr-Jun)	Season 3 (Jul-Sep)	Season 4 (Oct-Dec)
Shelf	25.5° N 90° W			Aug	Oct
Slope	27.25° N 90° W	Feb	May	Sep	Nov
Deep	28.5° N 90° W			Aug	Dec

ssp=sound speed profile

Acoustic fields were modeled using sound speed profiles for Season 1 and Season 3, and all three regions—East, Central, and West—used the same month. Profiles for Season 1 (February) provided the most conservative propagation environment because a surface duct, caused by upward refraction in the top 50–75 m, was present. Although a surface duct of this depth will not be able to prevent leakage of frequencies below 500–250 Hz (respectively), the ducting of frequencies above this cut off is important because these are the frequencies to which most marine mammals are most sensitive and the horizontal far-field acoustic projection from the airgun array seismic sources do have significant energy in this part of the spectrum. The modeling results obtained when the duct was present, therefore, represent the most precautionary propagation environment. Profiles for Season 3 (August or September) provided the least conservative results because they have weak to no sound channels at the surface and are strongly downward refracting in the top 200 m. Only the top 100 m of the water column are affected by the seasonal variation in the sound speed.

The possibility of separately modeling the spring and fall seasons was investigated; however, the results for spring and fall are almost identical to the results for summer, which were used as a proxy for the spring and fall results.

7.2.4.3.1. Sound Speed Profiles for Box Centers

Sound speed profiles were gathered from the center of each modeling box for Seasons 1 and 3. Table 57 presents the months modeled for each of these seasons. Figures 112 and 113 show the sound speed profiles for Seasons 1 and 3, respectively.

Table 57. Modeling seasons for each box.

Box	Region	Zone	Season 1	Season 3
1	West	Shelf	Feb	Aug
2		Slope		Sep
3	Central	Shelf		Aug
4		Slope		Sep
5		Deep		Aug
6	East	Slope		Sep
7		Shelf		Aug

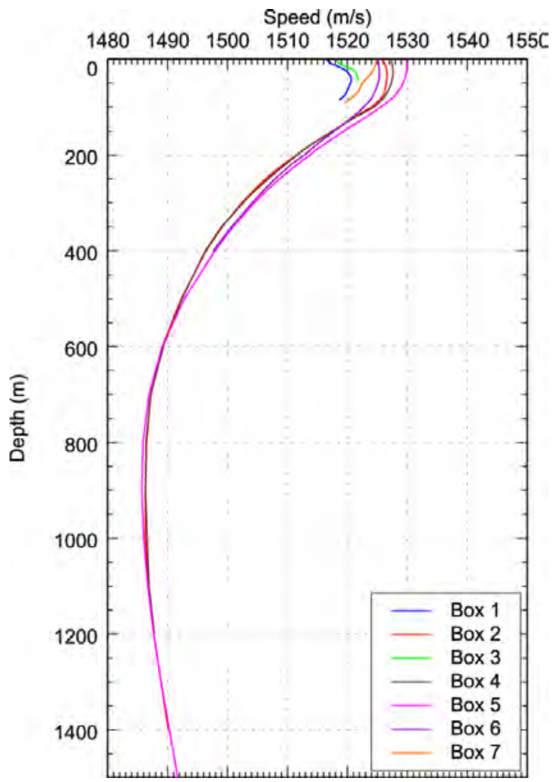


Figure 112. Sound speed profiles at modeling boxes, Season 1, derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

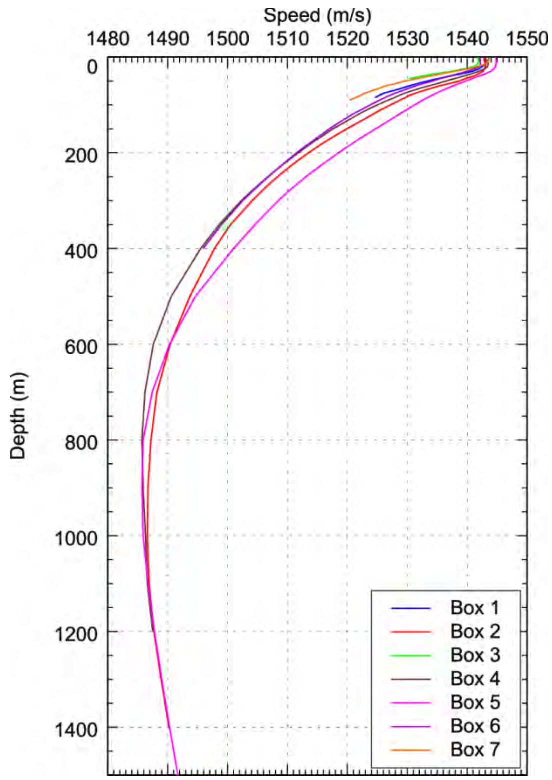


Figure 113. Sound speed profiles at modeling boxes, Season 3, derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

7.2.4.3.2. Sound Speed Profiles for Acoustic Modeling Sites along Transects

Sound speed profiles were obtained at three locations along each transect. Profiles were selected for Season 1 and Season 3. The months modeled for each season are presented in Table 58. Figures 114–116, show the sound speed profiles for transects in the West, Central, and East regions respectively.

Table 58. Modeling seasons for the sites along transects.

Region	Zone	Season 1	Season 3
	Shelf		Aug
West	Slope		Sep
	Shelf		Aug
	Shelf		Aug
Central	Slope	Feb	Sep
	Shelf		Aug
	Shelf		Aug
East	Slope		Sep
	Deep		Aug

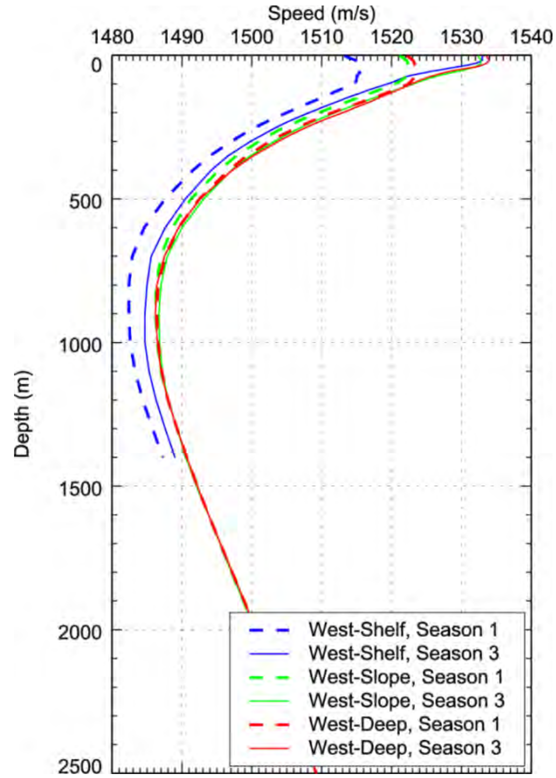


Figure 114. Sound speed profiles along the West transect, derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

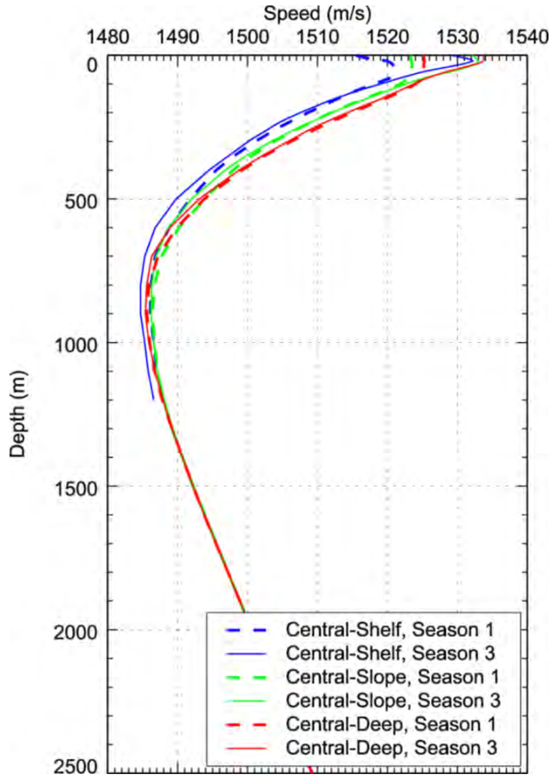


Figure 115. Sound speed profiles along Central transect, derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

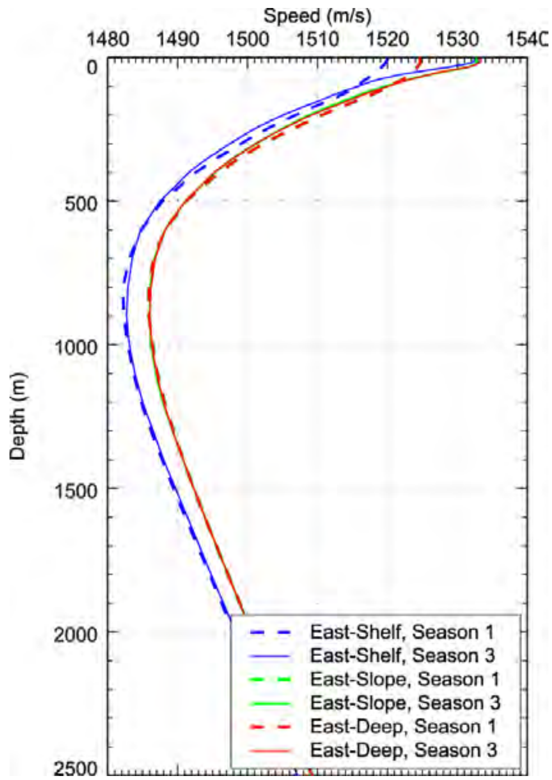


Figure 116. Sound speed profiles along East transect, derived from data obtained from GDEM V 3.0 (Teague et al. 1990, Carnes 2009).

7.2.5. 3MB Simulation Areas

The extents of the surveys were determined (Section 7.2.3.1), and the boxes surrounding the surveys for animat movement simulation were introduced (Figure 110, large red rectangles). These animat simulation boxes set the geographic limits of the 3MB simulation defined by the 3MB bathymetry file input. For large seismic surveys, potential behavioral disruption and NMFS criteria (for injury and behavior) were evaluated using the boxes shown Figure 110. Because potential injury assessed with SEL and peak SPL exposure criteria occurs at higher received levels (i.e., closer to the source) than those used to assess behavioral disruption and the NMFS criteria, the injury exposure boxes can be smaller than the behavioral disruption boxes. The extents of the simulation boxes for the surveys are described below.

7.2.5.1. Large Seismic Surveys

For the large seismic surveys, the injury simulation boxes extend outward (north, south, east, and west) by 10 km from the survey limits (Table 59), a distance over which the unweighted received levels drop below 160 dB re 1 μPa^2·s SEL for a single shot. This injury simulation box was therefore much larger than the area that would enclose received levels less than the high frequency-weighted 161 dB re 1 μPa^2·s SEL criterion, even for multiple shot accumulation. The behavior simulation boxes, on the other hand, extend outward by 50 km from the survey limits (Table 60), a distance necessary to ensure that the animat movement modeling extends out to where the M-weighted received levels drop to 120 dB re 1 μPa rms SPL or lower, and below 160 dB re 1 μPa^2·s SEL for unweighted received levels.

Since injury events are intrinsically rare, improved statistical assessment was achieved by using a higher animat modeling density, and prorating the final exposure estimates by the real-world species density in the final stage of the statistical analysis. The smaller injury simulation boxes, relative to the behavior simulation boxes, allows for higher modeling density to be used for injury without incurring a corresponding additional cost in computation time because the geographical area was smaller.

Because the 3MB modeling of animat movement requires significant computer resources, and lengthy computer run times, the same 3MB animat movement model results files were reused for the different large seismic surveys (although different for injury and behavior simulations), i.e., the 2-D, 3-D, and Coil surveys. Based on range to the received level limits, the animal simulation areas were large enough to satisfy the geographical extent requirements in each of the four cardinal directions.

Table 59. Geographic extent of the animat movement boxes for behavior simulation with the large seismic surveys.

Box	South latitude limit (degrees)	North latitude limit (degrees)	West longitude limit (degrees)	East longitude limit (degrees)
1	25.7385828	27.9873227	−97.697267	−96.035589
2	25.7750253	28.0114215	−96.324378	−94.686512
3	27.8386100	29.2946720	−92.552590	−90.027197
4	26.7853837	28.2521000	−91.865786	−89.357844
5	25.8836263	27.3817193	−89.809799	−87.302241
6	27.8304152	29.3656712	−87.819438	−85.244178
7	26.0299683	28.3155107	−84.739032	−82.985553

Table 60. Geographic extent of the animat movement boxes for injury simulation with the large seismic surveys.

Box	South latitude limit (degrees)	North latitude limit (degrees)	West longitude limit (degrees)	East longitude limit (degrees)
1	26.0989428	27.6269627	−97.29331627	−96.43953973
2	26.1353853	27.6510615	−95.92031909	−95.09057091
3	28.1989700	28.9343120	−92.14227901	−90.43750799
4	27.1457437	27.8917400	−91.45945302	−89.76417698
5	26.2439863	27.0213593	−89.40666570	−87.70537430
6	28.1907752	29.0053112	−87.40900447	−85.65461153
7	26.3903283	27.9551507	−84.33396603	−83.39061897

7.2.5.2. High-resolution Surveys

The received levels for the sources used in the high-resolution surveys drop off much more quickly with range than for the seismic survey sources discussed above. If we used the same approach for high-resolution sources as was used for large seismic surveys, very small boxes would result, which would prevent the animat movements from realistically behaving. Consequently, the 3MB simulation boxes to the high-resolution surveys were extended to 10 km from the center of the survey in each cardinal direction (Table 61), a much larger distance than that required for the received level conditions, but one that supports more realistic animal movements. Consequently, the behavior and injury simulations for high-resolution surveys used the same boxes, although, as discussed in the section above, a higher animat modeling density was used to simulate injury.

Table 61. Geographic extent of the animat movement boxes for both behavior and injury simulation with the high-resolution surveys.

Box	South latitude limit (degrees)	North latitude limit (degrees)	West longitude limit (degrees)	East longitude limit (degrees)
1	26.77588	26.95606	−96.8939	−96.6930
2	26.80408	26.98447	−95.6303	−95.4292
3	28.52530	28.70575	−91.3996	−91.1951
4	27.47697	27.65738	−90.7197	−90.5173
5	26.59023	26.77026	−88.6614	−88.4610
6	28.55562	28.73499	−86.6380	−86.4346
7	27.08567	27.26396	−84.0030	−83.8037

7.2.6. Animal Densities

Cetacean density estimates (animals/km^2) were obtained using the Marine Geospatial Ecology Laboratory (Duke University) model Roberts et al. (In preparation), preliminary results. These estimates were produced with distance sampling methodology (Buckland et al. 2001) from 195,000 linear km of shipboard and aerial surveys conducted by NOAA's Southeast Fisheries Science Center (SEFSC) in the Gulf of Mexico from 1992–2009. For each species, the count of animals per 10 km survey segment was modeled using a Horvitz-Thompson-like estimator (Marques and Buckland 2004, Miller et al. 2013). Species-specific detection functions were fitted using observation-level covariates such as Beaufort sea state, sun glare, and group size. When possible, availability and perception bias were estimated on a per-species basis using results from the scientific literature. After the sightings were corrected for detectability, availability, and perception bias, statistical regressions were used to model counts of animals per segment.

The density of frequently-sighted species were modeled with generalized additive models based on a collection of physiographic, physical oceanographic, and biological productivity predictor variables that plausibly relate to cetacean habitat. Both contemporaneous and climatological predictors were tested. Models were fitted to survey data and insignificant predictors were dropped from the models (Wood 2006). Final models were predicted across a time series of grids at 10 km resolution and averaged to produce a single surface representing mean density at each 10 km × 10 km grid square or cell.

There was insufficient data for infrequently seen species to model density from habitat variables. Instead, the geographic area of probable habitat was delineated from the scientific literature; patterns in the available sightings and density were estimated from the survey segments that occurred there using a statistical model that had no covariates. This model ran over the entire extent of the habitat area, yielding a uniform density estimate for the area.

Marine mammal density estimates for each species in the modeling zones are shown in Tables 62–68.

Table 62. Zone 1 Marine mammal density estimates.

Species	Movement surrogate	Seeding adjustment		Density estimate			
		Injury	Behavior	Min	Max	Mean	STD
Atlantic spotted dolphins		1.0	0.9988	0.000002	65.932686	19.561691	17.154286
Beaked whales		1.0	0.9879	0.000000	0.004306	0.000107	0.000402
Common bottlenose dolphins		1.0	0.9988	10.718610	143.330322	37.130025	20.297288
Bryde's whales		0.1661	0.2849	0.000000	0.167721	0.012267	0.035798
Clymene dolphins	Pantropical spotted dolphins	1.0	0.9988	0.000000	0.080756	0.000785	0.004739
False killer whales	Rough-toothed dolphins	1.0	0.9988	0.000000	0.748148	0.123816	0.278033
Fraser's dolphins	Short-finned pilot whales	1.0	0.9988	0.000000	0.388778	0.064342	0.144481
Killer whales		1.0	0.9988	0.000003	0.002641	0.000392	0.000507
Kogia	Short-finned pilot whales	1.0	0.9988	0.000000	0.381413	0.016379	0.046385
Melon-headed whales	Short-finned pilot whales	1.0	0.9988	0.000000	0.071767	0.002691	0.008428
Pantropical spotted dolphins		1.0	0.9988	0.000000	2.683713	0.111202	0.350165
Pygmy killer whales	Rough-toothed dolphins	1.0	0.9988	0.000000	0.026950	0.001253	0.003460
Risso's dolphins		1.0	0.9634	0.000000	0.489424	0.017854	0.055393
Rough-toothed dolphins		1.0	0.9988	0.000000	0.857693	0.406426	0.109876
Short-finned pilot whales		1.0	0.9988	0.078137	0.017168	0.000262	0.001151
Sperm whales*		0.1	0.1	0.000000	0.004952	0.000150	0.000473
Spinner dolphins	Pantropical spotted dolphins	1.0	0.9988	0.000000	2.888299	0.018491	0.124570
Striped dolphins	Pantropical spotted dolphins	1.0	0.9988	0.000000	0.180768	0.002602	0.012559

* Due to depth restrictions, in Zone 1 no sperm whale animats were seeded (placed in the model area) for injury and behavior. For this case, it was necessary to make a seeding adjustment = 0.1 to avoid a division by 0 error, but the dummy value did not contribute to the overall exposure estimate. See Section 7.2.7.1 for more information about seeding.

Table 63. Zone 2 Marine mammal density estimates.

Species	Movement surrogate	Seeding adjustment		Density estimate			
		Injury	Behavior	Min	Max	Mean	STD
Atlantic spotted dolphins		0.9532	0.8597	0.000001	30.319336	7.456256	9.462431
Beaked whales		0.9149	0.82	0.000000	0.000281	0.000003	0.000018
Common bottlenose dolphins		0.9532	0.8597	8.439063	113.845413	53.082960	22.977138
Bryde's whales*		0.1	0.2103	0.000000	0.028985	0.000164	0.001293
Clymene dolphins	Pantropical spotted dolphins	0.9532	0.8597	0.000000	0.000935	0.000002	0.000035
False killer whales	Rough-toothed dolphins	0.9532	0.8597	0.000000	0.748148	0.028735	0.143780
Fraser's dolphins	Short-finned pilot whales	0.9532	0.8597	0.000000	0.388778	0.014932	0.074716
Killer whales		0.9532	0.8597	0.000004	0.001135	0.000177	0.000192
Kogia	Short-finned pilot whales	0.9532	0.8597	0.000000	0.043914	0.000937	0.004897
Melon-headed whales	Short-finned pilot whales	0.9532	0.8597	0.000000	0.011606	0.000181	0.000979
Pantropical spotted dolphins		0.9532	0.8597	0.000000	0.131169	0.002317	0.012380
Pygmy killer whales	Rough-toothed dolphins	0.9532	0.8597	0.000000	0.004356	0.000078	0.000413
Risso's dolphins		0.7538	0.7252	0.000000	0.071479	0.000835	0.004760
Rough-toothed dolphins		0.9532	0.8597	0.154323	0.887101	0.394670	0.083382
Short-finned pilot whales		0.9532	0.8597	0.000000	0.002055	0.000010	0.000086
Sperm whales*		0.1	0.1	0.000000	0.000350	0.000007	0.000035
Spinner dolphins	Pantropical spotted dolphins	0.9532	0.8597	0.000000	0.000022	0.000000	0.000001
Striped dolphins	Pantropical spotted dolphins	0.9532	0.8597	0.000000	0.001711	0.000025	0.000141

* Due to depth restrictions, in Zone 2 no sperm whale animats were seeded (placed in the model area) for injury and behavior and no Bryde's whale animats were seeded for injury. For these cases, it was necessary to make a seeding adjustment = 0.1 to avoid a division by 0 error, but the dummy values did not contribute to the overall exposure estimates. See Section 7.2.7.1 for more information about seeding.

Table 64. Zone 3 Marine mammal density estimates.

Species	Movement surrogate	Seeding adjustment		Density estimate			
		Injury	Behavior	Min	Max	Mean	STD
Atlantic spotted dolphins		0.9916	0.9696	0.000071	27.600784	8.191627	7.035238
Beaked whales		0.9795	0.9522	0.000000	0.000140	0.000001	0.000012
Common bottlenose dolphins		0.9916	0.9522	8.936208	79.201904	39.405915	14.535437
Bryde's whales		0.0759	0.2908	0.000000	0.007863	0.000041	0.000375
Clymene dolphins	Pantropical spotted dolphins	0.9916	0.9696	0.000000	0.000152	0.000000	0.000007
False killer whales	Rough-toothed dolphins	0.9916	0.9696	0.000000	0.748148	0.013218	0.098562
Fraser's dolphins	Short-finned pilot whales	0.9916	0.9696	0.000000	0.388778	0.006869	0.051218
Killer whales		0.9916	0.9696	0.000006	0.000913	0.000191	0.000162
Kogia	Short-finned pilot whales	0.9916	0.9696	0.000000	0.024987	0.000187	0.001645
Melon-headed whales	Short-finned pilot whales	0.9916	0.9696	0.000000	0.006796	0.000062	0.000496
Pantropical spotted dolphins		0.9916	0.9696	0.000000	0.069956	0.000597	0.004851
Pygmy killer whales	Rough-toothed dolphins	0.9916	0.9696	0.000000	0.002749	0.000029	0.000223
Risso's dolphins		0.9073	0.895	0.000000	0.043172	0.000297	0.002568
Rough-toothed dolphins		0.9916	0.9696	0.277675	0.765203	0.396268	0.060134
Short-finned pilot whales		0.9916	0.9696	0.000000	0.001161	0.000005	0.000054
Sperm whales*		0.1	0.1	0.000000	0.000212	0.000002	0.000018
Spinner dolphins	Pantropical spotted dolphins	0.9916	0.9696	0.000000	0.000001	0.000000	0.000000
Striped dolphins	Pantropical spotted dolphins	0.9916	0.9696	0.000000	0.003908	0.000030	0.000310

* Due to depth restrictions, in Zone 3 no sperm whale animats were seeded (placed in the model area) for injury and behavior. For this case, it was necessary to make a seeding adjustment = 0.1 to avoid a division by 0 error, but the dummy value did not contribute to the overall exposure estimate. See Section 7.2.7.1 for more information about seeding.

Table 65. Zone 4 Marine mammal density estimates.

Species	Movement surrogate	Seeding adjustment		Density estimate			
		Injury	Behavior	Min	Max	Mean	STD
Atlantic spotted dolphins		1.0	1.0	0.000002	40.318748	2.781758	6.191489
Beaked whales		1.0	1.0	0.000000	4.682173	0.725775	1.107739
Common bottlenose dolphins		1.0	1.0	0.003873	66.720116	11.553444	12.482596
Bryde’s whales		1.0	0.9502	0.000000	0.167727	0.035179	0.055666
Clymene dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	7.119437	0.914148	1.012023
False killer whales	Rough-toothed dolphins	1.0	1.0	0.000000	0.748148	0.727735	0.121883
Fraser’s dolphins	Short-finned pilot whales	1.0	1.0	0.000000	0.388778	0.378170	0.063337
Killer whales		1.0	1.0	0.000090	0.094036	0.013264	0.015548
Kogia	Short-finned pilot whales	1.0	1.0	0.000000	2.564462	0.958299	0.613179
Melon-headed whales	Short-finned pilot whales	1.0	1.0	0.000000	4.612887	1.181967	1.227168
Pantropical spotted dolphins		1.0	1.0	0.000000	88.489113	21.767563	19.221821
Pygmy killer whales	Rough-toothed dolphins	1.0	1.0	0.000000	0.691082	0.296539	0.253896
Risso’s dolphins		1.0	1.0	0.000000	10.243490	1.419280	1.445694
Rough-toothed dolphins		1.0	1.0	0.501328	1.931466	0.961959	0.308922
Short-finned pilot whales		1.0	1.0	0.000000	5.891473	0.685525	0.842500
Sperm whales		0.184	0.3378	0.000000	2.049208	0.482223	0.480525
Spinner dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	145.747696	11.762649	17.414109
Striped dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	5.765086	0.799246	0.882350

Table 66. Zone 5 Marine mammal density estimates.

Species	Movement surrogate	Seeding adjustment		Density estimate			
		Injury	Behavior	Min	Max	Mean	STD
Atlantic spotted dolphins		1.0	1.0	0.000013	26.744694	2.031142	4.981907
Beaked whales		1.0	1.0	0.000000	3.432981	1.080930	0.851019
Common bottlenose dolphins		1.0	1.0	0.025899	46.434166	5.728691	8.809752
Bryde’s whales		1.0	0.9525	0.000000	0.167701	0.014526	0.039290
Clymene dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	15.461932	3.416620	3.148363
False killer whales	Rough-toothed dolphins	1.0	1.0	0.000000	0.748148	0.726846	0.124434
Fraser’s dolphins	Short-finned pilot whales	1.0	1.0	0.000000	0.388778	0.377708	0.064662
Killer whales		1.0	1.0	0.000159	0.056221	0.020153	0.014145
Kogia	Short-finned pilot whales	1.0	1.0	0.000000	1.972867	0.726706	0.450570
Melon-headed whales	Short-finned pilot whales	1.0	1.0	0.000000	3.859135	2.209811	1.321709
Pantropical spotted dolphins		1.0	1.0	0.000000	31.898088	15.504281	9.582240
Pygmy killer whales	Rough-toothed dolphins	1.0	1.0	0.000000	0.691082	0.456866	0.269419
Risso’s dolphins		1.0	1.0	0.000000	7.244700	0.972485	1.026923
Rough-toothed dolphins		1.0	1.0	0.484941	1.574484	1.050021	0.185273
Short-finned pilot whales		1.0	1.0	0.000000	3.430244	0.639206	0.665957
Sperm whales		0.6644	0.6107	0.000000	2.049208	0.725159	0.527590
Spinner dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	66.322189	4.154421	8.152655
Striped dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	4.547289	1.334442	0.985099

Table 67. Zone 6 Marine mammal density estimates.

Species	Movement surrogate	Seeding adjustment		Density estimate			
		Injury	Behavior	Min	Max	Mean	STD
Atlantic spotted dolphins		1.0	1.0	0.000007	17.078234	1.273500	3.317500
Beaked whales		1.0	1.0	0.000000	2.336602	0.832344	0.536911
Common bottlenose dolphins		1.0	1.0	0.030806	24.043407	3.342733	5.111497
Bryde's whales		1.0	0.9034	0.000000	0.167480	0.013691	0.037372
Clymene dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	16.132580	4.262516	3.869130
False killer whales	Rough-toothed dolphins	1.0	1.0	0.000000	0.748148	0.735816	0.095258
Fraser's dolphins	Short-finned pilot whales	1.0	1.0	0.000000	0.388778	0.382369	0.049501
Killer whales		1.0	1.0	0.000358	0.053226	0.019773	0.012304
Kogia	Short-finned pilot whales	1.0	1.0	0.000000	1.100742	0.411093	0.228572
Melon-headed whales	Short-finned pilot whales	1.0	1.0	0.000000	3.280858	1.890231	1.024283
Pantropical spotted dolphins		1.0	1.0	0.000000	16.103422	9.864202	5.300093
Pygmy killer whales	Rough-toothed dolphins	1.0	1.0	0.000000	0.691080	0.476313	0.254439
Risso's dolphins		1.0	1.0	0.000000	3.041948	0.794562	0.616821
Rough-toothed dolphins		1.0	1.0	0.420462	1.595734	0.997906	0.183769
Short-finned pilot whales		1.0	1.0	0.000000	5.996468	1.249850	1.434598
Sperm whales		0.7368	0.5215	0.000000	1.356392	0.486587	0.286136
Spinner dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	2.337054	0.236570	0.284845
Striped dolphins	Pantropical spotted dolphins	1.0	1.0	0.000000	1.833318	1.091651	0.565132

Table 68. Zone 7 Marine mammal density estimates.

Species	Movement surrogate	Seeding adjustment		Density estimate			
		Injury	Behavior	Min	Max	Mean	STD
Atlantic spotted dolphins		1.0	1.0	0.000000	0.001134	0.000004	0.000027
Beaked whales		1.0	1.0	0.222212	3.113844	0.519543	0.286857
Common bottlenose dolphins		1.0	1.0	0.001245	1.554906	0.027482	0.067843
Bryde's whales		1.0	1.0	0.000000	0.000004	0.000000	0.000000
Clymene dolphins	Pantropical spotted dolphins	1.0	1.0	0.005837	16.310186	2.627719	3.204962
False killer whales	Rough-toothed dolphins	1.0	1.0	0.748148	0.748148	0.748148	0.000000
Fraser's dolphins	Short-finned pilot whales	1.0	1.0	0.388778	0.388778	0.388778	0.000000
Killer whales		1.0	1.0	0.023988	0.101078	0.077865	0.016385
Kogia	Short-finned pilot whales	1.0	1.0	0.151227	0.825459	0.342218	0.062230
Melon-headed whales	Short-finned pilot whales	1.0	1.0	0.618728	4.204332	1.533612	0.671281
Pantropical spotted dolphins		1.0	1.0	10.890163	46.524502	26.087947	6.013833
Pygmy killer whales	Rough-toothed dolphins	1.0	1.0	0.643905	0.691082	0.661113	0.013441
Risso's dolphins		1.0	1.0	0.083161	2.332364	0.419790	0.237456
Rough-toothed dolphins		1.0	1.0	0.385164	1.895322	0.798816	0.276520
Short-finned pilot whales		1.0	1.0	0.003767	0.771689	0.121555	0.104179
Sperm whales		1.0	1.0	0.354441	1.140214	0.467025	0.131315
Spinner dolphins	Pantropical spotted dolphins	1.0	1.0	0.043222	24.800802	0.612156	1.245325
Striped dolphins	Pantropical spotted dolphins	1.0	1.0	0.541343	2.608293	1.365036	0.429627

7.2.6.1. Marine Mammal Density Estimates in Modeling Zones

The Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation) is a GIS-compatible raster of density estimates in 10 $km^2 \times 10\ km^2$ squares. The minimum, maximum, mean, and the standard deviation of the mean were obtained for each species in each zone. These density estimates and depth-restricted density adjustments (Section 7.2.7.1) are shown in Tables 62–68; Appendix A shows distribution maps.

7.2.7. Animal Movement: JEMS

The JASCO Exposure Modeling System (JEMS) combines animal movement data, the output from 3MB (Section 5.3), with pre-computed acoustic fields (Sections 5.1–5.2). The JEMS output was the time-history of received levels and slant ranges (the three dimensional distance between the animat and the source) for all animats of the 3MB simulation. Animat received levels and slant ranges are used to determine the risk of acoustic exposure. JEMS can use any acoustic field data provided as a 3-D radial grid (e.g., N×2-D MONM output). Source movement and shooting patterns can be defined, and multiple sources and sound fields used. For impulsive sources, a shooting pattern based on movement can be defined for each source, with shots distributed along the vessel track by location (or time). Because the acoustic environment varies with location, acoustic fields are pre-computed at selected sites in the simulation area and JEMS chooses the closest modeled site to the source at each time step.

7.2.7.1. Depth-restricted Density Adjustment

The number of animats that 3MB initially places, or seeds, in a simulation was based on the specified animat density (in units of animats per km^2) and simulation area. The model establishes a grid to cover the simulation area, then examines the bathymetry in the simulation area and determines the number of grid points where the water depth is greater than zero. The number of grid points where the water depth is greater than zero provides an estimate of the working area and the number of animats to seed is calculated from the working area and the animat's specified density. 3MB randomly selects grid points and evaluates the points based on the suitability for the animat species. For example, a depth restriction may be set that eliminates grid points too shallow for seeding a particular species. If the grid point is accepted, an animat is placed at that grid point (at a random depth location within the species-defined depth range) and 3MB decreases its animat seeding quota by one. The loop continues until the predetermined number animats is successfully seeded. For species whose definition accepts seeding locations in all water depths greater than zero, a uniform animat seeding density equal to the specified density is achieved in the simulation area. For species with depth restrictions, such as sperm whales that are restricted to water deeper than 1000 m, the number of animats determined by the working area and specified density will be concentrated within the area of the simulation that meets the restriction and their density effectively increased in that portion. The animat modeling density is a key value when calculating the exposure estimates, so exposure estimates are skewed if concentrating the animats increases the density. To avoid this problem, we calculated separately the number of acceptable grid points (based on the percentage of the working area that meets the depth restriction) and used this information to calculate an adjustment factor to pro-rate the exposure estimates.

7.2.7.2. Evaluation Time Period

Animat exposure histories were processed to calculate the number of animats exposed to levels exceeding threshold (the number of exposures). The time interval over which the counting was done must be defined. While there is no consensus on the time interval (see time interval effects in Section 6.5.1: Test Scenario 1), a 24 h period is often used (Southall et al. 2007). For this analysis, seven-day simulations were run and the exposures estimated in 24 h windows within the seven days. The first 24 h window begins at the start of the simulation and each subsequent window is advanced by 4 h. In this sliding-windows approach, 42 exposure estimate samples are obtained for each seven-day simulation. The mean value is then used as the 24 h exposure estimate for that survey.

7.2.7.3. Annual Aggregate Estimates

This analysis estimated the annual number of exposures for each species for each year for each type of source for the entire Gulf. To get these annual exposure estimates, the 24 h exposure estimates were scaled by the number of expected survey days. BOEM provided projections of survey level of effort (shown in Table 75) for each survey type in each year (2016–2025) in BOEM's Gulf of Mexico Planning Areas (eastern, central, and western; divided into shallow and deep zones). These survey projections were used to scale the 24 h exposure estimates from simulations in the appropriate locations.

7.3. Phase II Modeling Results

7.3.1. Acoustic Sources: Levels and Directivity

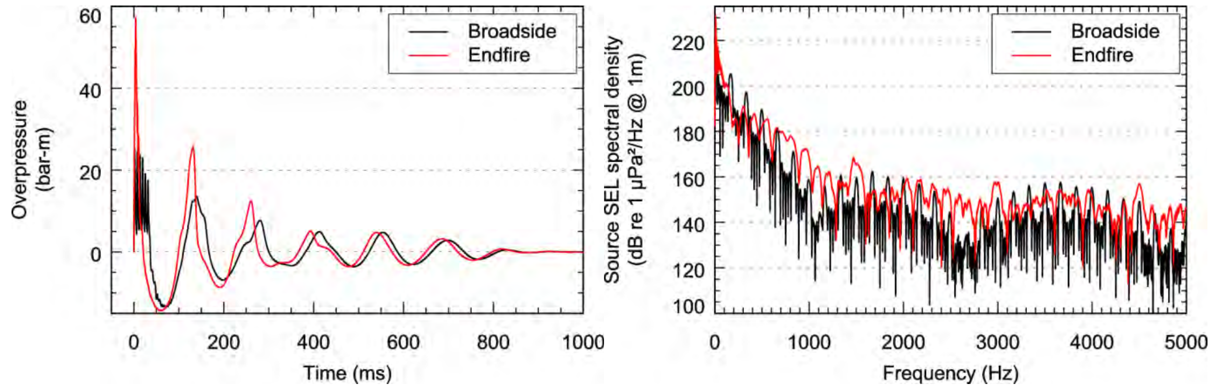
7.3.1.1. Airgun Sources

We used the Airgun Array Source Model (AASM) to model the pressure signatures of the individual airguns and the composite 1/3-octave-band source levels of the arrays, as functions of azimuthal angle in the horizontal plane (Section 5.1.1). While AASM accounts for effects of source depth on bubble interactions, the surface-reflected signal (i.e., surface ghost) was not included in the far-field source signatures. The acoustic propagation models account for surface reflections, which are a property of the medium, not the source.

7.3.1.1.1. Airgun Array—8000 in³

The broadside (perpendicular to the tow direction) and endfire (parallel to the tow direction) horizontal overpressure signatures (Figure 117a) consist of a strong primary peak, related to the initial firing of the airguns, followed by a series of pulses associated with the bubble oscillations. The broadside and endfire power spectrum levels were highest at frequencies below 500 Hz (Figure 117b). Frequency-dependent peaks and nulls in the spectrum were caused by interference among airguns in the array; they reflect the volumes and relative locations of the airguns. The broadband horizontal source levels are shown in Table 69.

As discussed in Section 5.1.1, directivity in the sound field was most noticeable at mid-frequencies. Maximum (horizontal) 1/3-octave-band source levels over all azimuths are shown in Figure 118. Horizontal 1/3-octave-band source levels are shown as a function of band center frequency and azimuth in Figure 119.



(a) (b)

Figure 117. Predicted (a) overpressure signature and (b) power spectrum in the broadside and endfire (horizontal) directions, for a generic 8000 in^3 airgun array towed at a depth of 8 m.

Table 69. Horizontal source level specifications for a generic 8000 in^3 airgun array.

Direction	Zero-to-peak SPL (dB re 1 μPa @ 1 m)	SEL (dB re 1 μPa^2 @ 1 m) 10 Hz to 5 kHz
Broadside	248.1	225.7
Endfire	255.2	231.8

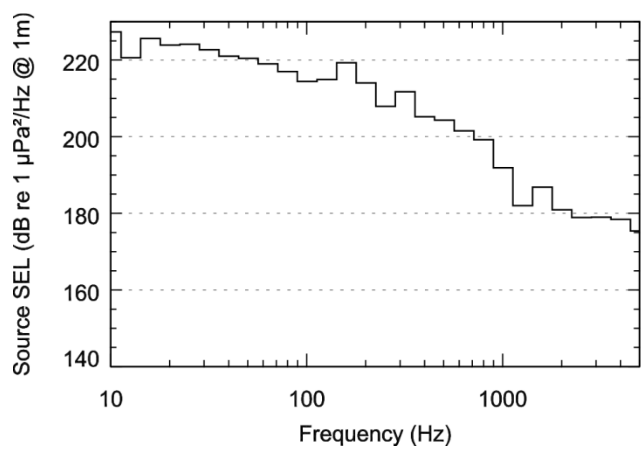


Figure 118. Maximum 1/3-octave-band source level in the horizontal plane for a generic 8000 in^3 airgun array. The maximum over all modeled azimuths is shown for each 1/3-octave-band.

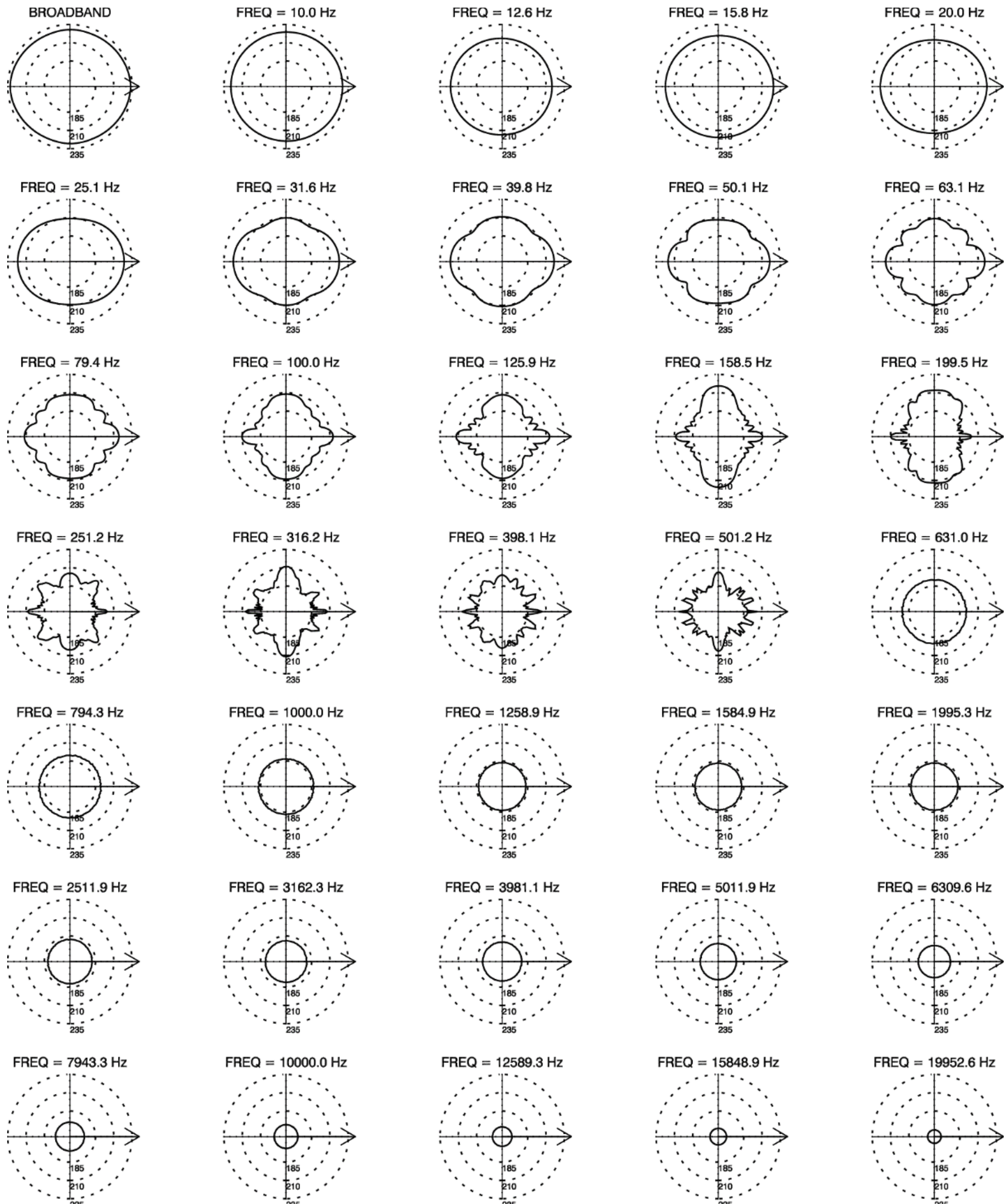
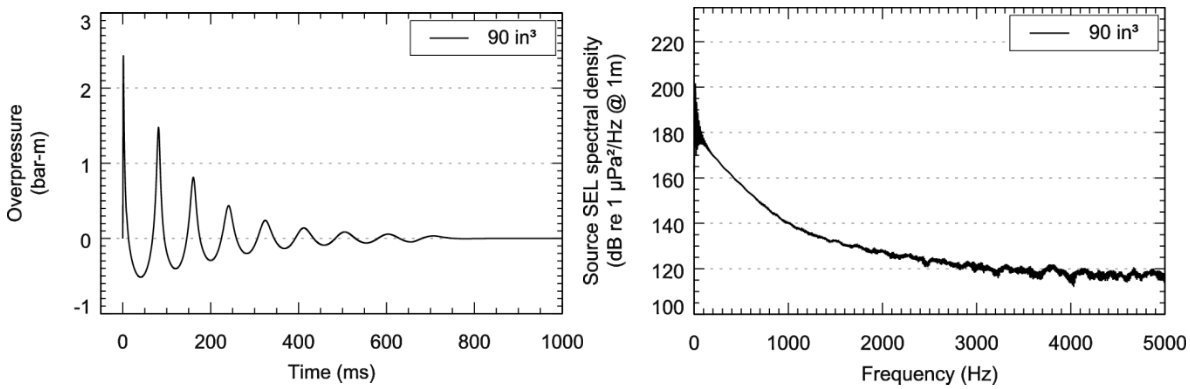


Figure 119. Directionality of predicted horizontal source levels for a generic 8000 in^3 airgun array. Source levels in dB re 1 μPa^2·s are shown as a function of azimuth for the center frequencies of the 1/3-octave-bands modeled; frequencies are indicated above the plots. Tow direction was to the right.

7.3.1.1.2. Single Airgun—90 in³

Since the source consists of one gun, the acoustic wave is omnidirectional and has virtually the same characteristics in all directions. The overpressure for a single 90 in^3 airgun towed at a depth of 6 m is shown in Figure 120. The overpressure signature (Figure 120a) consist of a strong primary peak, related to the initial firing of the airguns, followed by a series of pulses associated with the bubble oscillations. Most energy is produced at frequencies below 600 Hz (Figure 121). Zero-to-peak SPL is 227.7 dB re 1 μPa @ 1 m and source SEL is 207.8 dB re 1 μPa2 @ 1 m.

Maximum (horizontal) 1/3-octave-band source levels over all azimuths are shown in Figure 121.



(a) (b)

Figure 120. Predicted (a) overpressure signature and (b) power spectrum in the broadside and endfire (horizontal) directions for a single 90 in^3 airgun.

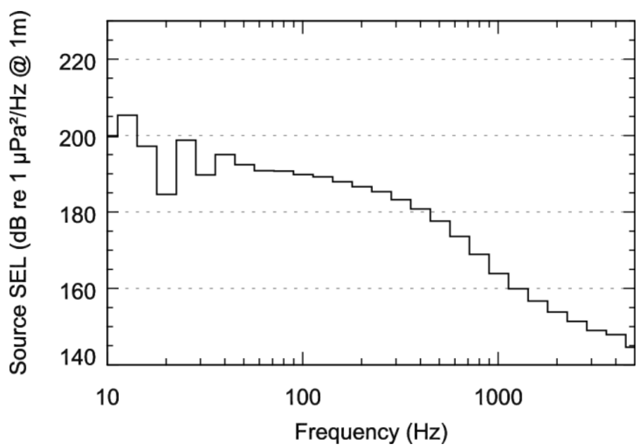


Figure 121. Maximum 1/3-octave-band source level in the horizontal plane for a single 90 in³ airgun. The maximum over all modeled azimuths is shown for each 1/3-octave-band.

7.3.1.2. Boomer

To estimate the broadband source level for the AA301 boomer (350 J input energy) from the source level for AP3000 system (1000 J input energy), we applied a −4.6 dB correction factor. The estimated source levels for the boomer plate—198.4 dB 1 µPa @ 1 m rms SPL and 168.0 dB re 1 µPa^2·s @ 1 m SEL—were significantly lower than those provided by the manufacturer because the manufacturer's level is estimated based only on the input energy. When electrical signals are converted into acoustic waves, output source levels are reduced.

The power spectrum of the boomer signal and the beamwidth at different frequencies were estimated based on Simpkin's (2005) study of the Huntec'70 Deep Tow Boomer, a typical boomer plate of comparable dimensions. The source level in each 1/3-octave-band was calculated based on the broadband source level and relative power spectrum data (Table 70).

The parameters of the AA301 boomer used for modeling were:

- Operating frequency (wide band): 100 Hz–10 kHz
- Beam width: omnidirectional –11°

- Beams: 1
- Beam direction: vertically down
- Maximum energy input (per shot): 350 J
- rms SPL: 198.4 dB re 1 µPa @ 1 m T_{rmsSPL}=0.2 ms (estimated from field measurements; Martin et al. 2012)
- Per pulse SEL: 171.0 dB re 1 µPa^2·s @ 1 m (estimated from field measurements; Martin et al. 2012)

Table 70. Estimated source levels (SELs) and beamwidths from the AA301 boomer plate at 350 J per pulse distributed into twenty 1/3-octave-bands.

1/3-octave-band center frequency (Hz)	Band SEL (dB re 1 µPa^2·s @ 1 m)	Beam width
100	152.0	Omnidirectional
125	153.0	Omnidirectional
160	154.0	Omnidirectional
200	155.0	Omnidirectional
250	155.4	Omnidirectional
315	156.1	Omnidirectional
400	156.7	Omnidirectional
500	157.5	Omnidirectional
630	158.4	Omnidirectional
800	159.0	Omnidirectional
1,000	159.8	Omnidirectional
1,250	160.5	105°
1,600	160.6	78°
2,000	160.9	60°
2,500	160.4	47°
3,150	159.8	37°
4,000	159.1	29°
5,000	157.9	23°
6,300	156.8	18°
8,000	155.1	14°
10,000	151.8	11°
Broadband	171.0	Omnidirectional

We compared the boomer source with the 90 in^3 airgun to confirm if acoustic field modeling results for the airgun were adequate to approximate the ones for the boomer. The broadband source levels for the airgun and the boomer were calculated after the set of M-weighted filters were applied (Table 71). As indicated in the Table 71, the broadband source level for the boomer is lower than for the airgun after application of all applicable M-weighting filters. Considering the negligible fraction of the surveys conducted using boomers and that the estimated impact from the 90 in^3 is always greater than for the boomer, the 90 in^3 airgun results were proposed as a conservative substitute for the boomer. Therefore, the source level modeling results presented in this section were not used in any acoustic field results or exposure estimates.

Table 71. Boomer and 90 in³ airgun broadband source levels after M-weighting filters were applied.

Source	FLAT	Type I LFC	Type I MFC	Type I HFC	Type II MFC	Type II HFC
90 in³	207.8	206.0	190.7	188.6	174.3	169.2
Boomer	171.2	171.0	170.7	170.5	158.0	155.6

LFC=low-frequency cetaceans, MFC= mid-frequency cetaceans, HFC=high-frequency cetaceans

7.3.1.3. High-resolution Acoustic Sources

7.3.1.3.1. Multibeam Echosounder—Simrad EM2000

For the multibeam echosounder, the operational parameters producing the greatest acoustic impact were modeled. The Simrad EM2000 multibeam echosounder was modeled at the operational frequency of 200 kHz, maximum source level of 203 dB re 1 µPa @ 1 m, the pulse length of 1.3 ms. The source beam pattern was modeled using rectangular transducer theory (Section 5.1.2.2).

The estimated beam pattern from the transmitter of Simrad EM2000 is provided in Figure 122 as vertical slices along- and across-track directions.

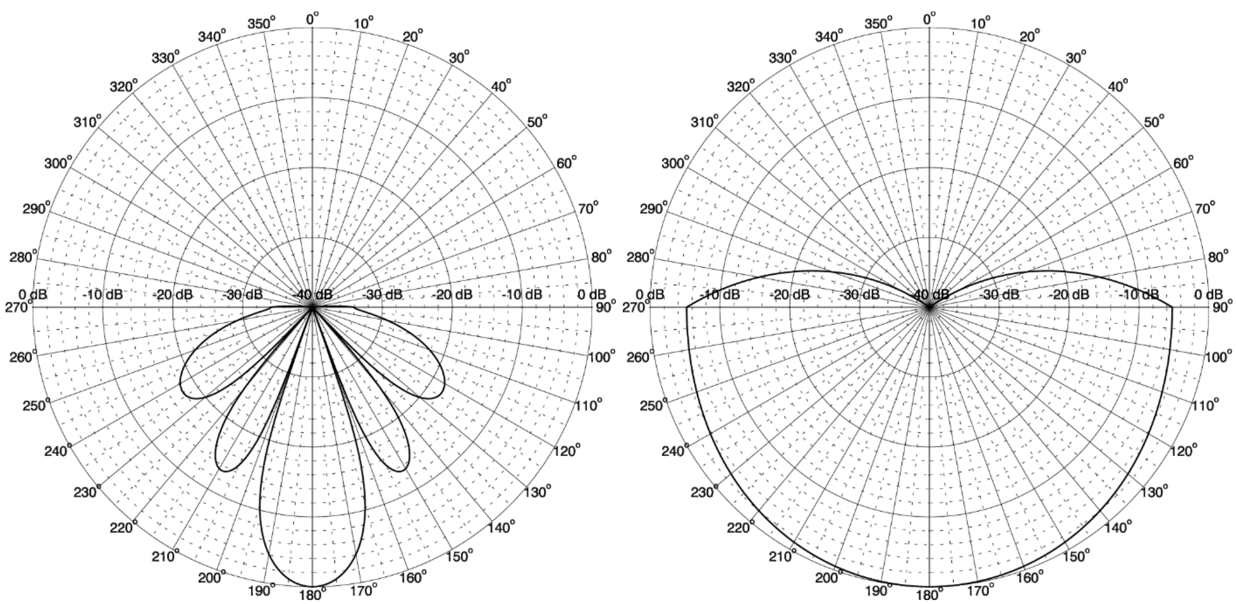


Figure 122. Vertical beam pattern calculated for the Simrad EM2000 multibeam 88° × 17° width in the (left) along- and (right) across-track directions.

7.3.1.3.2. Side-scan Sonar—EdgeTech 2200 IM

The side-scan sonar EdgeTech 2200 IM was modeled at two operational frequencies, 120 and 410 kHz. The rms SPL source level was estimated based on the peak source levels at 207 and 213 dB re 1 µPa @ 1 m for 120 and 410 kHz center frequencies. The SEL source level was estimated based on the rms SPL source level values and the pulse lengths at 186.2 and 186.8 dB re 1 µPa²·s for 120 and 410 kHz center frequencies.

The source beam pattern was modeled using rectangular transducer theory (Section 5.1.2.2). The estimated beam pattern from the transmitter of the EdgeTech 2200 IM side-scan sonar is provided in

Figure 123 as slices at 20° declination angle (through beam maximums) and vertical across-track directions.

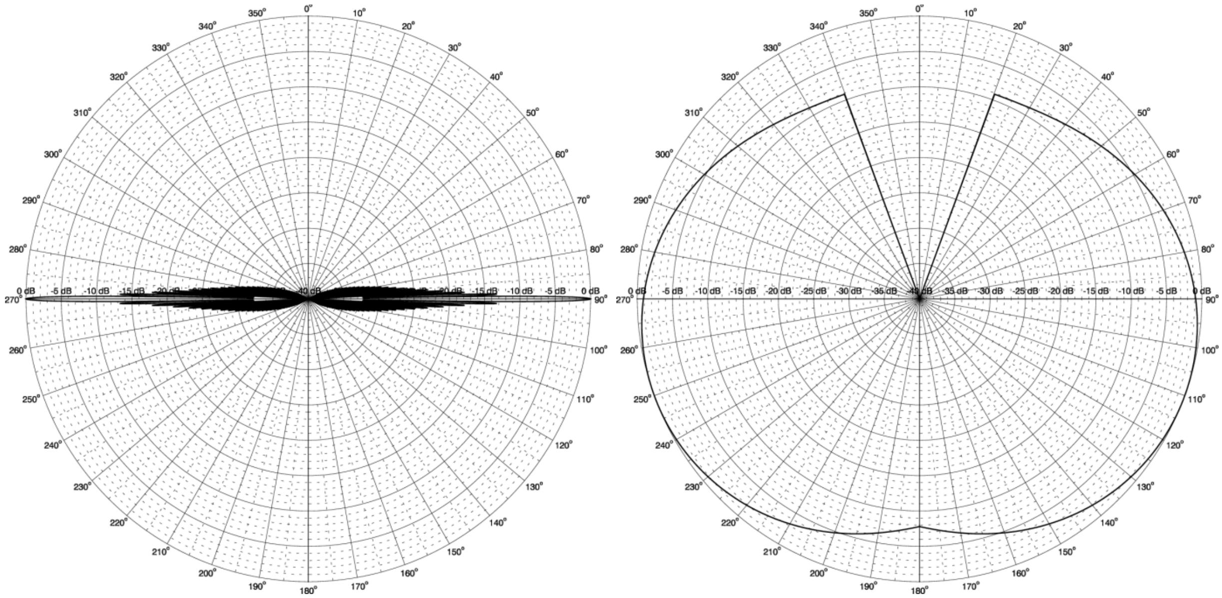


Figure 123. Vertical beam pattern calculated for the EdgeTech 2200 IM side-scan sonar 70° × 0.8° width and 20° declination angle. Slices (left) at 20° declination angle and (right) across-track directions.

7.3.1.3.3. Sub-bottom Profiler—EdgeTech 2200 IM, DW−424

The chirp sub-bottom profiler emits a pulse, with a frequency constantly changing over time from the lower frequency of the working band at the beginning of the pulse to the higher frequency at the end of the pulse. The amplitude of the pulse also changes. Field measurements on a similar chirp system (Zykov and MacDonnell 2013) showed that the maximum amplitude of the pulse is achieved at the center frequency of the range, approximately. The pulse amplitude holds this maximum in the two 1/3-octave-bands closest to the center frequency of the operational band and drops by about 10 dB for the 1/3-octave-bands on either side of the maximum, dropping farther by 30 dB from the maximum at either end of the operational band. As a result, the chirp sub-bottom profiler can be modeled with sufficient accuracy using only the center frequency of the operational band.

The chirp sub-bottom profiler of EdgeTech 2200 IM system was modeled at single frequency of 14 kHz. The rms SPL source level was considered at 200 dB re 1 µPa @ 1 m. The SEL source level was estimated based on the rms SPL source level and the pulse length at 180 dB re 1 $\mu Pa^2 \cdot s$. The beamwidth was estimated at 20° at the center frequency.

The source beam pattern was modeled using circular transducer beam theory (Section 5.1.2.1). The estimated beam pattern from the transmitter of the EdgeTech 2200 IM chirp sub-bottom profiler is provided in Figure 124 as a vertical slice. The beam is omnidirectional in the horizontal plain.

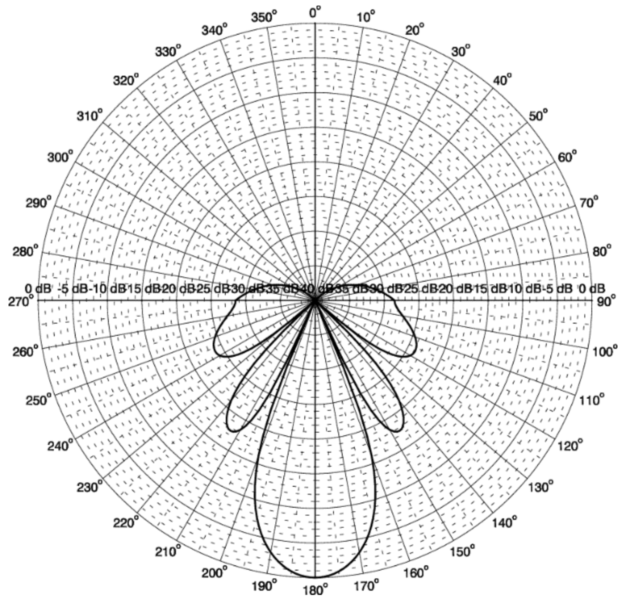


Figure 124. Vertical beam pattern calculated for the EdgeTech 2200 IM sub-bottom with 20° beamwidth.

7.3.2. Per-Pulse Acoustic Field

7.3.2.1. Per-Pulse Acoustic Field for Input to JEMS

Acoustic propagation modeling was performed for of all sources at the modeling sites. The per-pulse acoustic fields were used as input for the exposure simulation using JEMS (Section 7.2.7). The acoustic fields were passed as 3-D cylindrical grids (range-depth-azimuth) of received levels.

7.3.2.1.1. Seismic Survey (8000 in³ Airgun Array)

The acoustic field from 8000 in³ airgun array was modeled at 10 sites in each of the regions (East, Central, and West) for a total of 30 sites in the Gulf of Mexico (see Figure 110, Tables 48–51). At each site a towing azimuth of 0° or 90° was used based on the orientation of the survey box. Special consideration was given to the simulation of the Coil survey (Section 7.2.2.4) because of its continuously changing towing direction as the survey vessel follows a circular path. To accommodate the changing tow direction, additional acoustic fields were created using 9 different towing azimuths from 0° to 160° with a 20° step. The towing directions from 180° to 340° were represented by the same fields assuming source geometry symmetry for the towing axis. Considering the directivity pattern of the array, it was assumed that 20° towing azimuth step was optimal for exposure modeling.

Transmission loss was modeled along 15 radial profiles (angular step 22.5°) to the range of up to 50 km from the source location. The horizontal step along the radials was 10 m. At each surface sampling location, the sound field was sampled at multiple depths:

- 2 m
- Every 5 m from 5 to 20 m
- Every 10 m from 20 to 100 m
- Every 25 m from 100 to 200 m
- Every 50 m from 200 to 300 m

- Every 100 m from 300 to 1200 m
- Every 200 m from 1200 to 3000 m

The frequencies up to 5 kHz for the airgun array source were considered in the calculations of the broadband received levels. All 1/3-octave-band frequencies from 10 Hz to 5 kHz were used for the airgun array source level modeling (Section 7.3.1). For the transmission loss calculations, frequencies higher than 2 kHz were computationally intensive, so it was assumed that the transmission loss field for higher frequencies (up to 5 kHz) is identical to that at 2 kHz.

For each modeling scenario, the acoustic fields were calculated in SEL and rms SPL metrics. The rms SPL field was estimated from SEL field by applying range/depth/azimuth dependent conversion factor, which was obtained with full waveform modeling (Section 5.2.4). In addition to the unweighted acoustic fields, a set of filtered acoustic fields were calculated by applying M-weighting filters: Type I (low, medium, and high frequency) for rms SPL and Type II (medium and high frequency) for SEL. The total number of precomputed acoustic field grids prepared for the exposure simulation with JEMS was more than 1600.

7.3.2.1.2. Geotechnical Surveys with High-resolution sources

The acoustic field from the high-resolution sources (90 in^3 airgun, sub-bottom profiler, side-scan sonar, and multibeam sonar) was modeled at 7 sites: center of each survey box (see Figure 110 and Table 51). At each site, a towing azimuth of 0° or 90° was used based on the orientation of the survey box.

The high-frequency geotechnical sources have significantly finer structure to the beam pattern in the horizontal plane compared to the large airgun array. The geometry of the profiles along which the acoustic propagation was modeled was individually adjusted for each source based on the beam pattern (Table 72).

At each surface sampling location along the modeled profiles, the sound field was sampled at multiple depths:

- 2 m
- Every 5 m from 5 to 20 m
- Every 10 m from 20 to 100 m
- Every 25 m from 100 to 200 m
- Every 50 m from 200 to 300 m
- Every 100 m from 300 to 1200 m
- Every 200 m from 1200 to 3000 m

For each modeling scenario, the acoustic fields were calculated in SEL and rms SPL metrics. The rms SPL field was estimated from SEL field by applying constant conversion factor of +10 dB (see Section 5.2.4). In addition to the unweighted acoustic fields, a set of filtered acoustic fields were created by applying M-weighting filters: Type I (low, medium, and high frequency) for rms SPL and Type II (medium and high frequency) for SEL.

Table 72. Modeling parameters for the geotechnical sources.

Source	Frequencies modeled	Profiles	Range modeled (km)	Grid size (m)
90 in³ airgun	10–2000 Hz	72 (5° angle step)	50	10
Multibeam	200 kHz	130 (3° angle step)		
Side-scan sonar	120 kHz, 410 kHz	236 (see Table 73 for angle steps)	3	5
Sub-bottom profiler	14 kHz	90 (4° angle step)		

Table 73. Angle step configuration of profiles around side-scan sonar. In total, 236 profiles were modeled.

Horizontal range, in degrees, around source	Angle step, in degrees, for profiles
0–45	3
45–75	2
75–84	1
84–88	0.4
88–92	0.2
92–96	0.4
96–105	1
105–135	2
135–225	3
225–255	2
255–264	1
264–268	0.4
268–272	0.2
272–276	0.4
276–285	1
285–315	2
315–360	3

7.3.2.2. Range to Zero-to-Peak SPL Isopleths

To evaluate the risk of acoustic injury, the range to the unweighted, zero-to-peak SPL (dB re 1µPa) is needed for the 200 dB isopleth (high frequency cetaceans) and 230 dB isopleth (low and medium frequency cetaceans). The spherical spreading law:

$$L_{pk}(R) = L_{pkSL} - 20 \cdot \log(R)\,,$$

where L_{pkSL} is the peak SPL source level of the source and R is the range, was assumed as the propagation model for peak SPL. The ranges to the thresholds were calculated for each source (Table 74).

Table 74. Ranges to specific threshold levels for all sources.

Source	Source level (peak SPL; dB)	Range (m)	
		230 dB peak SPL	200 dB peak SPL
8000 in^3 airgun array	255.2	18	575
90 in^3 airgun array	227.7	–	24
Side-scan sonar	213	–	4.5
Sub-bottom profiler	203	–	–
Multibeam echosounder	206	–	–

7.3.2.3. Per-Pulse Acoustic Field for Threshold Ranges

The per-pulse acoustic fields were processed to provide two products:

- Tables of ranges to specific thresholds from 210 dB down to 110 dB with a 10 dB step
- Maps of the acoustic field around the sources

The tables of threshold ranges can help to determine at what range from each source a potential exposure can occur. The maps provide the view of azimuthal variability of the received acoustic field. Appendix E provides a sample of the tables of threshold ranges and maps for Site CM3 (Central-Slope zone, 750 m water depth). Appendix E provides results for all sources in Box 4 for Seasons 1 and 3 and in SEL and rms SPL metric. The threshold ranges were calculated for all applicable M-weighting filters.

7.3.3. 24-hour Exposure Estimates

Simulations were run in the 3MB survey areas (Section 7.2.5) and, using JEMS, were convolved with the per-pulse acoustic fields (Section 7.3.2). The result is the time history of acoustic exposure (received levels) for the animats in the simulation. There were many animats in the simulations and together their received levels represent the probability, or risk, of exposure for each survey. This can be seen by plotting the received levels as a histogram. Figure 125 shows the received-level SEL in a 24 h window for *Kogia* species. The frequency of occurrence of the received levels is plotted as a function of the received level, so the histogram is a discretized representation of the exposure probability density function (PDF). PDFs are often normalized so that the area under the curve is equal to 1. That can be accomplished by dividing by the modeling animat density to get the probability of occurrence for the operation. It is the number of animals exposed to levels exceeding threshold that we are interested in, so the probability can be multiplied by the real-world density of animals in the simulation area. Therefore, the number of individual animals expected to exceed threshold is the number of animats exposed to levels exceeding threshold multiplied by the real-world animal density/model animat density.

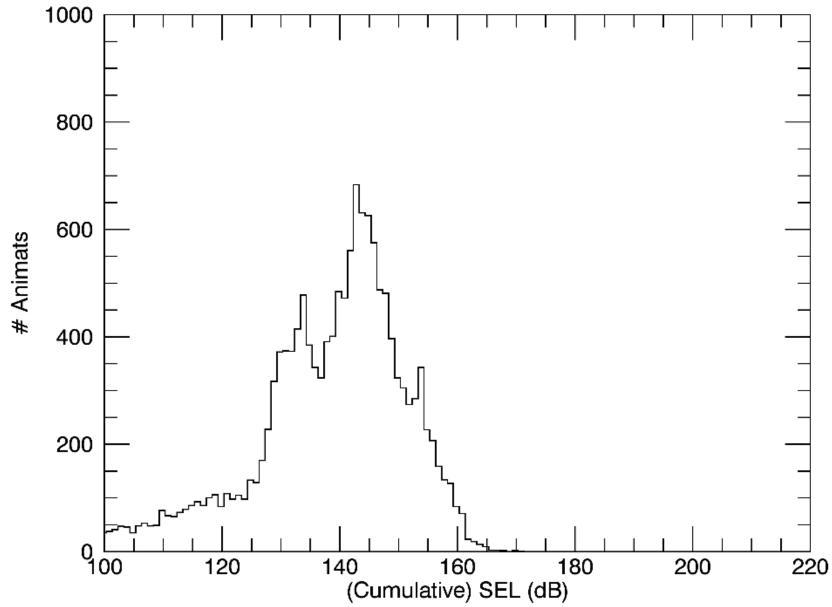


Figure 125. Probability density function of received levels shown as a histogram. Cumulative SEL for Kogia species using short-finned pilot whales as the surrogate and high-frequency weighting in Box 3 for a 2-D survey. The SEL threshold for injury is 161 dB re 1 μPa^2·s. 91 animats exceeded the threshold in this 24 h window.

Seven-day simulations were run and the number of animats exposed to levels exceeding threshold were determined in 24 h windows within the seven days. In a sliding-window approach, the first 24 h window begins at the start of the simulation and each subsequent window is advanced by 4 h. This gave 42 samples for each survey, and the mean value was used as the 24 h estimate for that survey. The number of individuals exposed to levels exceeding the NMFS criteria, 180 and 160 dB rms SPL, respectively for injury and behavior, were found. Additional metrics were used to evaluate potential injury, cumulative SEL and zero-to-peak SPL. SEL was determined by summing acoustic energy received from each source integrated over 24 h. Range was used to determine the zero-to-peak SPL for each animat relative to each source. The number of animats within the range where the received level could exceed threshold were found. A graded function was also used as an additional metric to evaluate potential behavioral response. SEL used Type I weighting for low-frequency species (Bryde's whales) and Type II weighting for the mid- and high-frequency species. Type I weighting was used for rms SPL sound fields with the graded function to evaluate potential behavioral response. The remaining metrics (NMFS criteria and zero-to-peak SPL) were not weighted.

The number of real-world individual animals expected to exceed the various thresholds were calculated using the 24-hour averaged exposure estimates for animats in each of the zones corresponding to our Gulf of Mexico modeling zones (Section 7.2.3). To get the real-world individual exposure estimates, the modeled exposure estimates were scaled by the ratio of the mean real-world density estimate from the zone to the modeled density. The mean real-world density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation; Section 7.2.6, and Tables 62–68). The exposure estimates for real-world animals is then known for 24 hours of operations in each modeling zone, for each source, for each of the modelled seasons, and for each species. These values represent the number of real-world individual animals potentially exposed to levels exceeding the various threshold criteria instead of animats. By integrating these results with the predicted number of days of operations of each source type (see Table 75), Tables F-1 through F-81 provided the annual estimates for each source (for all modeled zones) for each of the modelled years.

7.3.4. Annual Exposure Estimates

The overall goal of this analysis was to estimate the number of exposures for each species for each year for the entire Gulf. Projections of survey level of effort for the different survey types for the Gulf Planning Areas (Eastern, Central, and Western; divided into shallow and deep zones) were provided by BOEM (Table 75). Our modeling zones and survey locations were chosen, in part, to coincide with the Planning Areas so that the survey projections could be easily used for scaling. The shallow portion of the east, central, and western Planning Areas were the same as our modeling zones 1–3. A portion of each of the deep parts of Planning Areas maps directly to our modeling zones 4–6. The remainder of the deep parts of the Planning Areas were combined as modeling zone 7. The 24 h exposure estimates were scaled by the projected number of survey days to get the annual aggregate exposure estimates. The annual aggregate results are shown in Appendix F. Tables 76–82 show the sum of the annual results representing the 2016–2025 decade exposure estimates. The exposure estimates are the number of individual animals with the potential to exceed each of the criteria used to evaluate potential injury (SEL, peak SPL, and 180 dB rms SPL) and potential behavioral disruption (the step function, and 160 dB rms SPL). The estimates are for each type of survey and for each marine mammal species.

Table 75. Projected level of effort in days (24 h) for survey types in years 2016 to 2025. 2-D seismic survey is an 8000 in^3 airgun array with 1 vessel. 3-D seismic survey is an 8000 in^3 airgun array with two vessels. The WAZ seismic survey is an 8000 in^3 airgun array with four vessels. Coil seismic survey is an 8000 in^3 airgun array with four vessels. Shallow hazards seismic survey is a 90 in^3 airgun. The high resolution sources include for side-scan sonar, multibeam, and sub-bottom profiler. VSP is an 8000 in^3 airgun array with one vessel.

Year	Zone	2-D	3-D	WAZ	Coil	Shallow hazards	Boomer	High resolution sources	VSP
2016	1	0	0	0	0	0	0	1	0
	2	0	243	0	0	2	0	19	0
	3	0	30	0	0	0	0	4	0
	4	0	0	0	0	0	0	0	0
	5	56	389	192	82	0	0	26	2
	6	0	186	49	21	0	0	10	0
	7	69	515	248	106	0	0	34	2
2017	1	0	0	0	0	0	0	1	0
	2	0	364	43	19	2	0	19	0
	3	0	0	0	0	0	0	4	0
	4	33	0	0	0	0	0	0	0
	5	0	389	192	82	0	0	26	2
	6	0	99	0	0	0	0	11	0
	7	30	502	241	103	0	0	34	2
2018	1	0	0	0	0	0	0	1	0
	2	0	243	0	0	2	0	18	0
	3	0	0	0	0	0	0	4	0
	4	0	0	0	0	0	0	1	0
	5	0	342	160	69	0	0	27	2
	6	0	186	49	21	0	0	12	0
	7	0	456	208	89	0	0	36	2

Year	Zone	2-D	3-D	WAZ	Coil	Shallow hazards	Boomer	High resolution sources	VSP
2019	1	0	0	0	0	0	0	0	0
	2	0	364	43	19	2	1	16	0
	3	0	30	0	0	0	0	3	0
	4	66	61	21	9	0	0	1	0
	5	28	247	96	41	0	0	27	2
	6	0	99	0	0	0	0	12	0
	7	94	380	140	60	0	0	36	2
2020	1	0	0	0	0	0	0	0	0
	2	0	243	0	0	0	0	20	0
	3	0	0	0	0	0	0	3	0
	4	0	92	0	0	0	0	0	0
	5	0	295	192	82	2	1	25	2
	6	0	99	0	0	0	0	13	0
	7	0	467	241	103	3	2	34	3
2021	1	0	0	0	0	0	0	0	0
	2	0	364	43	19	0	0	18	0
	3	0	0	0	0	0	0	2	0
	4	0	92	0	0	0	0	1	0
	5	0	247	160	69	0	0	30	2
	6	0	186	49	21	0	0	13	0
	7	0	421	208	89	0	0	40	3
2022	1	0	0	0	0	0	0	0	0
	2	0	243	0	0	0	0	16	0
	3	0	30	0	0	0	0	2	0
	4	33	61	21	9	0	0	1	0
	5	28	247	160	69	0	0	32	2
	6	0	99	0	0	0	0	13	0
	7	64	380	220	94	0	0	43	3
2023	1	0	0	0	0	0	0	0	0
	2	0	364	43	19	0	0	16	0
	3	0	0	0	0	0	0	2	0
	4	11	61	0	0	0	0	1	0
	5	9	247	128	55	0	0	35	2
	6	0	99	0	0	0	0	13	0
	7	21	380	160	69	0	0	46	3
2024	1	0	0	0	0	0	0	0	0
	2	0	243	0	0	0	0	16	0
	3	0	0	0	0	0	0	2	0
	4	0	61	0	0	0	0	1	0

Year	Zone	2-D	3-D	WAZ	Coil	Shallow hazards	Boomer	High resolution sources	VSP
	5	0	200	192	82	0	0	35	2
	6	0	99	0	0	0	0	14	0
	7	0	321	241	103	0	0	47	3
2025	1	0	0	0	0	0	0	0	0
	2	0	364	43	19	0	0	13	0
	3	0	30	0	0	0	0	2	0
	4	5	61	0	0	0	0	1	0
	5	0	200	160	69	0	0	37	2
	6	0	99	0	0	0	0	14	0
	7	5	321	200	86	0	0	49	3

Table 76. Decade exposure estimates totals for 2-D survey (8000 in3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	15.4	0.4	799.2	11119.4	25677.0
Beaked whales	8.6	0.2	817.5	63149.9	14473.3
Common bottlenose dolphins	38.3	2.7	1537.0	28167.1	62589.2
Bryde’s whales	0.1	1.6	10.6	170.7	206.9
Clymene dolphins	53.3	4.1	1323.7	24009.2	44719.5
False killer whales	11.4	0.3	357.1	5674.4	10068.6
Fraser’s dolphins	5.3	0.1	434.5	3293.6	5461.2
Killer whales	0.6	0.0	51.3	356.0	513.9
Kogia	695.3	54.8	562.3	4109.2	9529.1
Melon-headed whales	27.5	0.5	2042.3	16758.4	30165.0
Pantropical spotted dolphins	392.2	32.9	9484.5	147959.4	233759.0
Pygmy killer whales	8.8	0.2	271.9	4103.6	6791.7
Risso’s dolphins	14.4	1.6	386.5	6152.2	11897.9
Rough-toothed dolphins	14.1	0.5	445.9	7404.2	13861.5
Short-finned pilot whales	6.4	0.1	373.6	3756.0	7949.1
Sperm whales	5.3	0.5	1155.7	8440.7	17049.9
Spinner dolphins	37.5	2.4	975.3	22080.0	48754.6
Striped dolphins	24.4	2.0	600.2	10310.2	18203.5

Table 77. Decade exposure estimates totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	3058.8	291.8	425998.1	1228034.9	1667456.2
Beaked whales	280.9	14.8	26069.3	1110419.9	278440.7
Common bottlenose dolphins	20841.3	987.6	2473207.9	6923848.5	8897488.1
Bryde's whales	1.9	80.1	290.4	3445.4	4136.5
Clymene dolphins	2178.8	188.1	42251.2	511975.3	958233.2
False killer whales	608.9	63.7	14073.8	123229.2	222375.7
Fraser's dolphins	287.4	20.1	11851.7	66174.0	110436.2
Killer whales	26.4	3.0	1464.6	6780.5	9922.1
Kogia	13737.4	3033.6	14719.0	76595.1	170808.1
Melon-headed whales	1378.5	103.4	54084.8	324416.8	577869.6
Pantropical spotted dolphins	12361.1	633.0	263990.9	2766953.3	4444346.7
Pygmy killer whales	449.7	43.4	9594.2	85023.0	147507.7
Risso's dolphins	554.3	80.1	11917.9	124421.0	230226.7
Rough-toothed dolphins	899.8	96.1	34970.6	212341.8	367525.5
Short-finned pilot whales	372.7	47.3	13308.4	92144.7	188732.9
Sperm whales	209.8	9.9	39711.3	200875.5	440333.7
Spinner dolphins	1326.5	52.8	26421.5	379755.9	755780.9
Striped dolphins	864.9	57.0	17617.0	202165.4	356206.0

Table 78. Decade exposure estimates totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	200.0	7.7	46492.0	176331.1	297393.7
Beaked whales	35.7	0.4	18840.3	509016.2	122280.5
Common bottlenose dolphins	731.6	23.9	214892.9	740252.6	1266979.2
Bryde's whales	0.4	8.0	232.1	1537.8	1778.4
Clymene dolphins	382.2	9.9	24392.2	242870.1	423953.6
False killer whales	90.8	7.8	6945.0	52221.3	88802.1
Fraser's dolphins	38.8	0.4	9055.6	30624.1	46756.5
Killer whales	3.8	0.6	984.1	3607.6	4493.7
Kogia	17564.6	328.7	11860.7	36823.3	78907.1
Melon-headed whales	192.9	1.9	42915.7	153249.3	254568.5
Pantropical spotted dolphins	2530.6	23.2	168480.7	1463671.7	2233856.1
Pygmy killer whales	70.6	6.8	5232.3	37762.1	60391.3
Risso's dolphins	95.7	11.8	5304.4	61686.3	107841.1
Rough-toothed dolphins	114.8	8.7	9990.9	71087.6	124947.1
Short-finned pilot whales	45.2	1.3	8862.5	35979.0	71216.1
Sperm whales	70.2	0.5	31667.8	88325.5	182929.6
Spinner dolphins	268.6	0.7	17124.8	208893.6	410523.8
Striped dolphins	165.7	2.6	10805.2	102441.1	170483.2

Table 79. Decade exposure estimates totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	289.2	9.1	13749.8	43206.0	61621.2
Beaked whales	99.3	4.0	5927.4	126419.5	25788.4
Common bottlenose dolphins	1408.5	72.1	53895.2	168113.4	206461.0
Bryde's whales	0.7	28.1	55.8	339.3	365.1
Clymene dolphins	705.8	36.8	11518.1	60515.5	86456.1
False killer whales	172.4	7.0	4008.4	17015.2	26092.4
Fraser's dolphins	78.7	1.8	2626.7	7884.0	9747.0
Killer whales	8.0	0.4	372.4	937.4	1085.9
Kogia	3430.4	925.4	3477.7	9621.9	16570.1
Melon-headed whales	380.8	9.2	12526.0	39889.1	53267.6
Pantropical spotted dolphins	5027.9	288.9	78535.6	363843.5	473365.5
Pygmy killer whales	130.8	5.0	3032.9	12322.3	18068.9
Risso's dolphins	193.1	16.9	2913.9	15014.2	20920.1
Rough-toothed dolphins	220.8	9.5	5459.9	22950.9	35966.9
Short-finned pilot whales	81.3	2.3	2637.2	9621.6	14859.6
Sperm whales	65.3	5.5	8703.0	24374.2	40181.5
Spinner dolphins	473.7	21.0	8156.9	51218.3	81117.5
Striped dolphins	316.6	17.2	5071.9	25453.3	35226.2

Table 80. Decade exposure estimates totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	7.0	50.1	104.1
Beaked whales	0.0	0.0	0.0	34.8	1.8
Common bottlenose dolphins	0.0	0.0	57.7	228.8	353.6
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	1.0	2.9	3.4
False killer whales	0.0	0.0	0.2	0.9	1.4
Fraser’s dolphins	0.0	0.0	0.2	0.5	0.7
Killer whales	0.0	0.0	0.0	0.1	0.1
Kogia	0.1	0.0	0.3	0.5	0.9
Melon-headed whales	0.0	0.0	1.1	2.0	3.1
Pantropical spotted dolphins	0.0	0.0	6.1	20.0	25.3
Pygmy killer whales	0.0	0.0	0.2	0.5	0.7
Risso’s dolphins	0.0	0.0	0.2	0.7	1.1
Rough-toothed dolphins	0.0	0.0	0.5	4.6	7.7
Short-finned pilot whales	0.0	0.0	0.2	0.4	0.7
Sperm whales	0.0	0.0	0.4	2.1	4.6
Spinner dolphins	0.0	0.0	1.0	2.3	2.3
Striped dolphins	0.0	0.0	0.4	1.3	1.6

Table 81. Decade exposure estimates totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	1.3	7.5	15.0
Beaked whales	0.0	0.0	0.0	23.2	1.2
Common bottlenose dolphins	0.0	0.0	9.0	33.3	51.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.7	1.9	2.3
False killer whales	0.0	0.0	0.1	0.5	0.7
Fraser's dolphins	0.0	0.0	0.2	0.3	0.4
Killer whales	0.0	0.0	0.0	0.0	0.1
Kogia	0.1	0.0	0.2	0.4	0.6
Melon-headed whales	0.0	0.0	0.7	1.3	2.0
Pantropical spotted dolphins	0.0	0.0	4.1	13.3	16.8
Pygmy killer whales	0.0	0.0	0.1	0.3	0.5
Risso's dolphins	0.0	0.0	0.1	0.5	0.8
Rough-toothed dolphins	0.0	0.0	0.2	1.1	1.7
Short-finned pilot whales	0.0	0.0	0.1	0.3	0.4
Sperm whales	0.0	0.0	0.3	1.4	3.1
Spinner dolphins	0.0	0.0	0.6	1.5	1.5
Striped dolphins	0.0	0.0	0.3	0.9	1.0

Table 82. Decade exposure estimate totals for the high resolution sources (side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	8.2	9.0	34.3	11.4
Beaked whales	0.0	0.7	0.7	45.6	0.0
Common bottlenose dolphins	0.0	95.2	122.8	245.3	68.5
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.1	0.1	0.1	0.0
False killer whales	0.0	0.0	0.0	0.1	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.1	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.1	0.1	0.1	0.0
Pantropical spotted dolphins	0.0	0.4	0.4	0.4	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.4	0.4	1.6	0.7
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.3	0.4	0.5	0.0
Spinner dolphins	0.0	0.1	0.1	0.1	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

8. Discussion

This study provides estimates of annual marine mammal acoustic exposure due to geological and geophysical exploration activity in the Gulf of Mexico for years 2016 to 2025. Exposure estimates were computed from modeled sound levels received by simulated animals for several types of geophysical surveying. Because animals and sources move relative to the environment and each other, and the sound fields generated by the sources are shaped by various physical parameters, the sound levels received by an animal are a complex function of location and time. The basic modeling approach was to use acoustic models to compute the three-dimensional (3-D) sound fields and their variations in time. Simulated animals (animats) were modeled moving through these fields to sample the sound levels in a manner similar to how real animals would experience these sounds. From the time histories of the received sound levels of all animats, the numbers of animals exposed to levels exceeding effects threshold criteria were determined and then adjusted by the number of animals expected in the area, based on density information, to estimate the potential number of animals impacted.

In the preliminary Phase I component of this study (Section 6.3), a Test Case simulating a typical 3-D WAZ survey at two locations was performed to demonstrate and test the basic modeling approach and, importantly, to evaluate its limitations and accuracy of results prior to employing the methods in the main Phase II study (Section 7.2). A series of Test Scenarios were examined using, primarily, the results of the Test Case to investigate the effects of methodological choices on exposure estimates. With the overall modeling goal to estimate exposure levels from future survey activity whose individual details such as exact location and duration are unknown, a primary concern was how to scale results to account for different survey types, locations and spatial extents, and durations.

In Test Scenario 1 (Section 6.5.1), issues arising when estimating impacts during long-duration surveys were investigated and a method was suggested. In this study, a 24 h reset period was used, meaning that received levels for all animats were reset to zero after any 24 h evaluation period. For time-based, SEL metrics, energy accumulation was restarted at zero after 24 h, and the time-independent SPL metrics maximum values were reset to zero. After each reset, animals were again available to be taken (counted as exposed above the effects threshold). A reset period creates a scaling time-basis for impact analysis, and 24 h is short relative to most surveys. It was shown in Test Scenario 1 that scaling (multiplying) the average 24 h exposure estimate by the number of days of survey was more conservative (produced lower number of animats exposed to levels exceeding threshold) than evaluating exposure for longer periods because individual animats could be counted multiple times. The parameters governing animal movement were obtained from short-duration events, such as several dives, and for this modeling project did not include long-duration behavior like migration or periodically revisiting an area as part of a circulation pattern. These behaviors could be modeled, but there are no data available currently to support detailed modeling of this type of behavior in the Gulf of Mexico.

It was also found in Test Scenario 1 that the location-specific details of the survey had the greatest impact on exposure estimates—that is, whether the survey is conducted in shallow or deep water has a greater influence on exposure estimates than trends due to short-duration movement of the animats. Because specific location details for future surveys were not know, the modeling goal was to determine accurate 24 h exposure estimates from representative surveys in the areas where future surveys may be conducted. The simulations should cover relevant acoustic environments, including areas with different sound velocity profiles, depths, and geoacoustic properties. Seven day simulations were chosen to ensure differing environments would be sampled.

Sound velocity profiles change continuously, but it was shown in Test Scenario 2 (Section 6.5.2) that the primary difference in acoustic propagation due to changes in the sound velocity profile was the presence or absence of a sound conducting channel near the surface. In the Gulf, a surface duct only occurs in the winter season. To account for this difference in acoustic propagation, simulations were performed in winter and summer (with summer also representing spring and fall). The seven day simulations were analyzed in 24 h periods using a sliding window approach to get the average 24 h estimate for each survey type in each modeling zone. Future surveys of unknown duration may be conducted during any portion of the year and in any location within a specified Planning Area, so the aim of the modeling and analysis was to determine accurate 24 h exposure estimates to be scaled by the projected level of effort for the different survey types in order to provide yearly exposure estimates.

With any modeling exercise, uncertainty in the input parameters results in uncertainty in the output. Sources of uncertainty and their effects on exposure estimates were investigated in Test Scenario 2. The primary source of uncertainty in this project was the location of the animals at the times of the surveys, which drives the choice of using an agent-based modeling approach and Monte Carlo sampling. Uncertainty in the density estimates of the animals is related to the uncertainty in the location of the animals. For the Phase II assessment we used density estimates from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation) (Section 7.2.6.1). The model does not include seasonal variations of densities in the Gulf, and because surveys could occur at any location within a Planning Area, the density estimates were taken over an entire modeling zone. Similarly, the density was assumed to be uniform and static over the area covered by each survey. Real world animal densities can fluctuate significantly, but assuming many surveys will be conducted in many locations the variations in density are expected to average toward the mean. Sources of uncertainty in the other modeling parameters were found to affect the variance of the modeling results, as opposed to their mean. Our common use of mean input parameters is therefore justified by the same argument as using mean animal densities. For example, the nominal pressure of an operating airgun array may be specified as 2000 psi, but in practice the pressure will sometimes be higher or lower; therefore, the source level will be somewhat higher or lower. Again, over many surveys the average source level, and therefore received sound levels, will tend toward the specified nominal values. The effects of the variability in many of the modeling parameters on exposure estimates were quantified using a resampling technique (Bootstrap resampling). It was found that uncertainty in parameters such as animal density and social group size had a profound effect on the distribution of the exposure estimates, but not on the mean exposure. That is, the distribution shape and range of the number of animals above threshold changed, but the mean number of animals above threshold remained the same. Though a relatively minor effect, a small variability in the source level could increase the number of animals above threshold because the numbers of animals just below threshold is usually greater than the number of animats just above threshold.

Some modeling options do affect the mean of the exposure estimates. Mitigation procedures, such as shutting down the airgun array when animals were detected within an established exclusion zone, could reduce the injury exposure estimates. Mitigation effectiveness, (Test Case 3, Section 6.5.3), was found to be influenced by several factors, such as the density of the animals in the survey area and detection probability. Some species are more easily detected than others, and detection probability varies with weather and observational set up. Weather during any seismic survey is unknown beforehand and detection probabilities are difficult to predict. As a conservative measure, the potential effects of mitigation were not included in the exposure estimates.

Likewise, aversion, or animals avoiding loud or annoying sounds, could lead to reduced numbers of injury exposure estimates (Test Case 4, Section 6.5.4). Aversion is a behavioral response and depends on the context in which the sound is received and on biological factors, such as energetic and reproductive state, sociality, and health status of individual animals. Currently, too little is known about the factors that could influence aversion, including the thresholds for received sound levels that might elicit an aversion response, or movement of averting animals to justify decreasing the exposure estimates by assuming aversion.

In summary, the choice of a 24 h resetting period separated the analysis of a survey into portions typically much shorter duration than the survey itself. The average 24 h exposure estimate scaled by the duration of the survey in days gives the exposure estimate for the total survey. There is variance associated with 24 h exposure estimates due to sampling, movement of the survey, and uncertainty in modeling parameters. Variance, in general, affects the distribution shape of the number of animals above exposure criteria, but it did not significantly affect the mean number of animals above the criteria. When many surveys are pooled the effects of uncertainty are decreased. The aim of Phase II components of this study was to estimate the exposure distributions for each species, for each year, and over the entire gulf that result from many surveys. The resulting exposure estimates of Phase II represent the aggregate average exposure risk from future surveys given the specified levels of effort for each survey type in each year.

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Appendix A. Per-Pulse Acoustic Field Example Radii Tables and Maps

As with the per-pulse acoustic field input to ESME (Section 6.3.1.2), the per-pulse acoustic field for exclusion zone radii were computed for the Survey sites A and B modeling locations. Transmission loss was modeled along 72 radial profiles (angular step 5°) to the range of up to 130 km from the source location. The horizontal step along the radials was 10 m. At each surface sampling location, the sound field was sampled at multiple depths:

- 2 m
- Every 5 m from 5 to 25 m
- Every 25 m from 50 to 100 m
- Every 50 m from 150 to 300 m
- Every 100 m from 400 to 1200 m
- Every 200 m from 1400 to 3000 m

At each sampling range along the surface, the sound field was sampled at various depths. The received SEL at a surface sampling location was taken as the maximum value that occurs over all samples within the water column below, i.e., the maximum-over-depth received SEL. This provided a conservative prediction of the received sound level around the source, independent of depth. These maximum-over-depth per-pulse SELs were also converted to rms SPL estimates and are presented as color contours around the source in the shaded maps in Figures 126–128. For each sound level threshold, two statistical estimates of the safety radii are provided: (1) the maximum range (R_{max}, in meters) and (2) the 95% range ($R_{95\%}$, in meters). Given a regularly gridded spatial distribution of sound levels, the $R_{95\%}$ for a given sound level was defined as the radius of the circle, centered on the source, encompassing 95% of the grid points with sound levels at or above the given value. This definition is meaningful in terms of potential impact to animals because, regardless of the shape of the contour for a given sound level, $R_{95\%}$ is the range from the source beyond which less than 5% of a uniformly distributed population would be exposed to sound at or above that level. The R_{max} for a given sound level is simply the distance to the farthest occurrence of the threshold level (equivalent to $R_{100\%}$). It is more conservative than $R_{95\%}$, but may overestimate the effective exposure zone. For cases where the volume ensonified to a specific level is discontinuous and small pockets of higher received levels occur far beyond the main ensonified volume (e.g., due to convergence), R_{max} would be much larger than $R_{95\%}$ and could therefore be misleading if not given along with $R_{95\%}$.

The per-pulse threshold radii for the 8000 in^3 airgun array, with August sound speed profile, are presented at three modeling sites. Radii for the two Survey site A provinces, S01 and S02, are presented in Tables 83 and 84; and for the Survey site B province, D01, in Table 85. The maps of maximum-over-depth sound pressure levels around the sources are also provided in Figures 126, 127, and 128, respectively.

Table 83. 8000 in³ airgun array at the Survey site A, S01 modeling province: maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband (10–5000 Hz) maximum-over-depth sound level thresholds, for August, without and with auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC).

Type I M-Weighting									
SEL (dB re 1 µPa²·s)	SPL_{rms} (dB re 1 µPa)	Un-weighted		LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	210	40	40	40	32	10	10	< 10	< 10
190	200	150	130	140	120	50	50	30	30
180	190	500	410	480	390	150	132	120	110
170	180	1800	1460	1680	1370	510	455	390	351
160	170	4240	3680	4160	3580	1740	1560	1320	1160
150	160	10700	8690	10400	8580	5190	4470	4660	4160
140	150	34400	23700	31100	21400	14600	10300	11600	5240
130	140	> 130000	> 130000	> 130000	> 130000	57400	21100	21700	18600
120	130					> 130000	> 130000	> 130000	> 130000

Type II M-Weighting					
SEL (dB re 1 µPa²·s)	SPL_{rms} (dB re 1 µPa)	MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	210 †				
190	200 †	< 10	< 10	< 10	< 10
180	190 †	20	20	10	10
170	180 †	70	61	40	40
160	170 †	250	230	130	120
150	160 †	780	700	420	380
140	150 †	3800	2520	1430	1250
130	140 †	5630	4860	4940	4310
120	130 †	19900	13600	11800	5360
110	120 †	107000	56400	21900	18900
100	110 †	> 130000	> 130000	> 130000	> 130000

† rms levels computed by adding 10 dB to per-shot SEL levels.

Table 84. 8000 in³ airgun array at the Survey site A, S02 modeling province: maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband (10–5000 Hz) maximum-over-depth sound level thresholds, for August, without and with auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC).

Type I M-Weighting									
SEL (dB re 1 µPa²·s)	SPL_{rms} (dB re 1 µPa)	Un-weighted		LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	210 †	40	40	40	32	10	10	< 10	< 10
190	200 †	160	130	150	120	50	50	30	30
180	190 †	560	461	530	434	150	132	120	110
170	180 †	1580	1330	1540	1300	520	462	400	354
160	170 †	6490	4670	5770	4310	1870	1640	1690	1490
150	160 †	16500	12100	16500	11100	7370	6620	6950	4910
140	150 †	44500	32000	44400	29200	29600	16100	16700	15300
130	140 †	99300	80300	97900	75500	67000	49800	54500	40800
120	130 †	> 100000	> 100000	> 100000	> 100000	> 100000	> 100000	> 100000	> 100000

† rms levels computed by adding 10 dB to per-shot SEL levels.

Type II M-Weighting					
SEL (dB re 1 µPa²·s)	SPL_{rms} (dB re 1 µPa)	MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	210 †				
190	200 †	< 10	< 10	< 10	< 10
180	190 †	20	20	10	10
170	180 †	70	61	40	40
160	170 †	250	230	130	120
150	160 †	810	711	430	381
140	150 †	3920	2080	1730	1530
130	140 †	15800	7010	7010	5380
120	130 †	41900	27800	17100	15600
110	120 †	80900	62100	54600	41800
100	110 †	> 100000	> 100000	> 100000	> 100000

Table 85. 8000 in³ airgun array at the Survey site B, D01 modeling province: maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband (10–5000 Hz) maximum-over-depth sound level thresholds, for August, without and with auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC).

Type I M-Weighting									
SEL (dB re 1 µPa²·s)	SPL_{rms} (dB re 1 µPa)	Un-weighted		LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	210 †	40	40	40	32	10	10	< 10	< 10
190	200 †	150	130	140	120	50	50	30	30
180	190 †	500	404	470	383	150	132	120	110
170	180 †	1620	1310	1540	1240	510	454	390	352
160	170 †	5700	4270	5020	4070	1690	1500	1280	1120
150	160 †	19800	12700	14900	12700	6320	5620	4740	4140
140	150 †	47600	35100	43400	32100	15500	8970	9690	8810
130	140 †	101000	77300	100000	65900	20700	16800	18000	15600
120	130 †	> 130000	> 130000	> 130000	> 130000	34900	24300	26300	22000
110	120 †					71100	50300	53600	38900
100	110 †					> 130000	> 130000	128000	94300

† rms levels computed by adding 10 dB to per-shot SEL levels.

Type II M-Weighting					
SEL (dB re 1 µPa²·s)	SPL_{rms} (dB re 1 µPa)	MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
200	210 †				
190	200 †	< 10	< 10	< 10	< 10
180	190 †	20	20	10	10
170	180 †	70	61	40	40
160	170 †	250	230	130	120
150	160 †	770	683	420	373
140	150 †	2680	2370	1380	1210
130	140 †	8760	7820	5190	4500
120	130 †	16800	9530	9750	8870
110	120 †	23800	20100	18300	15700
100	110 †	43800	32200	26400	22200

† rms levels computed by adding 10 dB to per-shot SEL levels.

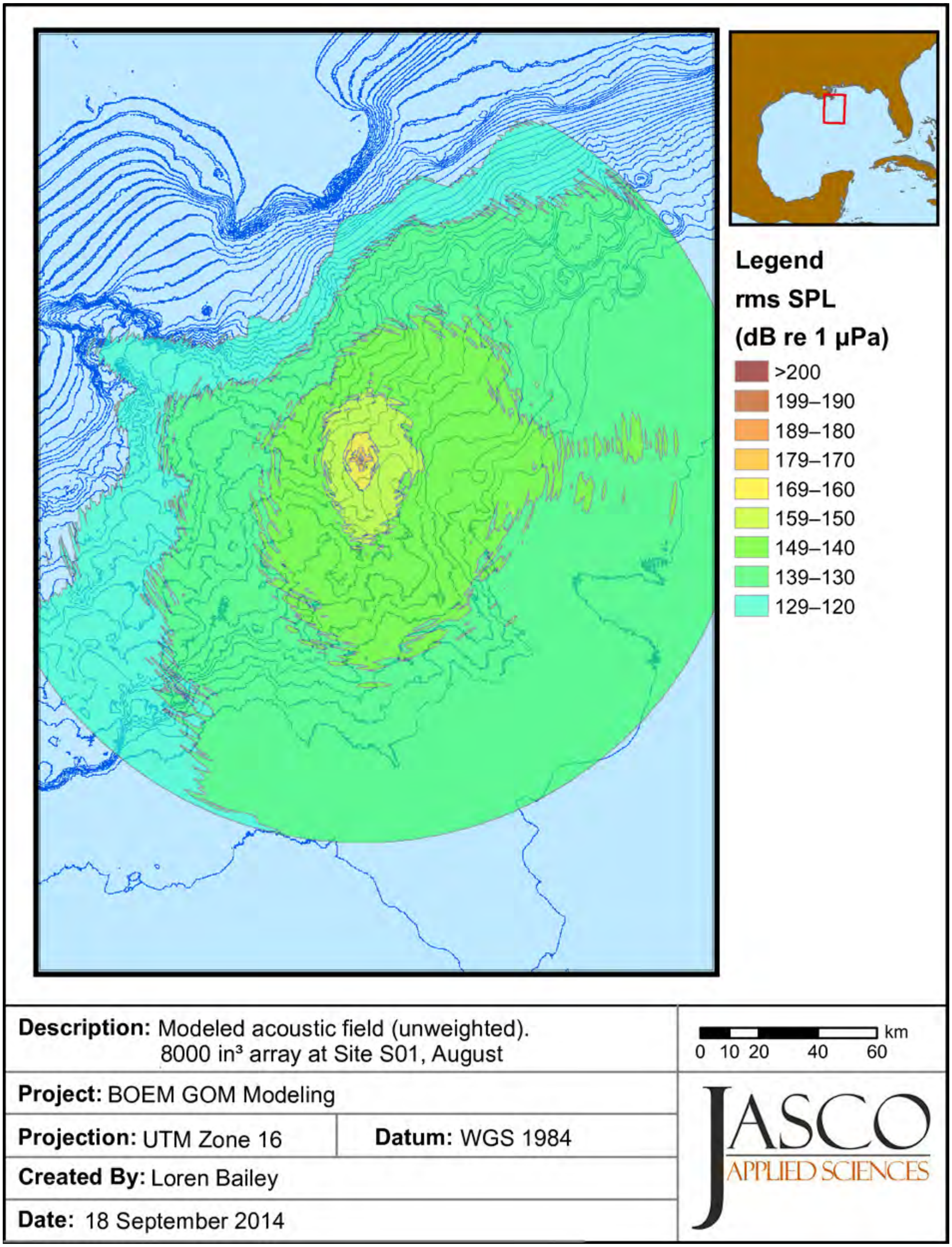

Figure 126. Broadband (10–5000 Hz) maximum-over-depth sound pressure levels for 8000 in³ airgun array, in August at the Survey site A, S01 modeling province. Blue contours indicate water depth in meters.

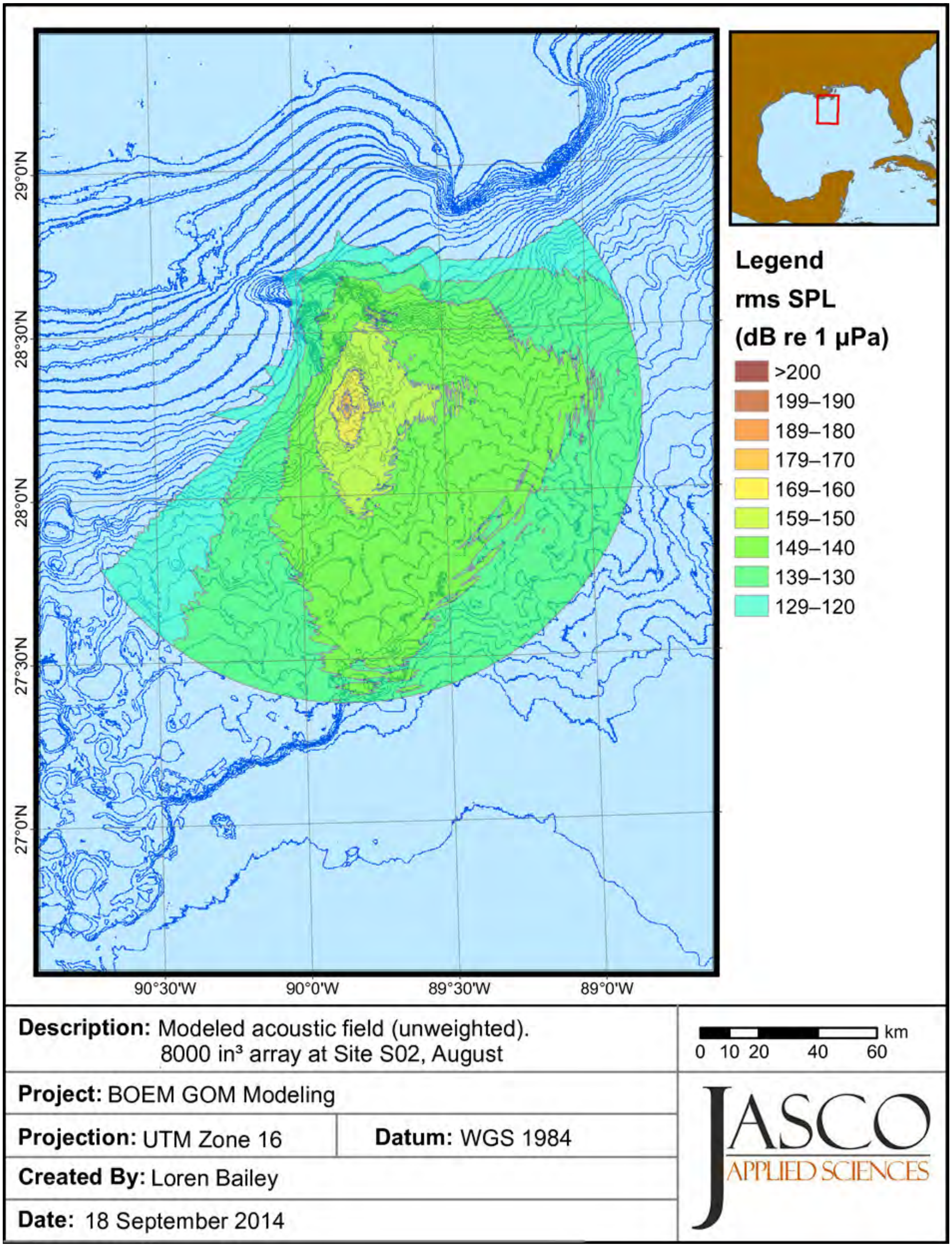

Figure 127. Broadband (10–5000 Hz) maximum-over-depth sound pressure levels for 8000 in³ airgun array, in August at the Survey site A, S02 modeling province. Blue contours indicate water depth in meters.

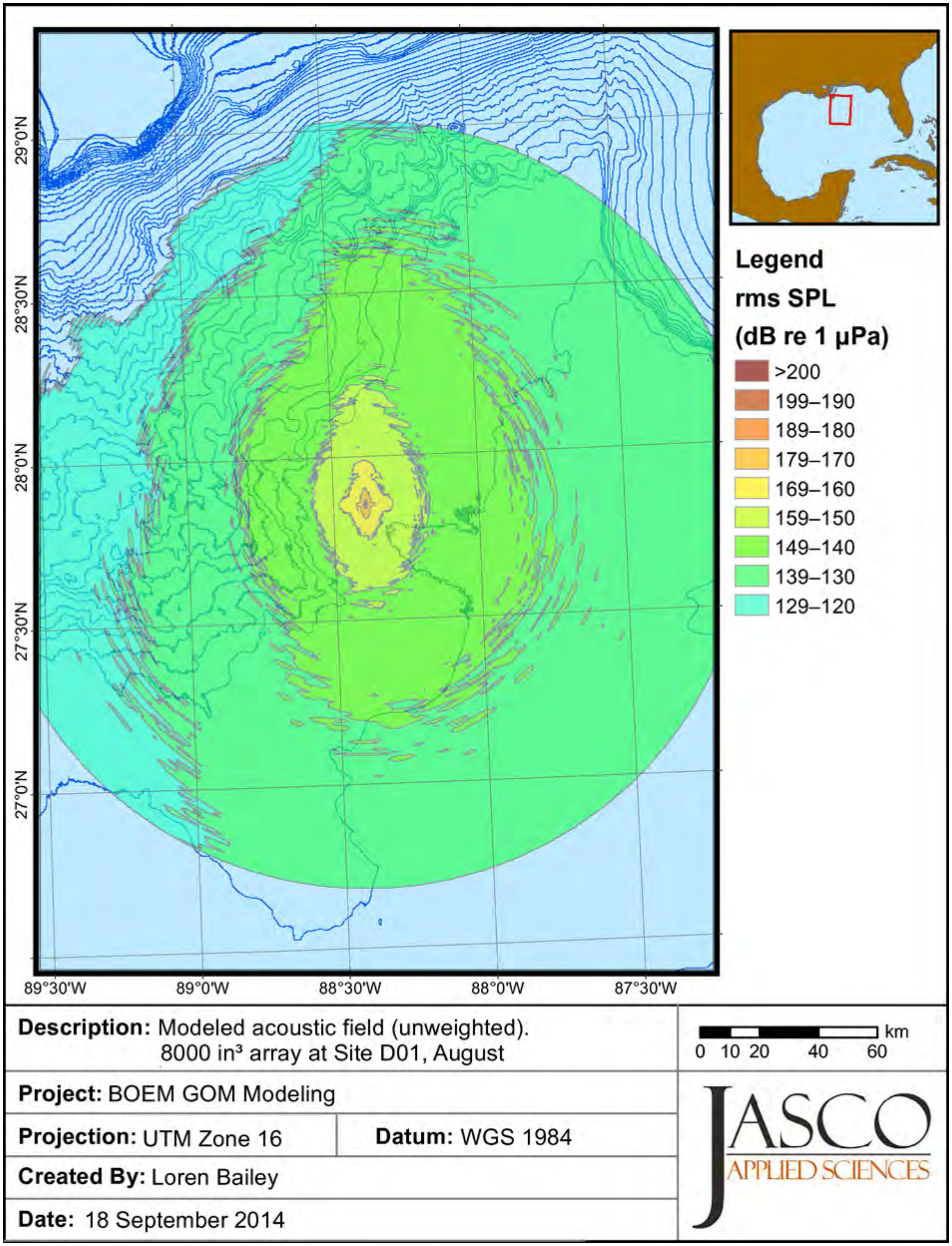

Figure 128. Broadband (10–5000 Hz) maximum-over-depth sound pressure levels for 8000 in³ airgun array, in August at the Survey site B, D01 modeling province. Blue contours indicate water depth in meters.

Appendix B. Test Case Simulation Received Levels

Figure B-1 to Figure B-6 show the occurrence frequency of cumulative SEL for all of the animats in the simulations for the combined acoustic energy of the airgun arrays during the five day simulation, panel A is Survey site A and panel C is Survey site B. The occurrence frequency of the maximum rms SPLs that animats received during the thirty-day simulation are shown in panel B for Survey site A and panel D for Survey site B

B.1. Bryde's Whales

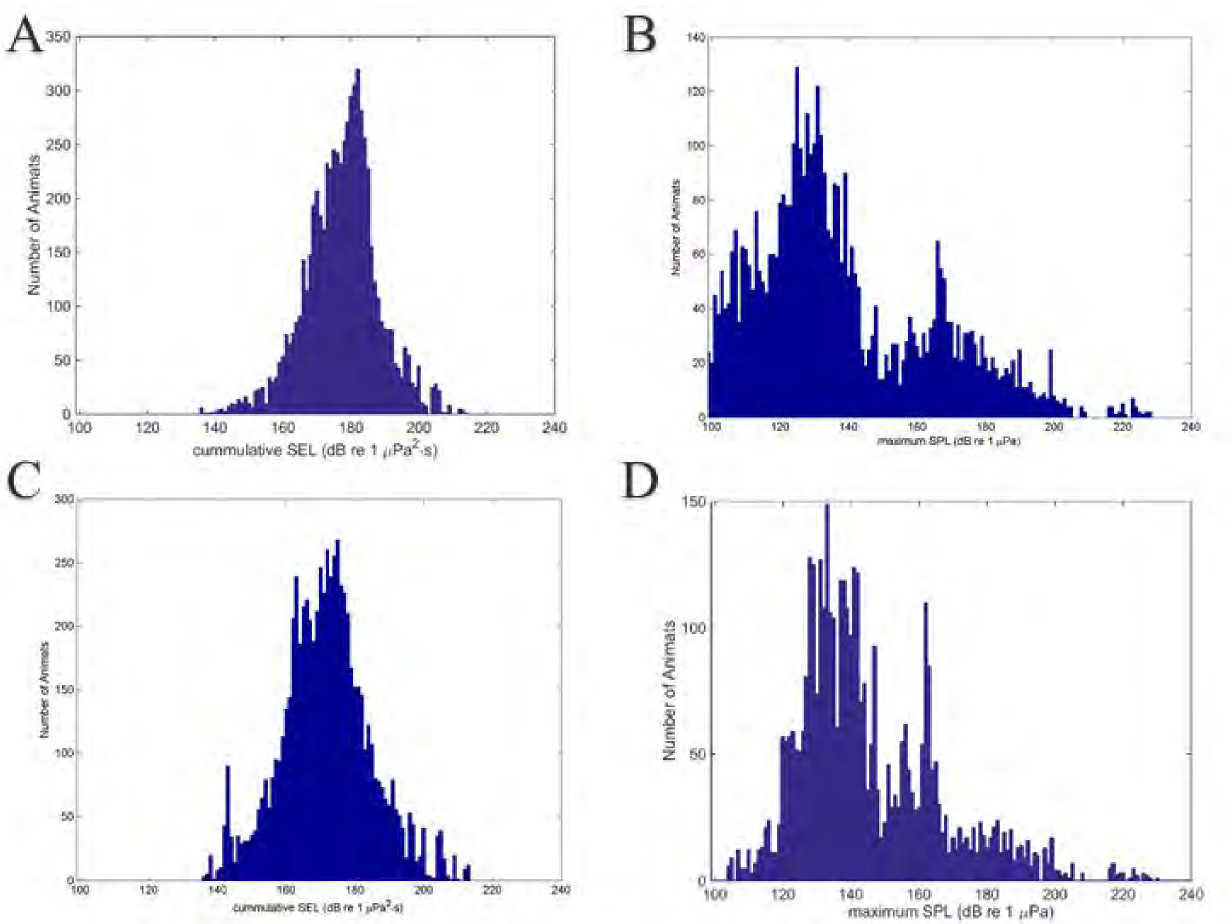

Figure B-1. Bryde's whale exposure frequency for injury (5 day) and behavior (30 day) simulations. (A) cumulative sound exposure level (SEL) for Survey site A; (B) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site A; (C) cumulative sound exposure level (SEL) for Survey site B; and (D) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site B.

B.2. Cuvier's Beaked Whales

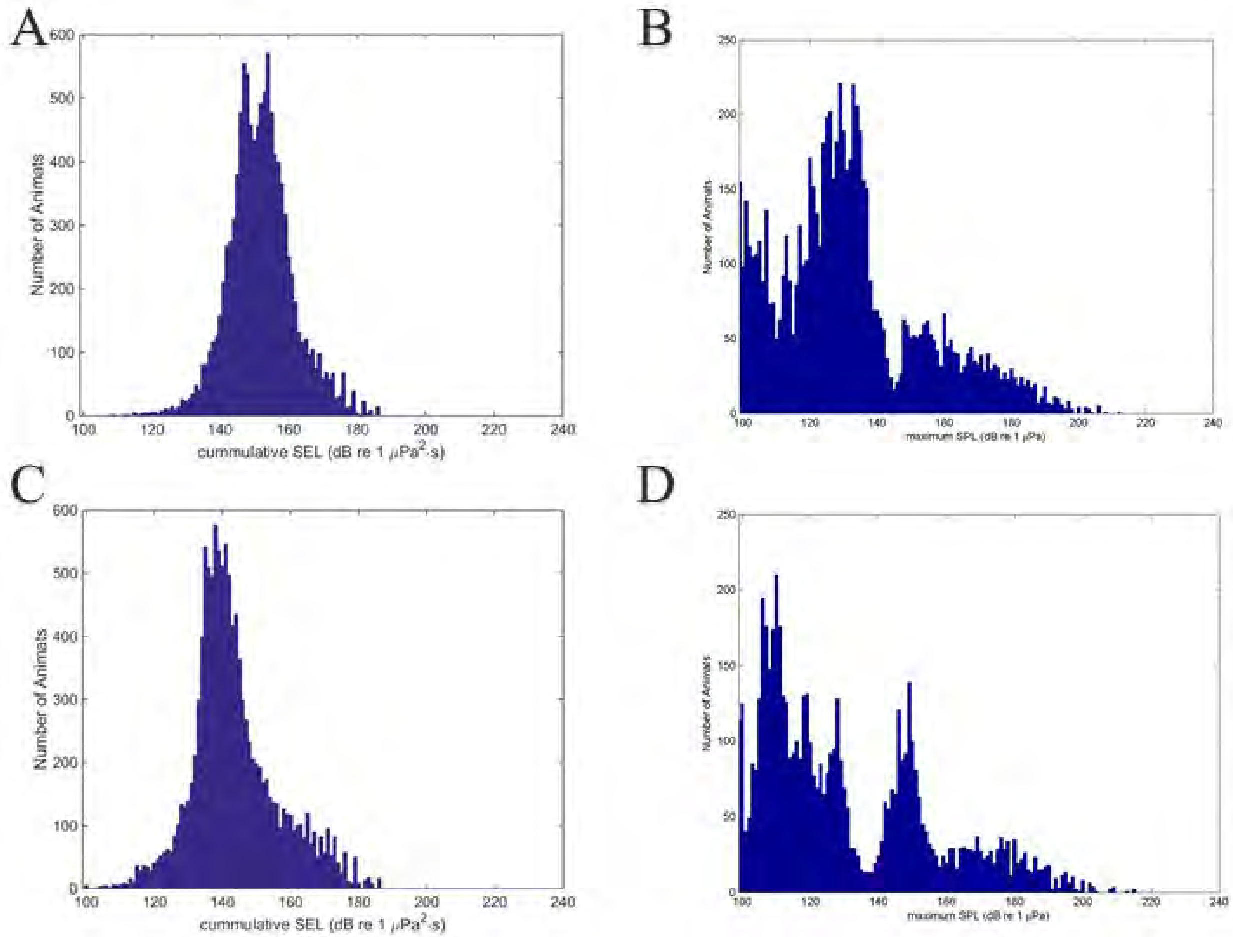

Figure B-2. Cuvier's beaked whale exposure frequency for injury (5 day) and behavior (30 day) simulations. (A) cumulative sound exposure level (SEL) for Survey site A; (B) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site A; (C) cumulative sound exposure level (SEL) for Survey site B; and (D) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site B.

B.3. Common bottlenose Dolphins

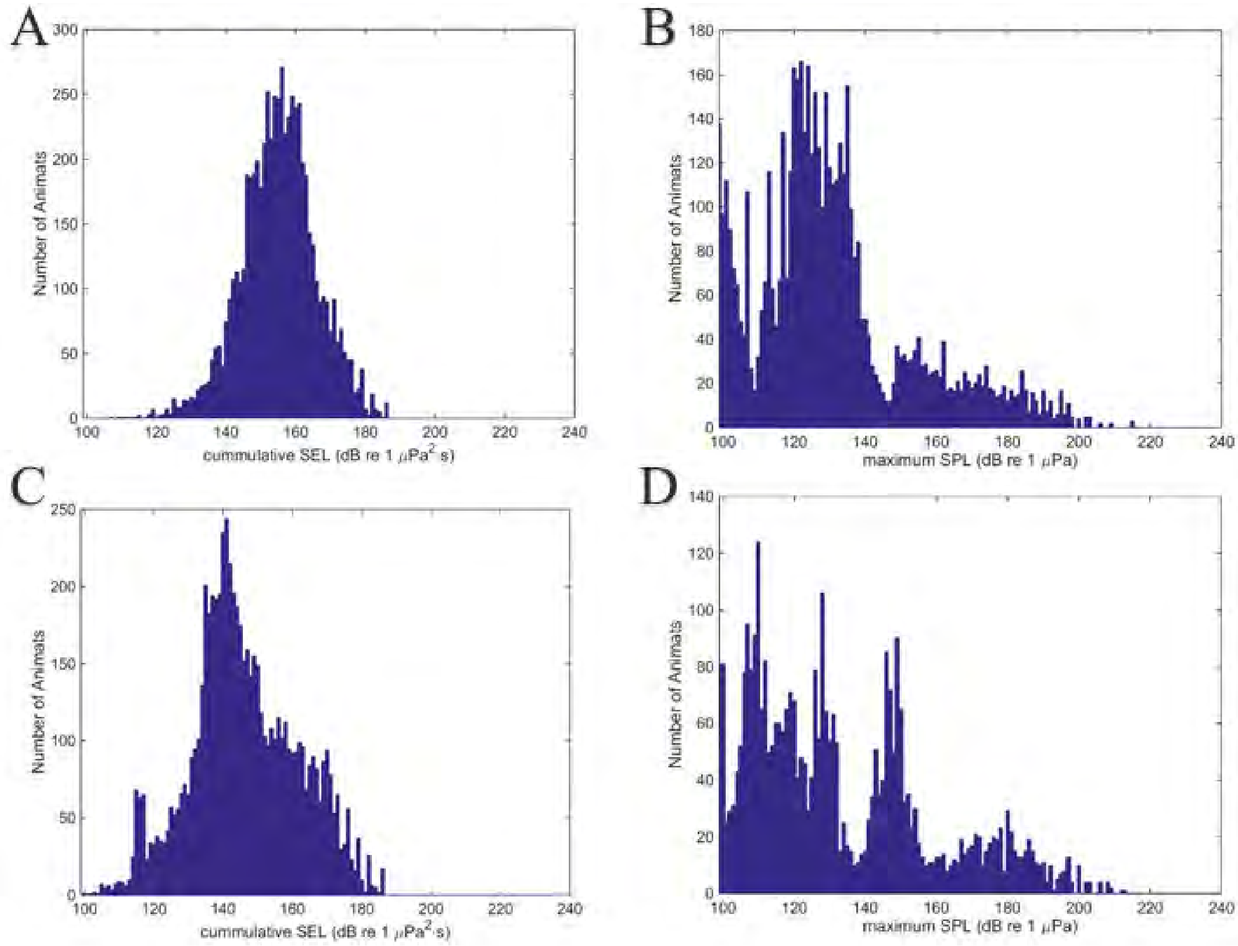

Figure B-3. Common bottlenose dolphin exposure frequency for injury (5 day) and behavior (30 day) simulations. (A) cumulative sound exposure level (SEL) for Survey site A; (B) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site A; (C) cumulative sound exposure level (SEL) for Survey site B; and (D) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site B.

B.4. Short-Finned Pilot Whales

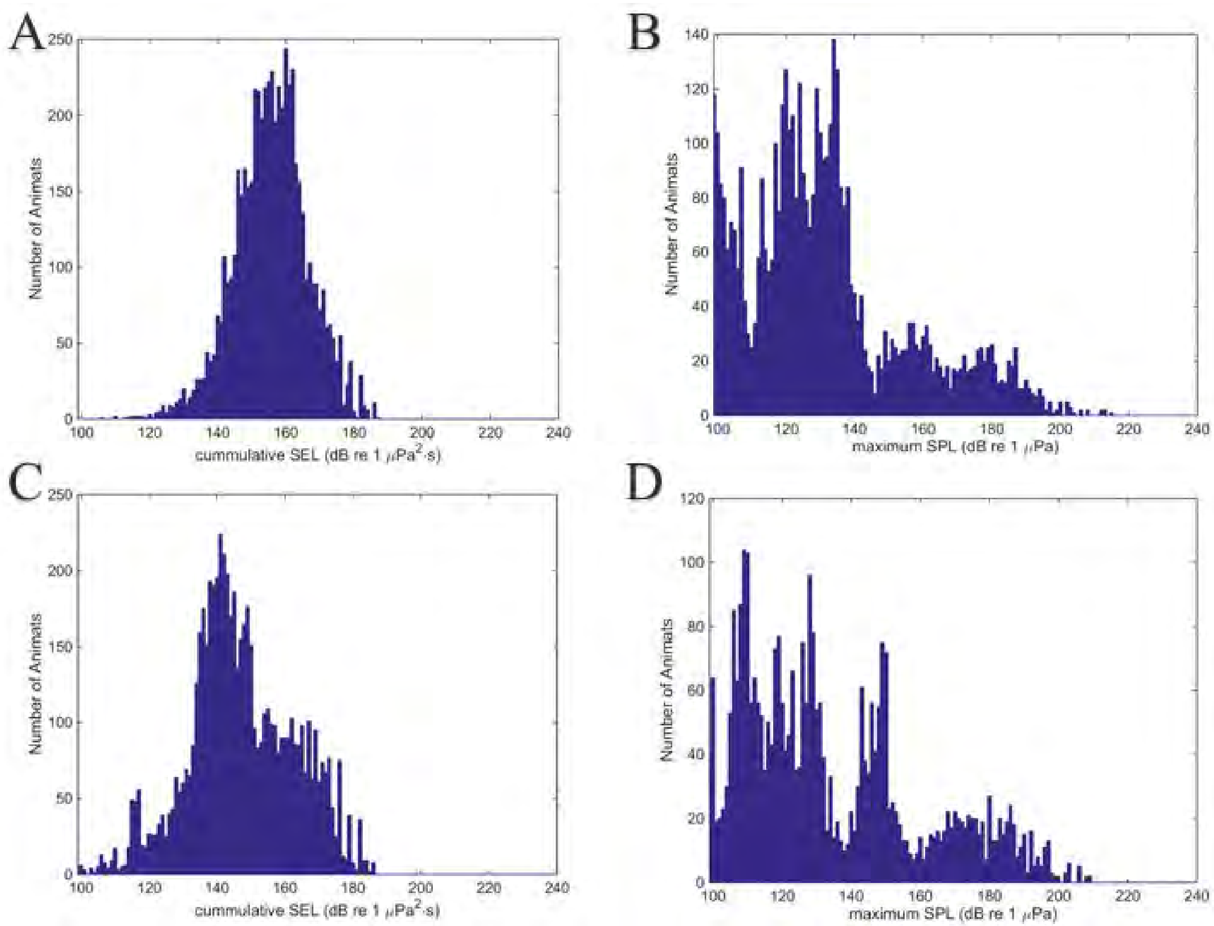

Figure B-4. Short-finned pilot whale exposure frequency for injury (5 day) and behavior (30 day) simulations. (A) cumulative sound exposure level (SEL) for Survey site A; (B) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site A; (C) cumulative sound exposure level (SEL) for Survey site B; and (D) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site B.

B.5. Sperm Whales

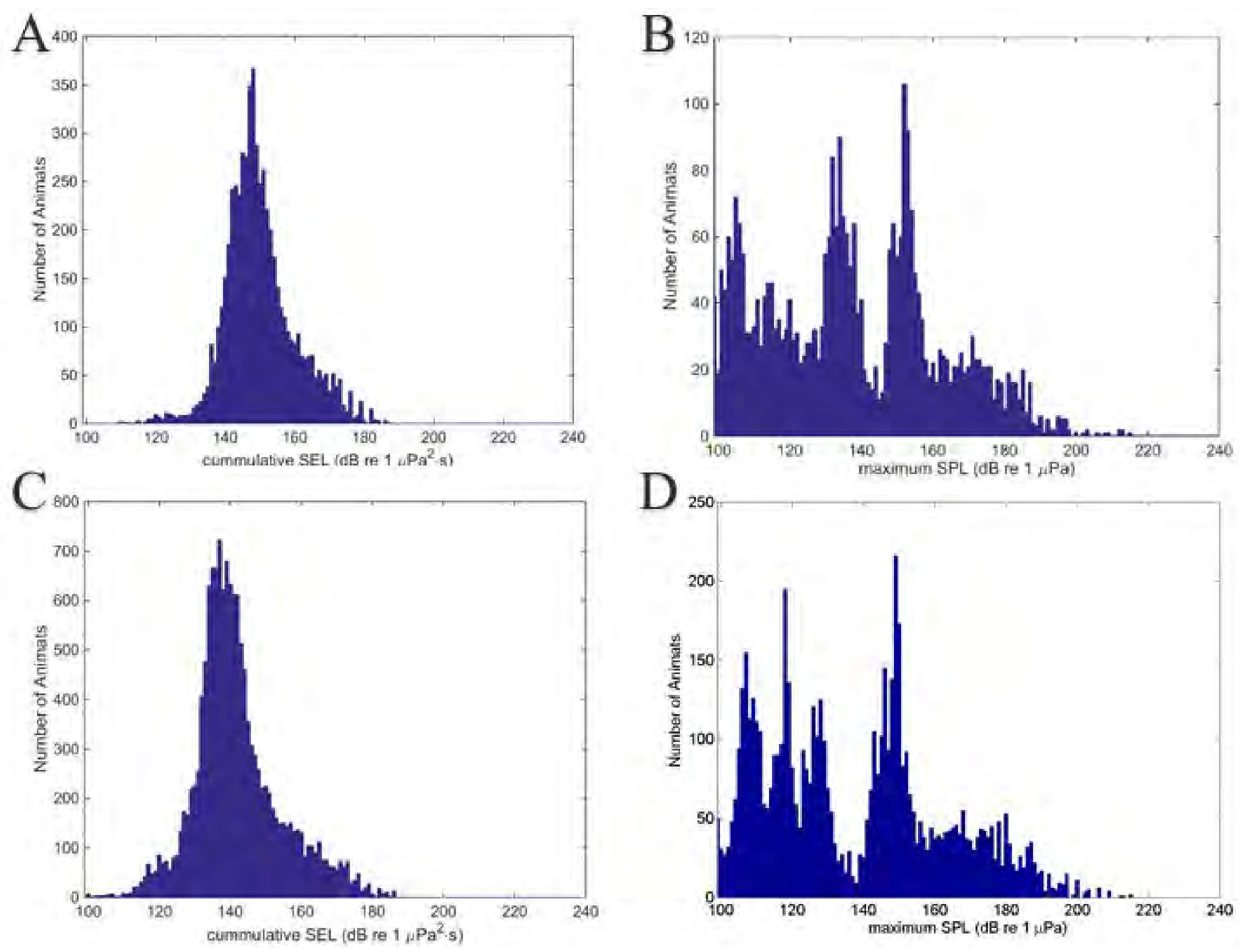

Figure B-5. Sperm whale exposure frequency for injury (5 day) and behavior (30 day) simulations. (A) cumulative sound exposure level (SEL) for Survey site A; (B) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site A; (C) cumulative sound exposure level (SEL) for Survey site B; and (D) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site B.

B.6. Dwarf Sperm Whales

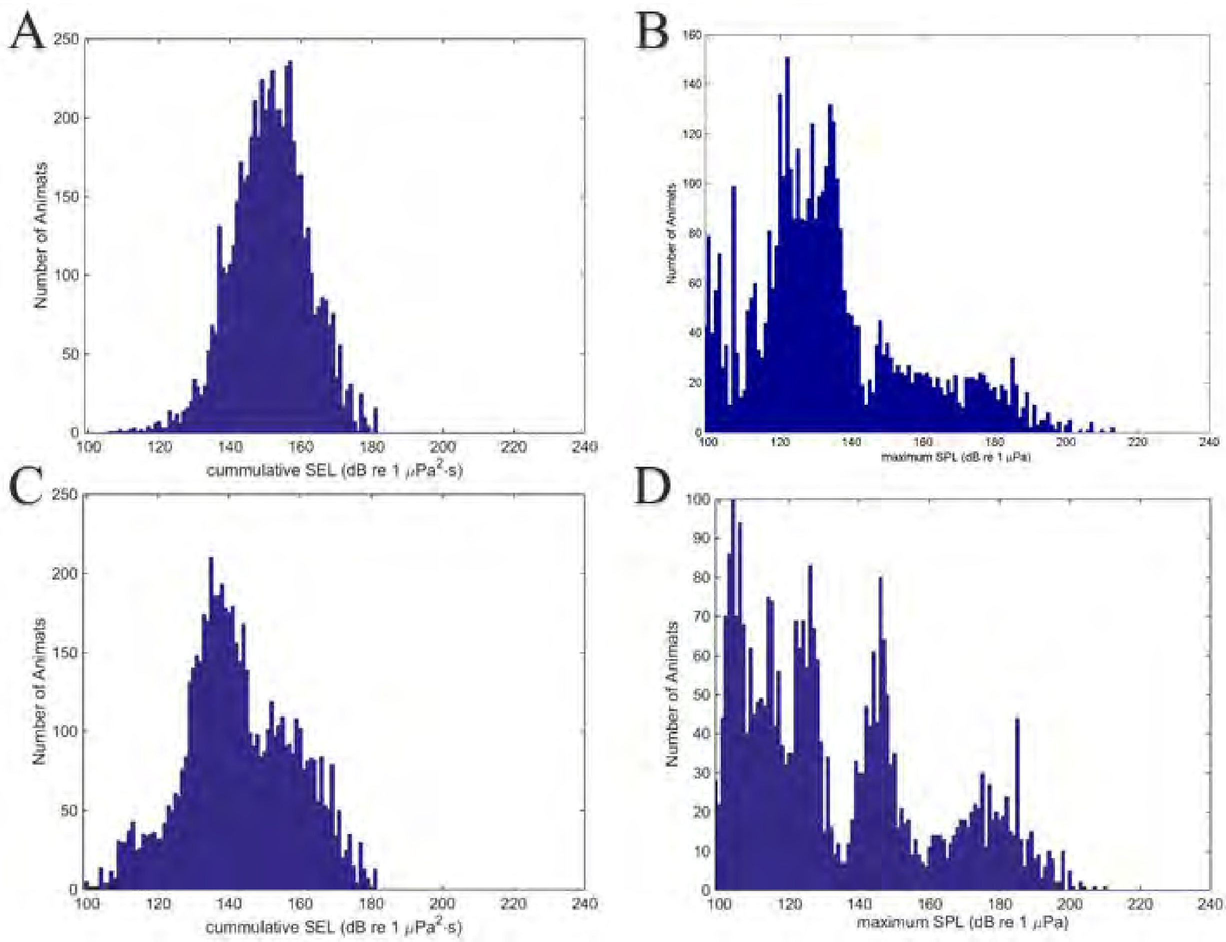

Figure B-6. Dwarf sperm whale exposure frequency for injury (5 day) and behavior (30 day) simulations. (A) cumulative sound exposure level (SEL) for Survey site A; (B) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site A; (C) cumulative sound exposure level (SEL) for Survey site B; and (D) maximum root-mean-square (rms) sound pressure level (SPL) for Survey site B.

Appendix C. Marine Mammal Distribution in the Gulf of Mexico

This appendix contains distribution maps for the marine mammal species likely to be affected by geological and geophysical exploration surveys. The distributions were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation) as GIS-compatible rasters of density estimates in 100 km^2 areas. These animal distributions guided our selection of modeling zones, which were also patterned on BOEM's planning areas, and to maintain acoustic uniformity throughout zones. The zone boundaries are shown as overlays in the figures.

The minimum, maximum, and mean density values and standard deviations of the means were obtained for each species in each zone (Table 62–Table 68).

C.1. Atlantic Spotted Dolphins

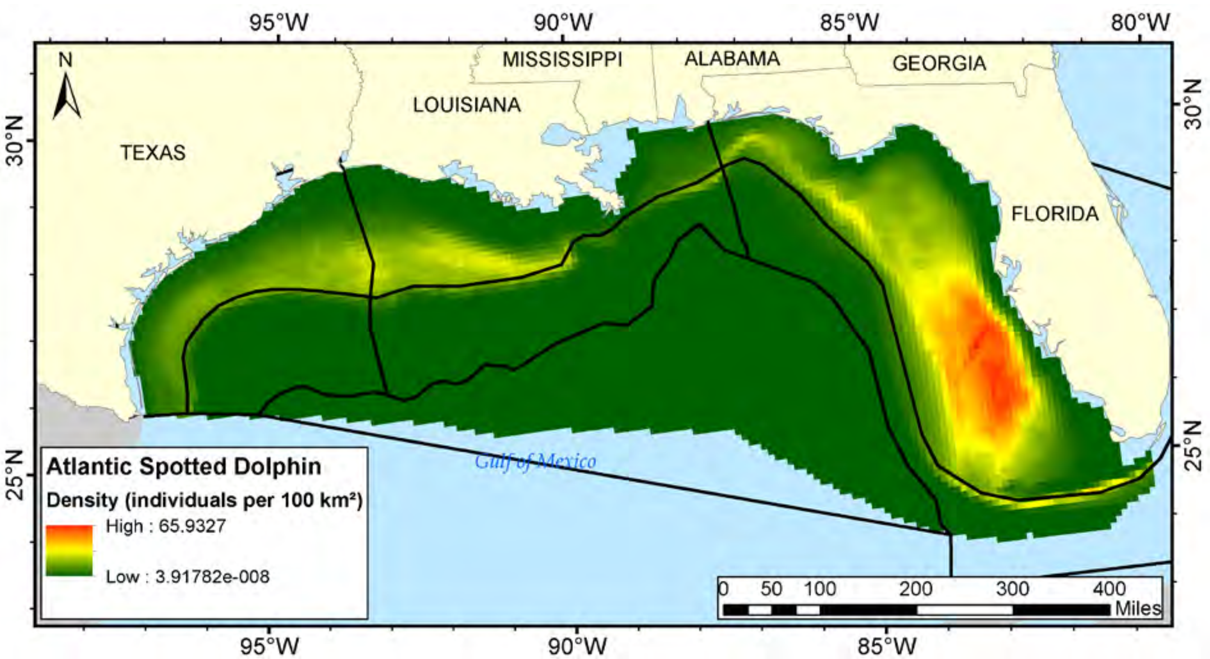

Figure C-1. Atlantic spotted dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.2. Beaked Whales

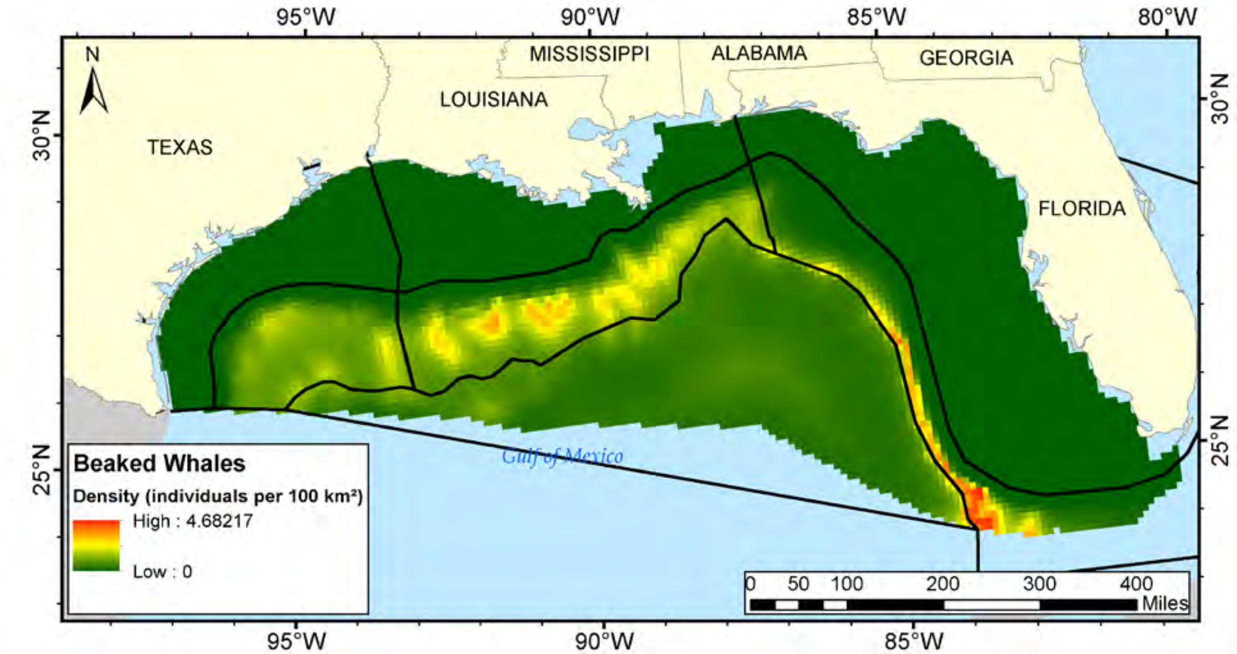

Figure C-2. Beaked whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.3. Common Bottlenose Dolphins

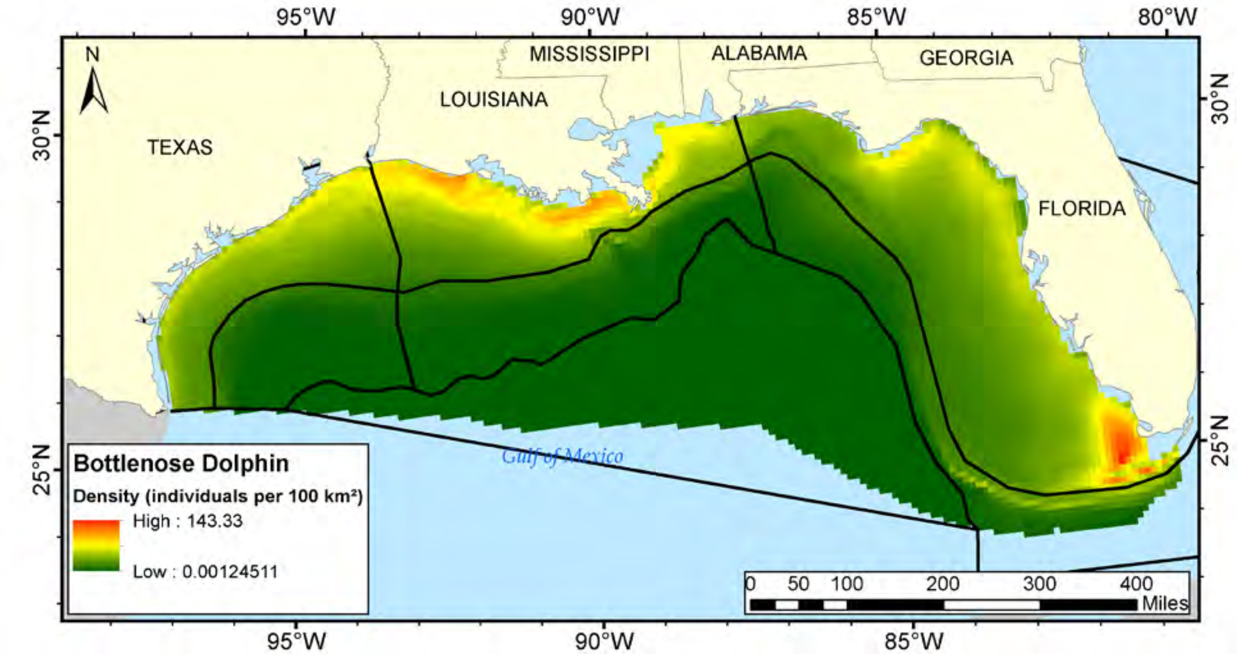

Figure C-3. Common bottlenose dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.4. Bryde's Whales

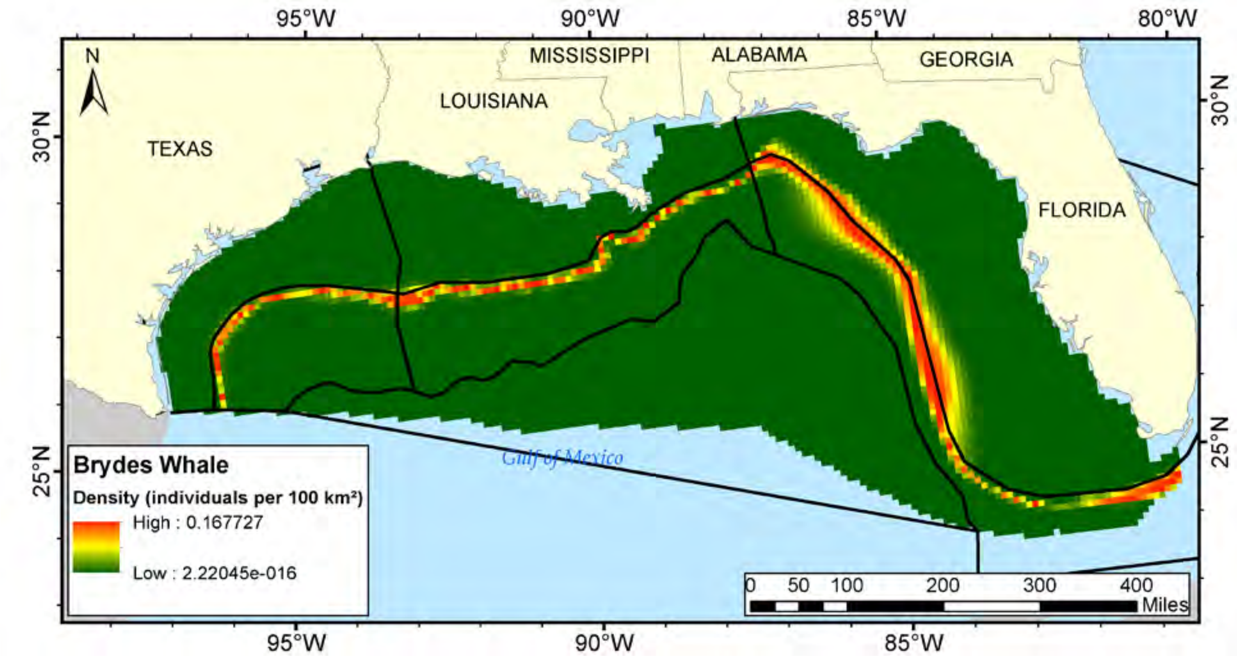

Figure C-4. Bryde's whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.5. Clymene Dolphins

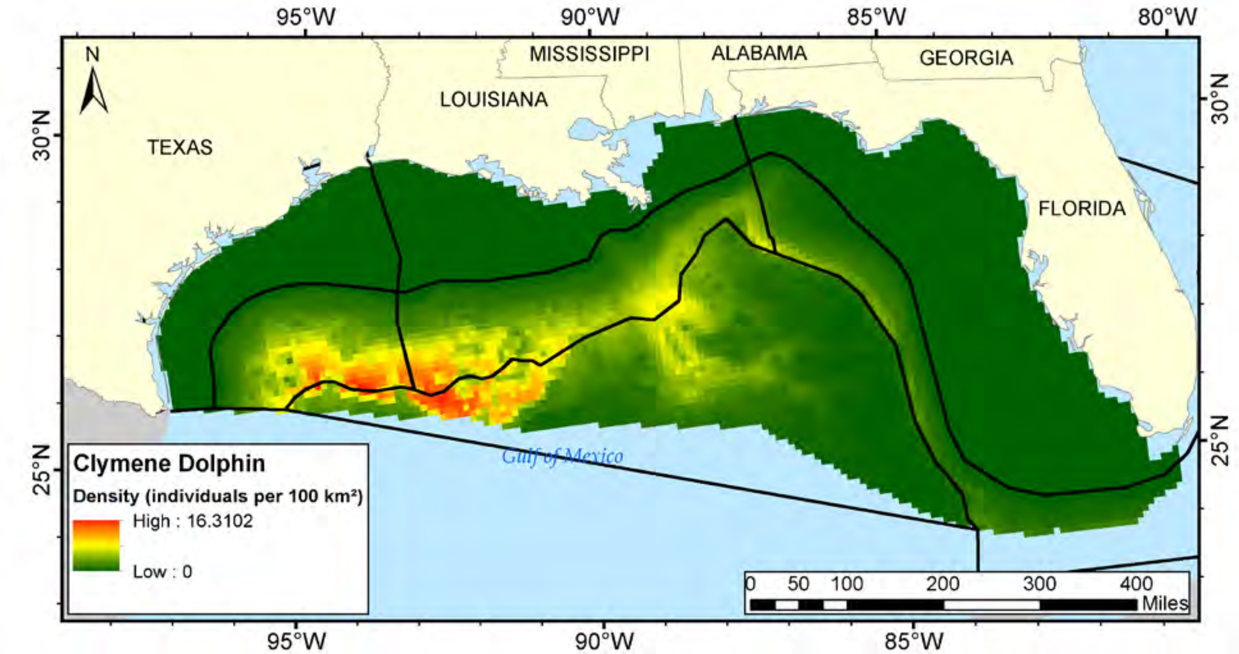

Figure C-5. Clymene dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.6. False Killer Whales

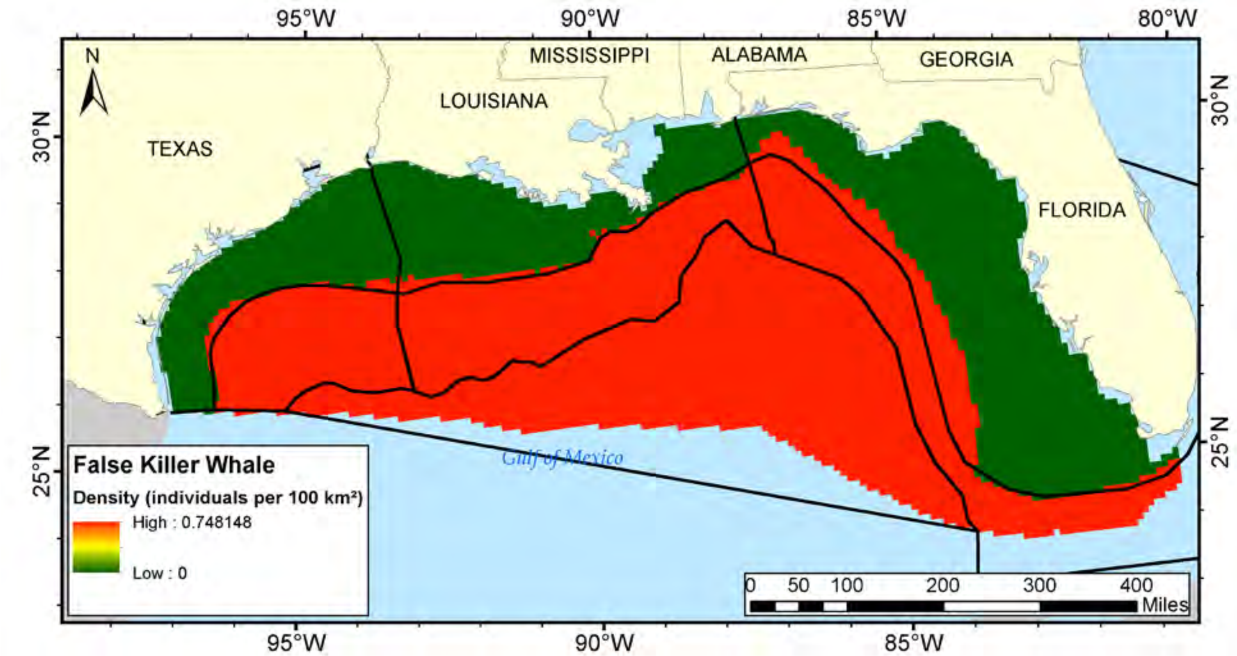

Figure C-6. False killer whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.7. Fraser's Dolphins

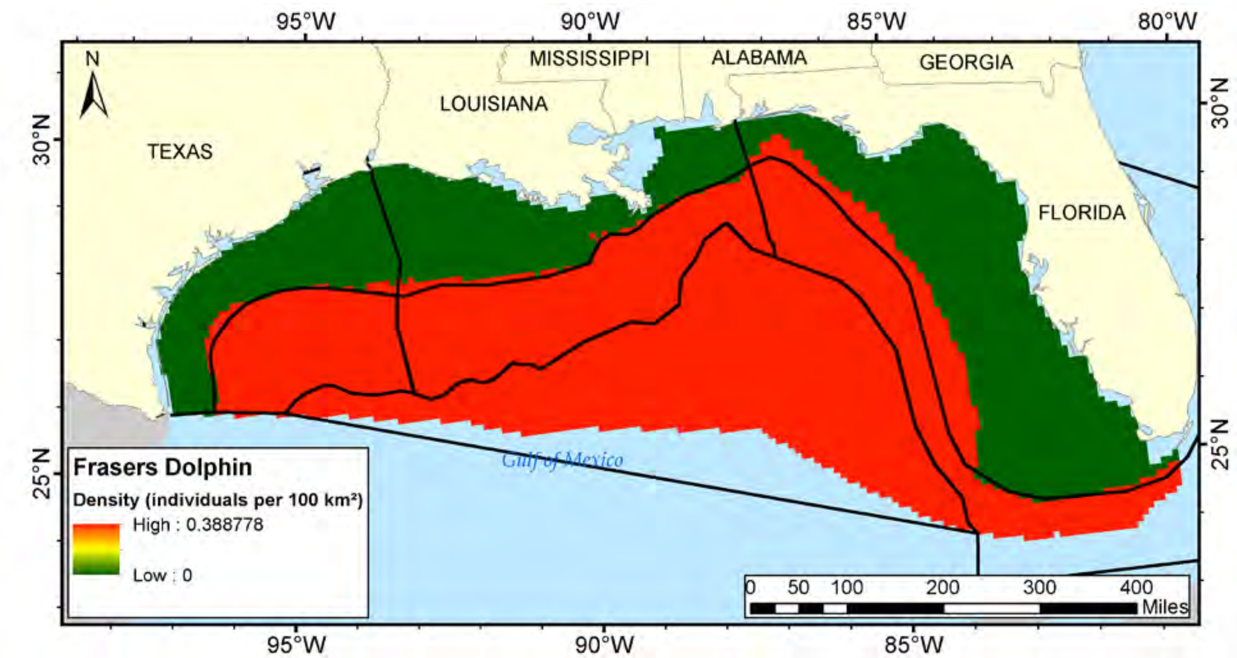

Figure C-7. Fraser's dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.8. Killer Whales

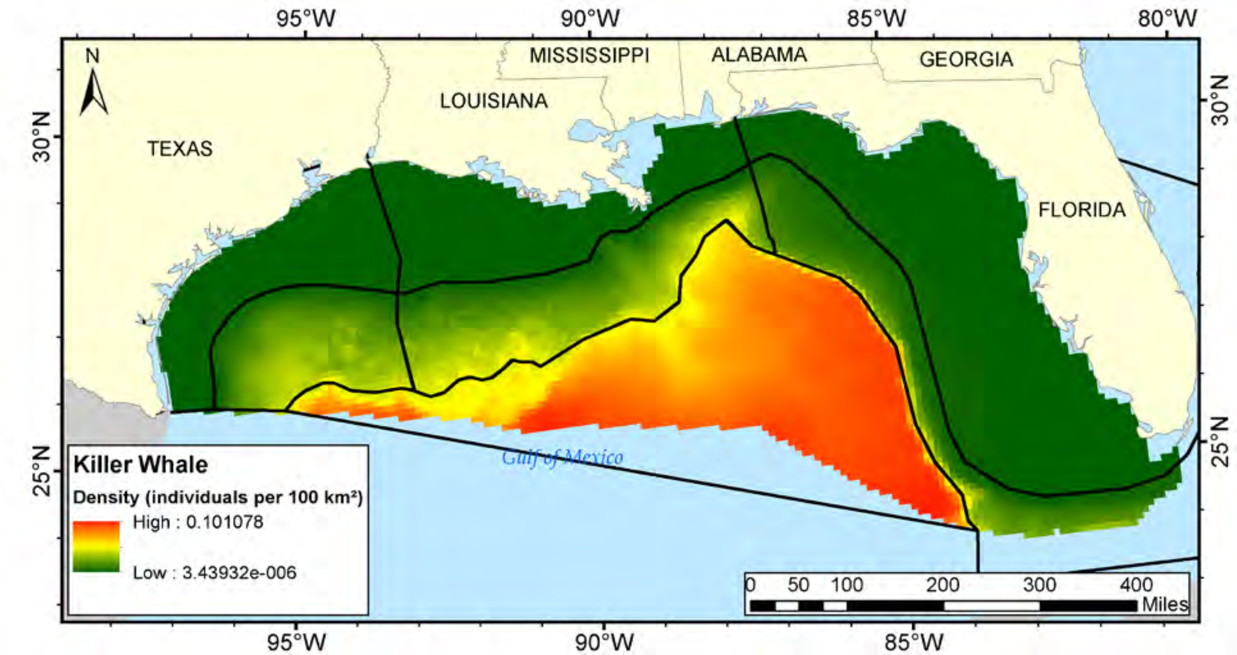

Figure C-8. Killer whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.9. Kogia Species

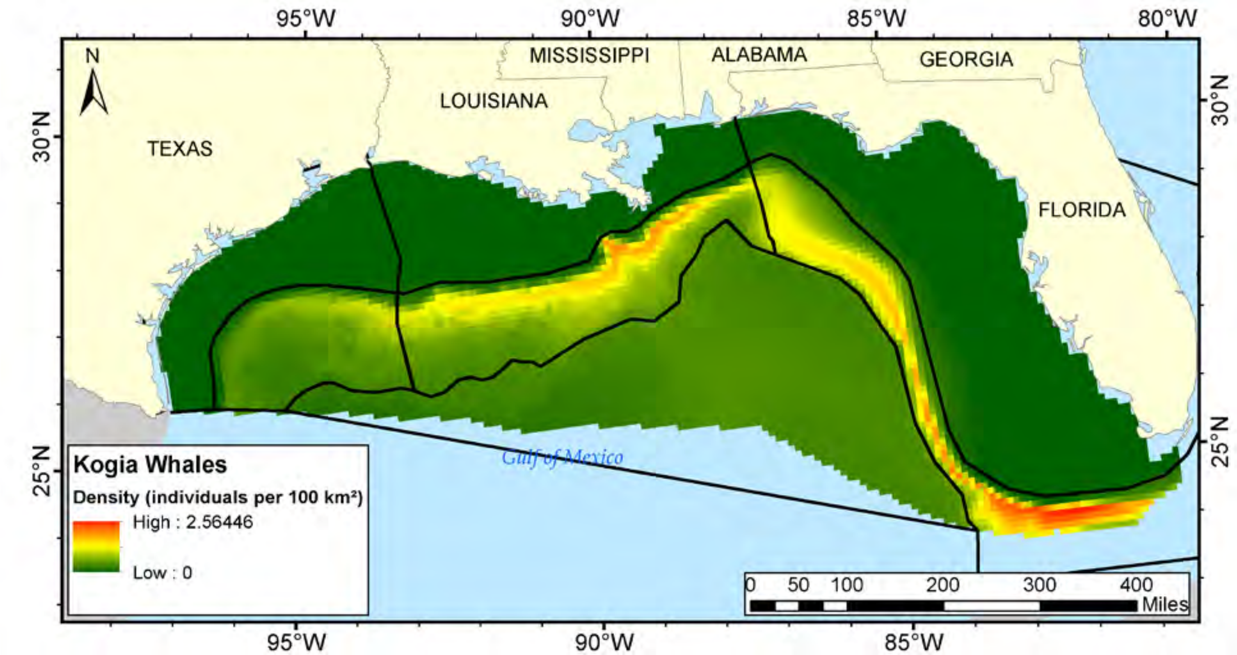

Figure C-9. *Kogia* distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.10. Melon-headed Whales

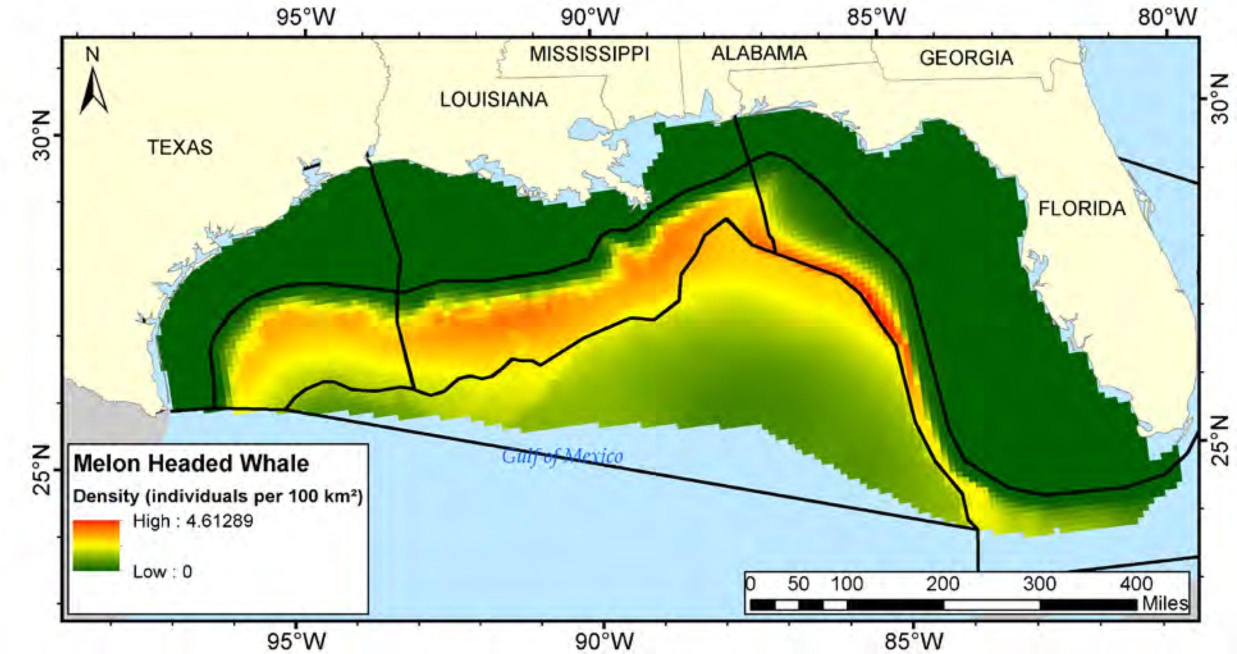

Figure C-10. Melon-headed whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.11. Pantropical Spotted Dolphins

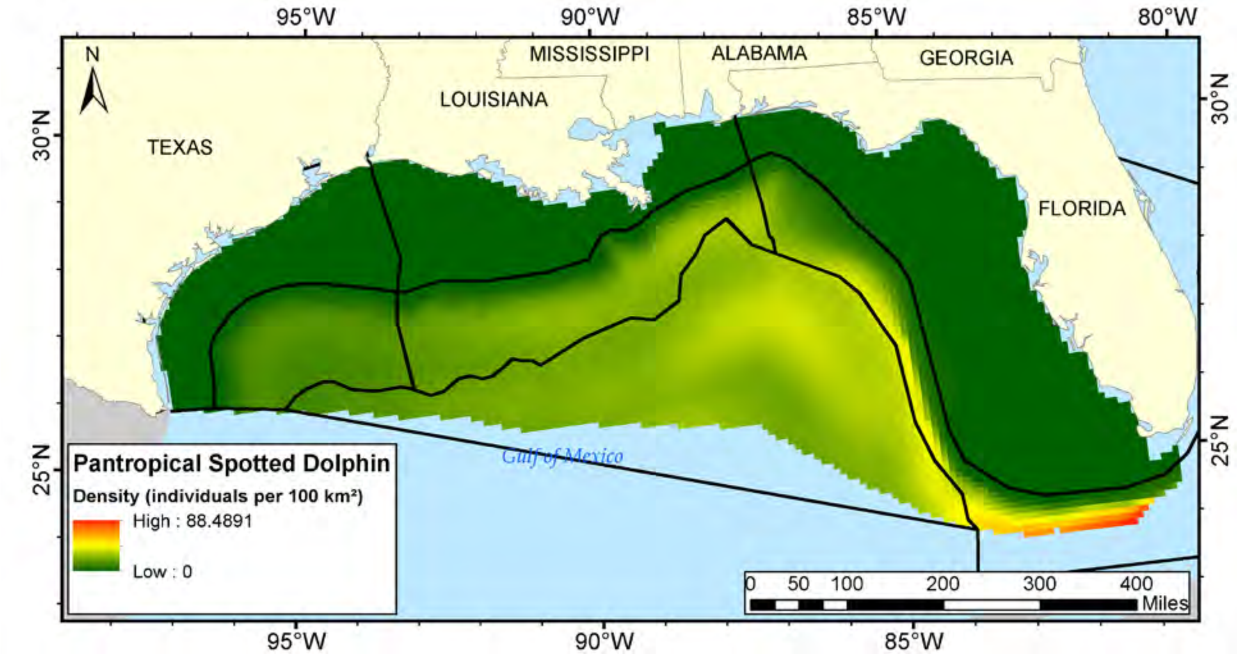

Figure C-11. Pantropical spotted dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.12. Pygmy Killer Whales

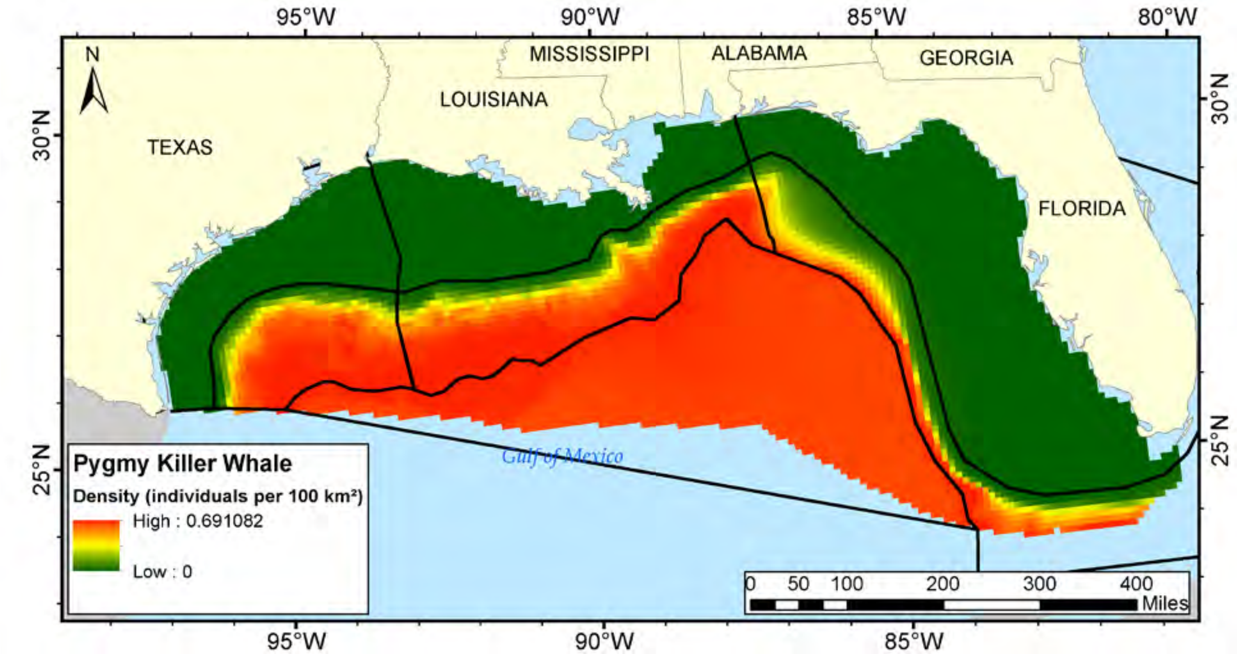

Figure C-12. Pygmy killer whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.13. Risso's Dolphins

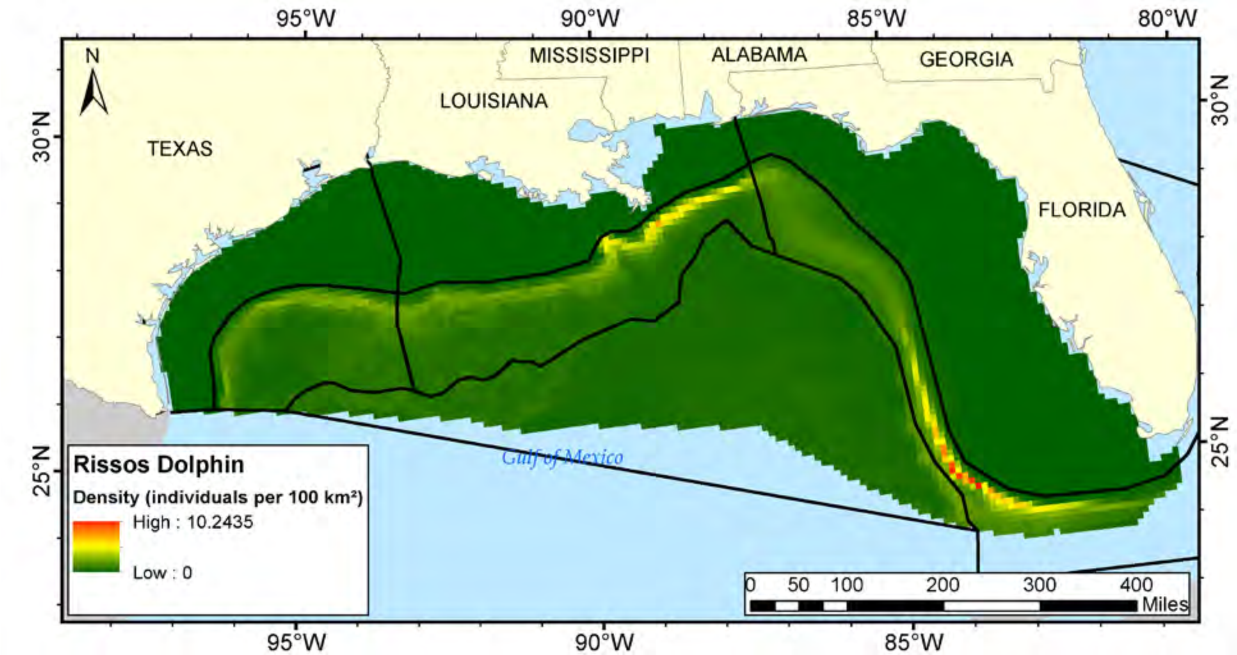

Figure C-13. Risso's dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.14. Rough-toothed Dolphins

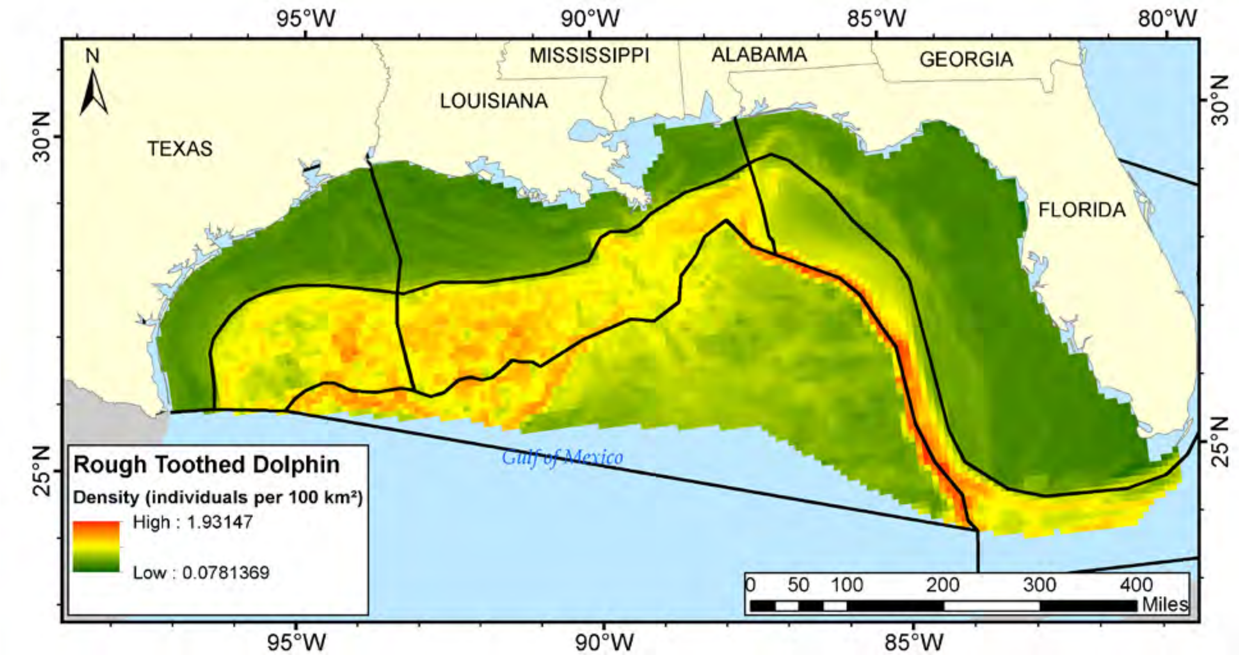

Figure C-14. Rough-toothed dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.15. Short-finned Pilot Whales

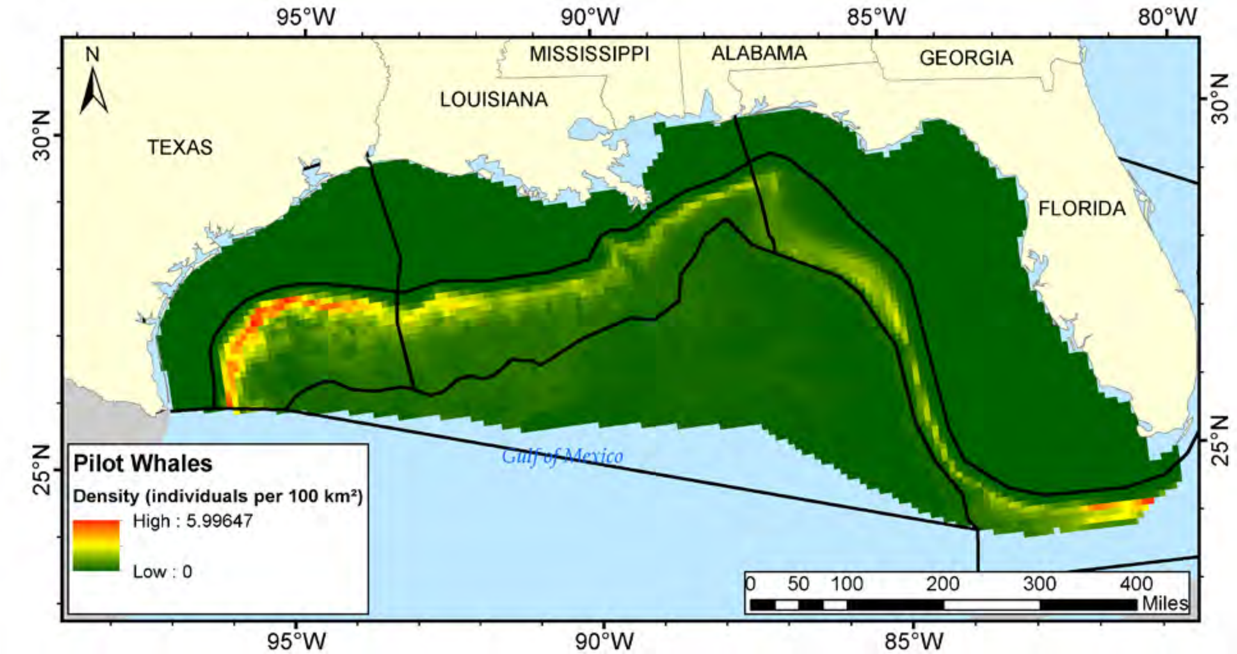

Figure C-15. Short-finned pilot whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.16. Sperm Whales

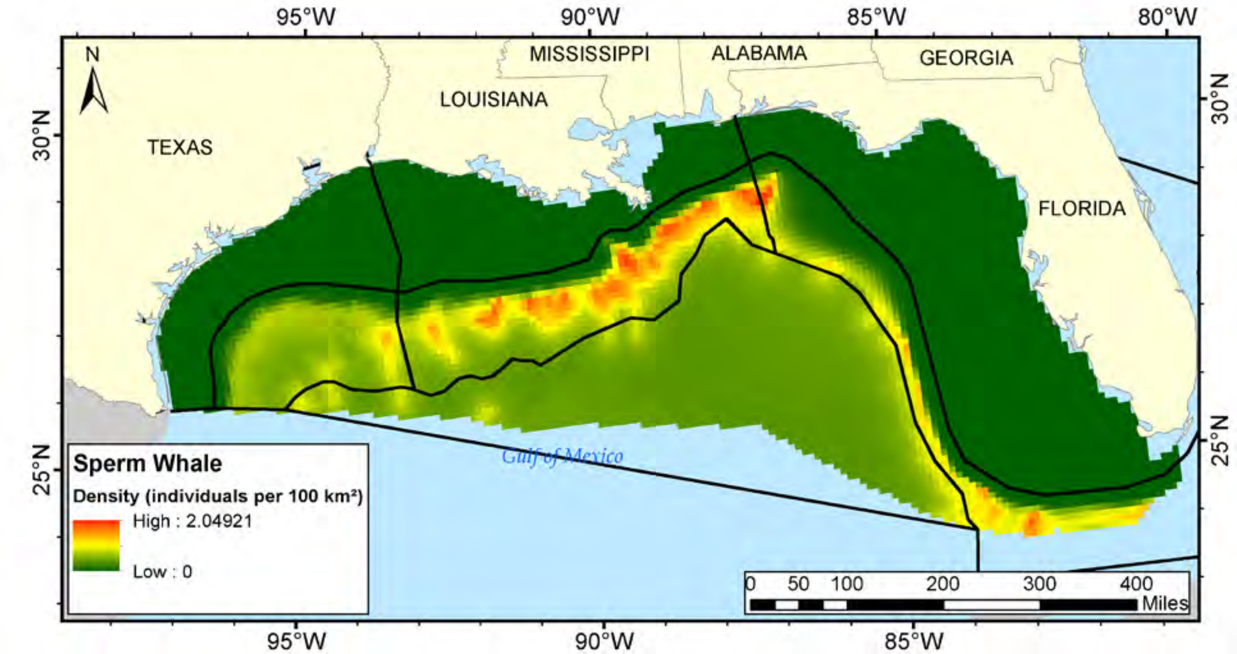

Figure C-16. Sperm whale distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.17. Spinner Dolphins

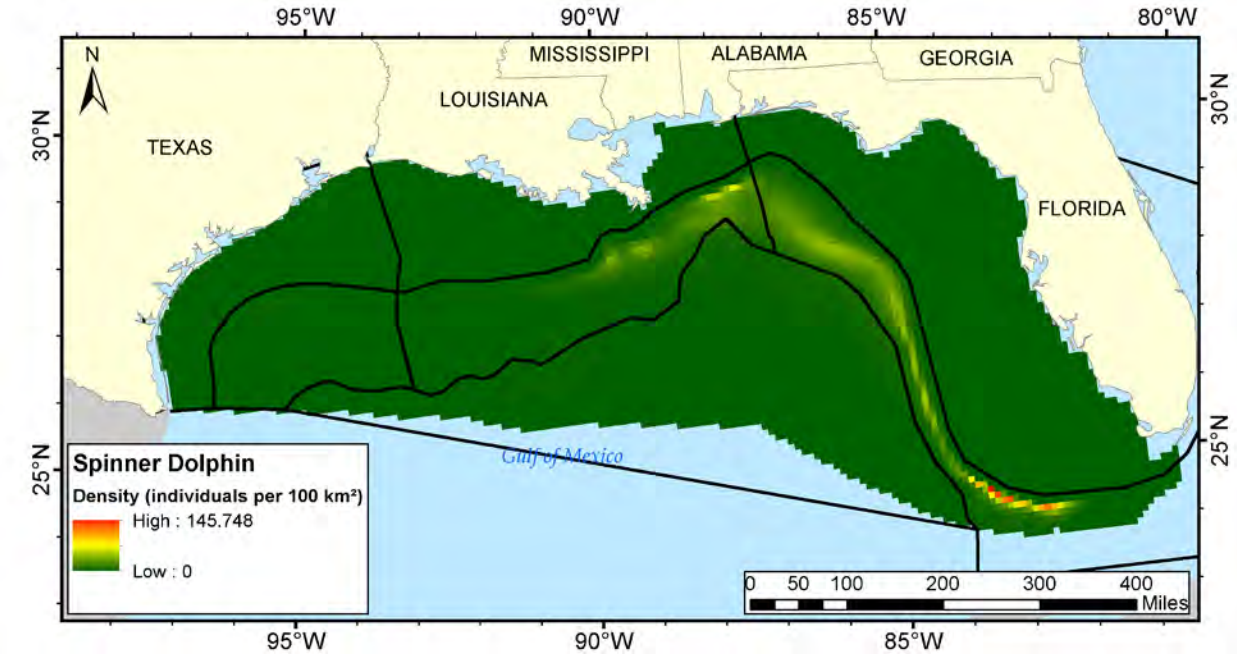

Figure C-17. Spinner dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

C.18. Striped Dolphins

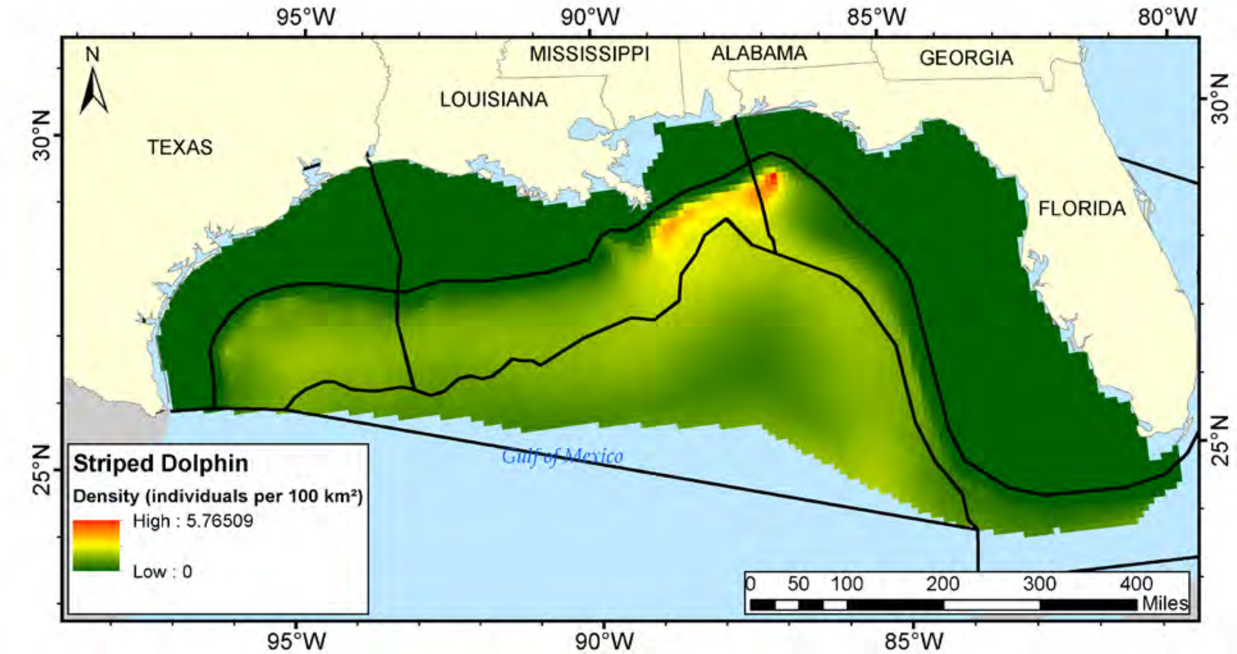

Figure C-18. Striped dolphin distribution in the Gulf of Mexico project area. Density estimates were obtained from the Marine Geospatial Ecology Laboratory (Duke University) model (Roberts et al. In preparation), black lines depict the boundaries of the modeling zones.

Appendix D. 3MB Animal Movement Parameters

The marine mammal movement and behavior (3MB) model uses previously measured animal movements to forecast how animals move in new situations and locations. 3MB creates simulated animals, referred to as animats, which are used to populate a simulation area. The animats are receivers; the sound levels they receive are logged as they move through the simulation.

3MB controls animat movement in horizontal and vertical directions using sub-models (see Houser and Cross 2014). Travel sub-models determine horizontal movement, including sub-models for the animats' travel direction and the travel rate (speed of horizontal movement). Dive sub-models determine vertical movement. Diving behavior sub-models include ascent and descent rates, maximum dive depth, bottom following, reversals, and surface interval. Bottom following describes the animat's behavior when it reaches the seafloor, for example during a foraging dive. If the bottom-following option is selected, the animat will continue along the same bathymetric contour line instead of the horizontal direction determined by another sub-model. Reversals simulate foraging behavior by defining the number of vertical excursions the animat makes after it reaches its maximum dive depth. The surface interval is the amount of time an animat spends at the surface before diving again.

Species-specific, realistic movement is simulated by supplying the sub-models with appropriate input parameters for each species. Parameter values are determined by visually observing species and reviewing tagging studies. For most sub-models, the input parameter is a probability distribution. When detailed information about a species' movements and behaviors are available, a user-created distribution vector should be used. When there is little to no information, either Gaussian or uniform distributions are used in the model. The user determines the appropriate mean and standard deviation for Gaussian distribution or the range if uniform distributions are being used. For behaviors with no directional preference, such as, perhaps, feeding and playing, a random walk model is used to define the bearing of an animats' travel direction. In a random walk model, at each parameter transition time step all bearings are equally likely choices. A variation of the random walk model, the correlated random walk, includes a directional bias. This variant should be used when animals have a preferred absolute direction, such as migration. The correlated random walk option smooths the changes in bearing by using the current bearing as the mean of the distribution from which the next heading is selected. Another option to control travel direction allows the user to create a vector of directional probabilities. In addition to the input distribution, parameters have a termination function that governs how long the parameter persists in a simulation. Houser (2006) and Houser and Cross (2014) discuss these input parameters in more detail.

3MB allows a user to define multiple behavioral states, which distinguish between specific subsets of behaviors like shallow and deep dives, or more general behavioral states such as foraging, resting, and socializing. The transition probability between these states can be defined as a probability value and related to the time of day. The level of detail included depends on the amount of data available for the species, and on the temporal and spatial framework of the simulation.

The animal movement parameters developed for each species are in the following sections. There is little or no data available for some species included in this study. In these cases we used a surrogate, which reflects values for a similar species: Pantropical spotted dolphins were used as a surrogate for Clymene, spinner, and striped dolphins; short-finned pilot whales were a surrogate for Fraser's dolphin, the *Kogia* species, and melon-headed whales; and rough-toothed dolphin as the surrogate for false killer whales and pygmy killer whales. Table D-19 lists the groups used for animal movement modeling.

D.1. Atlantic Spotted Dolphins

Table D-1. Distribution data for Atlantic spotted dolphins. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Random Max: 5.69, Min: 0.08)	Davis et al. 1996
	Ascent rate (m/s)	Gaussian 1.15 (0.8)	Griffin et al. 2005
	Descent rate (m/s)	Gaussian 1.23 (0.48)	Griffin et al. 2005
	Average depth (m)	Random Max: 60	Davis et al. 1996
	Bottom following	Yes	Griffin et al. 2005
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Best estimate
	Number of reversals	2 (2)	Griffin et al. 2005
	Time in reversal log (s)	20.81 (21.5)	Griffin et al. 2005
	Surface interval (s)	Gaussian 63.59 (52.66)	Griffin et al. 2005

D.2. Beaked Whale spp.

This category includes Cuvier's, Blainville's, and Gervais' whales. Diving behavior for Blainville's and Cuvier's beaked whales (Baird et al. 2006b) is similar to the diving behavior documented for northern common bottlenose whales (Hooker and Baird 1999).

Table D-2. Distribution data for beaked whale spp. are based on Cuvier's beaked whale data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Deep dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.508 (0.392)	Schorr et al. 2009
	Ascent rate (m/s)	Gaussian 0.7 (0.2)	Baird et al. 2006b, Tyack et al. 2006
	Descent rate (m/s)	Gaussian 1.39 (0.19)	Baird et al. 2006b, Tyack et al. 2006
	Average depth (m)	Gaussian 1070 (317)	Tyack et al. 2006
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Best estimate
	Number of reversals	5 (3)	Baird et al. 2006a
	Time in reversal log (s)	696 (228)	Baird et al. 2006a
	Surface interval (s)	Gaussian 486 (1035)	Baird et al. 2006b
	Bout duration (s)	3480 (684)	Best estimate
Shallow dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.508 (0.392)	Schorr et al. 2009
	Ascent rate (m/s)	Gaussian 0.66 (0.2)	Baird et al. 2006b, Tyack et al. 2006
	Descent rate (m/s)	Gaussian 0.7 (0.46)	Baird et al. 2006b, Tyack et al. 2006
	Average depth (m)	Gaussian 221 (100)	Tyack et al. 2006
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Best estimate
	Number of reversals	3 (2)	Baird et al. 2006a
	Time in reversal log (s)	304 (156)	Baird et al. 2006a
	Surface interval (s)	Gaussian 486 (1035)	Baird et al. 2006b
	Bout duration (s)	912 (312)	Best estimate

D.3. Common Bottlenose Dolphins

Table D-3. Distribution data for common bottlenose dolphins. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Foraging	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.19 (0.71)	Bearzi 2005
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. 2010
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. 2010
	Average depth (m)	Gaussian 25 (5)	Hastie et al. 2006
	Bottom following	Yes	Best estimate
	Reversals	Gaussian 18 (1.1)	Best estimate
	Probability of reversal	0.09	Best estimate
	Reversal dive rate	Gaussian 1.0 (0.2)	Best estimate
	Time in reversal (s)	Gaussian 1 (0.1)	Best estimate
	Surface interval (s)	Gaussian 46.4 (2.5)	Lopez 2009
Playing	Travel Direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.19 (0.71)	Bearzi 2005
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. 2010
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. 2010
	Average depth (m)	Gaussian 7 (3)	Wursig and Wursing 1979, Hastie et al. 2006
	Bottom following	Yes	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 3 (2)	Best estimate
Resting	Travel Direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.19 (0.71)	Bearzi 2005
	Ascent rate (m/s)	Gaussian 0.5 (0.1)	Best estimate
	Descent rate (m/s)	Gaussian 0.5 (0.1)	Best estimate
	Average depth (m)	Random Max: 2	Best estimate
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 3 (2)	Best estimate
Socializing	Travel Direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.19 (0.71)	Bearzi 2005
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. 2010
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. 2010

Behavior	Variable	Value	Reference
	Average depth (m)	Random Max: 10	Wursig and Wursing 1979, Hastie et al. 2006
	Bottom following	Yes	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 3 (2)	Best estimate
Travel	Travel Direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.19 (0.71)	Bearzi 2005
	Ascent rate (m/s)	Gaussian 2.1 (0.3)	Houser et al. 2010
	Descent rate (m/s)	Gaussian 1.6 (0.2)	Houser et al. 2010
	Average depth (m)	Gaussian 7 (3)	Wursig and Wursing 1979, Hastie et al. 2006
	Bottom following	Yes	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 3 (2)	Best estimate

D.4. Bryde's Whales

Table D-4. Distribution data for Bryde's whales. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.39 (0.83)	Kato and Perrin 2009
	Ascent rate (m/s)	Gaussian 0.95 (0.55)	Alves et al. 2010
	Descent rate (m/s)	Gaussian 1.25 (0.4)	Alves et al. 2010
	Average depth (m)	Random Max: 292	Alves et al. 2010
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Best estimate
	Number of reversals	4 (3)	Alves et al. 2010
	Time in reversal log (s)	72 (21.2)	Alves et al. 2010
	Surface interval (s)	Gaussian 188 (48)	Di Sciara 1983
	Bout duration (s)	288 (63.6)	Best estimate

D.5. Clymene Dolphins

Table D-5. Distribution data for Clymene dolphins based on Pantropical spotted dolphin data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 2.39 (1.22)	Pantropical spotted dolphins
	Ascent rate (m/s)	Gaussian 0.42 (0.24)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.58 (0.34)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 22.1 (15.71)	Pantropical spotted dolphins
	Bottom following	No	Pantropical spotted dolphins
	Reversals	No	Pantropical spotted dolphins
	Surface interval (s)	Gaussian 59.4 (293.4)	Pantropical spotted dolphins
Night dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.83 (1.54)	Pantropical spotted dolphins
	Ascent rate (m/s)	Gaussian 0.74 (0.41)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.93 (0.54)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 24 (27.1)	Pantropical spotted dolphins
	Bottom following	No	Pantropical spotted dolphins
	Reversals	Gaussian	Pantropical spotted dolphins
	Probability of reversal	0.5	Pantropical spotted dolphins
	Number of reversals	3 (1)	Pantropical spotted dolphins
	Time in reversal log (s)	39 (55.2)	Pantropical spotted dolphins
	Surface interval (s)	Gaussian 47.4 (106.8)	Pantropical spotted dolphins

D.6. False Killer Whales

Table D-6. Distribution data for false killer whales. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Random Min: 1.18; Max: 1.59	Baird et al. 2010
	Ascent rate (m/s)	Gaussian 0.77 (0.61)	Minamikawa et al. 2013
	Descent rate (m/s)	Gaussian 0.74 (0.72)	Minamikawa et al. 2013
	Average depth (m)	Gaussian 63.3 (131.5)	Minamikawa et al. 2013
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Minamikawa et al. 2013
	Number of reversals	2 (1)	Minamikawa et al. 2013
	Time in reversal log (s)	65.76 (73.84)	Minamikawa et al. 2013
	Surface interval (s)	Gaussian 569.69 (630.68)	Minamikawa et al. 2013
Night dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Random Min: 1.18; Max: 1.59	Baird et al. 2010
	Ascent rate (m/s)	Gaussian 0.51 (0.42)	Minamikawa et al. 2013
	Descent rate (m/s)	Gaussian 0.43 (0.4)	Minamikawa et al. 2013
	Average depth (m)	Gaussian 26.4 (46.5)	Minamikawa et al. 2013
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Minamikawa et al. 2013
	Number of reversals	2 (1)	Minamikawa et al. 2013
	Time in reversal log (s)	127.68 (63.84)	Minamikawa et al. 2013
	Surface interval (s)	Gaussian 299.4 (345.98)	Minamikawa et al. 2013

D.7. Fraser's Dolphins

Table D-7. Distribution data for Fraser's dolphins based on Short-finned pilot whale data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Short-finned pilot whales
	Ascent rate (m/s)	Gaussian 2.2 (0.2)	Short-finned pilot whales
	Descent rate (m/s)	Gaussian 2 (0.2)	Short-finned pilot whales
	Average depth (m)	Gaussian 30 (20)	Short-finned pilot whales
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Short-finned pilot whales
Night dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Short-finned pilot whales
	Ascent rate (m/s)	Gaussian 3.2 (0.4)	Short-finned pilot whales
	Descent rate (m/s)	Gaussian 3 (0.4)	Short-finned pilot whales
	Average depth (m)	Gaussian 300 (100)	Short-finned pilot whales
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Short-finned pilot whales

D.8. Killer Whales

Table D-8. Distribution data for killer whales. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Shallow dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 2 (1.61)	Dahlheim and White 2010
	Ascent rate (m/s)	Gaussian 1.832 (1.448)	Baird 1994
	Descent rate (m/s)	Gaussian 1.822 (1.51)	Baird 1994
	Average depth (m)	Gaussian 8 (2)	Miller et al. 2010
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 3 (2)	Miller et al. 2010
Deep dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 2 (1.61)	Dahlheim and White 2010
	Ascent rate (m/s)	Gaussian 1.832 (1.448)	Baird 1994
	Descent rate (m/s)	Gaussian 1.822 (1.51)	Baird 1994
	Average depth (m)	Gaussian 40 (20)	Miller et al. 2010
	Bottom following	No	Best estimate
	Reversals	Random	Best estimate
	Probability of reversal	1	Best estimate
	Number of reversals	Min: 2, Max: 5	Best estimate
	Time in reversal log (s)	10 (1)	Best estimate
	Surface interval (s)	Gaussian 3 (2)	Miller et al. 2010

D.9. *Kogia spp.* including Dwarf Sperm Whales and Pygmy Sperm Whales (*Kogia sima* and *K. breviceps*)

Table D-9. Distribution data for Kogia spp. based on short-finned pilot whale data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Short-finned pilot whales
	Ascent rate (m/s)	Gaussian 2.2 (0.2)	Short-finned pilot whales
	Descent rate (m/s)	Gaussian 2 (0.2)	Short-finned pilot whales
	Average depth (m)	Gaussian 30 (20)	Short-finned pilot whales
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Short-finned pilot whales
Night dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Short-finned pilot whales
	Ascent rate (m/s)	Gaussian 3.2 (0.4)	Short-finned pilot whales
	Descent rate (m/s)	Gaussian 3 (0.4)	Short-finned pilot whales
	Average depth (m)	Gaussian 300 (100)	Short-finned pilot whales
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Short-finned pilot whales

D.10. Melon-headed Whales

Table D-10. Distribution data for melon-headed whales based on short-finned pilot whale data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Short-finned pilot whales
	Ascent rate (m/s)	Gaussian 2.2 (0.2)	Short-finned pilot whales
	Descent rate (m/s)	Gaussian 2 (0.2)	Short-finned pilot whales
	Average depth (m)	Gaussian 30 (20)	Short-finned pilot whales
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Short-finned pilot whales
Night dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Short-finned pilot whales
	Ascent rate (m/s)	Gaussian 3.2 (0.4)	Short-finned pilot whales
	Descent rate (m/s)	Gaussian 3 (0.4)	Short-finned pilot whales
	Average depth (m)	Gaussian 300 (100)	Short-finned pilot whales
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Short-finned pilot whales

D.11. Pantropical Spotted Dolphins

Table D-11. Distribution data for pantropical spotted dolphins. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 2.39 (1.22)	Scott and Chivers 2009
	Ascent rate (m/s)	Gaussian 0.42 (0.24)	Scott and Chivers 2009
	Descent rate (m/s)	Gaussian 0.58 (0.34)	Scott and Chivers 2009
	Average depth (m)	Gaussian 22.1 (15.71)	Scott and Chivers 2009
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 59.4 (293.4)	Scott and Chivers 2009
Night dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.83 (1.54)	Scott and Chivers 2009
	Ascent rate (m/s)	Gaussian 0.74 (0.41)	Scott and Chivers 2009
	Descent rate (m/s)	Gaussian 0.93 (0.54)	Scott and Chivers 2009
	Average depth (m)	Gaussian 24 (27.1)	Scott and Chivers 2009
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Best estimate
	Number of reversals	3 (1)	Best estimate
	Time in reversal log (s)	39 (55.2)	Best estimate
	Surface interval (s)	Gaussian 47.4 (106.8)	Scott and Chivers 2009

D.12. Pygmy Killer Whales

Table D-12. Distribution data for pygmy killer whales based on pantropical spotted and rough-toothed dolphin data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Travel dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.805 (0.05)	Baird et al. 2011
	Ascent rate (m/s)	Gaussian 0.42 (0.24)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.58 (0.34)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 6 (4)	Rough-toothed dolphins
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 59.4 (293.4)	Pantropical spotted dolphins
Forage dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.805 (0.05)	Baird et al. 2011
	Ascent rate (m/s)	Gaussian 0.74 (0.41)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.93 (0.54)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 25 (20)	Rough-toothed dolphins
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Best estimate
	Number of reversals	3 (1)	Best estimate
	Time in reversal log (s)	23.3 (50)	Rough-toothed dolphins
	Surface interval (s)	Gaussian 47.4 (106.8)	Pantropical spotted dolphins

D.13. Risso's Dolphins

Table D-13. Distribution data for Risso's dolphins based on short-finned pilot whale data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.997 (1.058)	Wells et al. 2009
	Ascent rate (m/s)	Gaussian 2.2 (0.2)	Short-finned pilot whales
	Descent rate (m/s)	Gaussian 2 (0.2)	Short-finned pilot whales
	Average depth (m)	Gaussian 11 (10)	Wells et al. 2009
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 11 (4)	Bearzi et al. 2011

D.14. Rough-toothed Dolphins

Table D-14. Distribution data for rough-toothed dolphins based on pantropical spotted dolphin data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Travel dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.25 (0.5)	Ritter 2002
	Ascent rate (m/s)	Gaussian 0.42 (0.24)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.58 (0.34)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 6 (4)	Wells et al. 2008
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 59.4 (293.4)	Pantropical spotted dolphins
Forage dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 2 (0.8)	Wells et al. 2008
	Ascent rate (m/s)	Gaussian 0.74 (0.41)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.93 (0.54)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 25 (20)	Best estimate
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Best estimate
	Number of reversals	3 (1)	Best estimate
	Time in reversal log (s)	23.3 (50)	Norris et al. 1965
	Surface interval (s)	Gaussian 47.4 (106.8)	Pantropical spotted dolphins

D.15. Short-finned Pilot Whales

Table D-15. Distribution data for short-finned pilot whales. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Wells et al. 2013
	Ascent rate (m/s)	Gaussian 2.2 (0.2)	Aguilar Soto et al. 2009
	Descent rate (m/s)	Gaussian 2 (0.2)	Aguilar Soto et al. 2009
	Average depth (m)	Gaussian 30 (20)	Wells et al. 2013
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Sakai et al. 2011
Night dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.875 (0.572)	Wells et al. 2013
	Ascent rate (m/s)	Gaussian 3.2 (0.4)	Aguilar Soto et al. 2009
	Descent rate (m/s)	Gaussian 3 (0.4)	Aguilar Soto et al. 2009
	Average depth (m)	Gaussian 300 (100)	Wells et al. 2013
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 165 (69)	Best estimate

D.16. Sperm Whales

Table D-16. Distribution data for sperm whales. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Deep foraging dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. 2004
	Ascent rate (m/s)	Gaussian 1.3 (0.2)	Watwood et al. 2006
	Descent rate (m/s)	Gaussian 1.1 (0.2)	Watwood et al. 2006
	Average depth (m)	Gaussian 546.9 (130)	Watwood et al. 2006
	Bottom following	No	Best estimate
	Reversals	Gaussian 8.2 (4.2)	Aoki et al. 2007
	Reversal dive rate (m/s)	Gaussian 1.8 (0.5)	Aoki et al. 2007
	Time in reversal (s)	Gaussian 141 (82.7)	Amano and Yoshioka 2003, Aoki et al. 2007
	Surface interval (s)	Gaussian 486 (156)	Watwood et al. 2006
Inactive bottom time	Travel Direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. 2004
	Ascent rate (m/s)	Gaussian 1.13 (0.07)	Amano and Yoshioka 2003
	Descent rate (m/s)	Gaussian 1.4 (0.13)	Amano and Yoshioka 2003
	Average depth (m)	Gaussian 490 (74.6)	Amano and Yoshioka 2003
	Bottom following	No	Best estimate
	Reversals	Gaussian 1.0 (0)	Best estimate
	Reversal dive rate (m/s)	Gaussian 0.1 (0.1)	Best estimate
	Time in reversal (s)	Gaussian 1188 (174.6)	Amano and Yoshioka 2003
	Surface interval (s)	Gaussian 546 (354)	Amano and Yoshioka 2003
V dive	Travel Direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. 2004
	Ascent rate (m/s)	Gaussian 0.67 (0.43)	Amano and Yoshioka 2003
	Descent rate (m/s)	Gaussian 0.85 (0.05)	Amano and Yoshioka 2003
	Average depth (m)	Gaussian 282.7 (69.9)	Amano and Yoshioka 2003
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 408 (114)	Amano and Yoshioka 2003

Behavior	Variable	Value	Reference
Surface inactive (head down)	Travel Direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.0 (0.0)	Best estimate
	Ascent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. 2008
	Descent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. 2008
	Average depth (m)	Gaussian 16.5 (4.9)	Miller et al. 2008
	Bottom following	No	Best estimate
	Reversals	Gaussian 1.0 (0)	Best estimate
	Reversal dive rate (m/s)	Gaussian 0.0 (0.0)	Best estimate
	Time in reversal (s)	Gaussian 804 (522)	Miller et al. 2008
	Surface interval (s)	Gaussian 462 (360)	Miller et al. 2008
	Bout duration*	T50 = 8.1, K = 0.9	Best estimate
Surface inactive (head up)	Travel Direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.0 (0.0)	Best estimate
	Ascent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. 2008
	Descent rate (m/s)	Gaussian 0.1 (0.1)	Miller et al. 2008
	Average depth (m)	Gaussian 8.6 (4.8)	Miller et al. 2008
	Bottom following	No	Best estimate
	Reversals	Gaussian 1.0 (0)	Best estimate
	Reversal dive rate (m/s)	Gaussian 0.0 (0.0)	Best estimate
	Time in reversal (s)	Gaussian 708 (552)	Miller et al. 2008
	Surface interval (s)	Gaussian 462 (360)	Miller et al. 2008
	Bout duration*	T50 = 8.1, K = 0.9	Best estimate
Surface active	Travel Direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.88 (0.27)	Miller et al. 2004
	Ascent rate (m/s)	Gaussian 0.67 (0.43)	Amano and Yoshioka 2003
	Descent rate (m/s)	Gaussian 0.85 (0.05)	Amano and Yoshioka 2003
	Average depth (m)	Gaussian 25.0 (25.0)	Amano and Yoshioka 2003
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 408 (114)	Amano and Yoshioka 2003

* Sigmoidal function: T50 is the midpoint in minutes, K is the steepness

D.17. Spinner Dolphins

Table D-17. Distribution data for spinner dolphins based on pantropical spotted dolphin data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 0.72 (0.83)	Würsig et al. 1994
	Ascent rate (m/s)	Gaussian 0.42 (0.24)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.58 (0.34)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 22.1 (15.71)	Pantropical spotted dolphins
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 59.4 (293.4)	Pantropical spotted dolphins
Night dive	Travel direction	Correlated random walk	Best estimate
	Perturbation value	10	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 1.36 (0.83)	Würsig et al. 1994
	Ascent rate (m/s)	Gaussian 0.74 (0.41)	Pantropical spotted dolphins
	Descent rate (m/s)	Gaussian 0.93 (0.54)	Pantropical spotted dolphins
	Average depth (m)	Gaussian 24 (27.1)	Pantropical spotted dolphins
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Pantropical spotted dolphins
	Number of reversals	3 (1)	Pantropical spotted dolphins
	Time in reversal log (s)	39 (55.2)	Pantropical spotted dolphins
	Surface interval (s)	Gaussian 47.4 (106.8)	Pantropical spotted dolphins

D.18. Striped Dolphins

Table D-18. Distribution data for striped dolphins based on pantropical spotted dolphin data. Unless otherwise indicated, numbers in the Value column represent means with their standard deviations in brackets after.

Behavior	Variable	Value	Reference
Day dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 3.035 (1.22)	Au and Perryman 1982
	Ascent rate (m/s)	Gaussian 0.6 (0.37)	Minamikawa et al. 2003
	Descent rate (m/s)	Gaussian 0.538 (0.343)	Minamikawa et al. 2003
	Average depth (m)	Gaussian 22.6 (17.5)	Minamikawa et al. 2003
	Bottom following	No	Best estimate
	Reversals	No	Best estimate
	Surface interval (s)	Gaussian 55.7 (32.1)	Minamikawa et al. 2003
Night dive	Travel direction	Random walk	Best estimate
	Termination coefficient	0.2	Best estimate
	Travel rate (m/s)	Gaussian 3.035 (1.22)	Au and Perryman 1982
	Ascent rate (m/s)	Gaussian 1.542 (0.709)	Minamikawa et al. 2003
	Descent rate (m/s)	Gaussian 1.463 (0.668)	Minamikawa et al. 2003
	Average depth (m)	Gaussian 126.7 (120.9)	Minamikawa et al. 2003
	Bottom following	No	Best estimate
	Reversals	Gaussian	Best estimate
	Probability of reversal	0.5	Pantropical spotted dolphins
	Number of reversals	3 (1)	Pantropical spotted dolphins
	Time in reversal log (s)	39 (55.2)	Pantropical spotted dolphins
	Surface interval (s)	Gaussian 65.8 (32)	Minamikawa et al. 2003

D.19. Animal Movement Modeling Species and Groups

Table D-19. Group name and species in each animal movement modeling group.

Group name	Species represented
Atlantic spotted dolphins	Atlantic spotted dolphins
Beaked whales	Cuvier’s beaked whales, Blainville’s beaked whales, Gervais’ beaked whales
Common bottlenose dolphins	Common bottlenose dolphins
Bryde's whales	Bryde's whales
Killer whales	Killer whales
Pantropical spotted dolphins	Pantropical spotted dolphins, Clymene dolphins, Spinner dolphins, Striped dolphins
Risso’s dolphins	Risso’s dolphins
Rough-toothed dolphins	Rough-toothed dolphins, False killer whales, Pygmy killer whales
Short-finned pilot whales	Short-finned pilot whales, Fraser’s dolphins, *Kogia spp.* (dwarf sperm whales, pygmy sperm whales), Melon-headed whales
Sperm whales	Sperm whales

Appendix E. Per-Pulse Acoustic Field Maps and Radii

The 3-D per-pulse acoustic fields used as inputs for acoustic exposure analysis were also processed to provide two other products:

- Plan-view maps of the acoustic field around the sources
- Tables of ranges to various isopleths (radii tables) for each source

The maps and radii tables are, respectively, 2-D and 1-D projections of the 3-D sound fields, which serve as quality assurance checkpoints to verify the acoustic modeling output and control the results of the exposure simulation.

Maps were created from the 3-D grid of the acoustic pressure levels by taking the maximum-over-depth value at each horizontal sampling location. The maps therefore represent the maximum received acoustic level over all depths at each location.

The ranges to isopleths in the radii tables are provided as two statistical estimates:

- The maximum range (R_{max}, in meters)
- The 95% range ($R_{95\%}$, in meters)

Given a regularly gridded spatial distribution of sound levels, the $R_{95\%}$ for a given sound level is defined as the radius of the circle, centered on the source, encompassing 95% of the grid points with sound levels at or above the given value. This definition is meaningful in terms of potential effects on animals because, regardless of the shape of the contour for a given sound level, $R_{95\%}$ is the range from the source beyond which only 5% of a uniformly distributed population would be exposed to sounds at or above that level.

The R_{max} for a given sound level is the maximum distance at which the specified received level occurs (equivalent to $R_{100\%}$). It is more conservative than $R_{95\%}$, but could be relevant for defining exclusion zones to avoid any chance of exposures above the specified level. For cases where the volume ensonified to a specific level is discontinuous and small pockets of higher received levels occur far beyond the main ensonified volume (e.g., due to convergence), the R_{max} can be much larger than $R_{95\%}$. Interpretation of these cases can be difficult if R_{max} if not presented with $R_{95\%}$.

Example modeling results the 8000 in^3 airgun array at site CM3, located in the Central-Slope zone at 750 m water depth, are presented below as maps of unweighted, per-pulse SEL, and SPL fields (Figure E-1 to Figure E-4). Site CM3 results are present as example results because that site is centrally located within the Gulf (see Tables 48–50 for all modeling site locations). The corresponding radii tables for the site are shown in Table E-1 to Table E-4 for Seasons 1 (January to March) and 3 (July to September) in SEL and rms SPL metrics with all applicable M-weighted filtering.

Example modeling results for the geotechnical survey sources at Box 4, an animat movement simulation box, are presented below as maps of unweighted, per-pulse SEL and SPL fields (Figure E-5 to Figure E-6, Table E-6 to Table E-12). Box 4 results are present as example results because that box is centrally located within the Gulf (See Table 51 for all box locations.) Radii tables for each site and season and for all sources have been calculated and can be accessed at https://www.boem.gov/Gulf-of-Mexico-Geological-and-Geophysical-Activities-Programmatic-EIS/#Additional.

E.1. 8000 in^3 Airgun Array

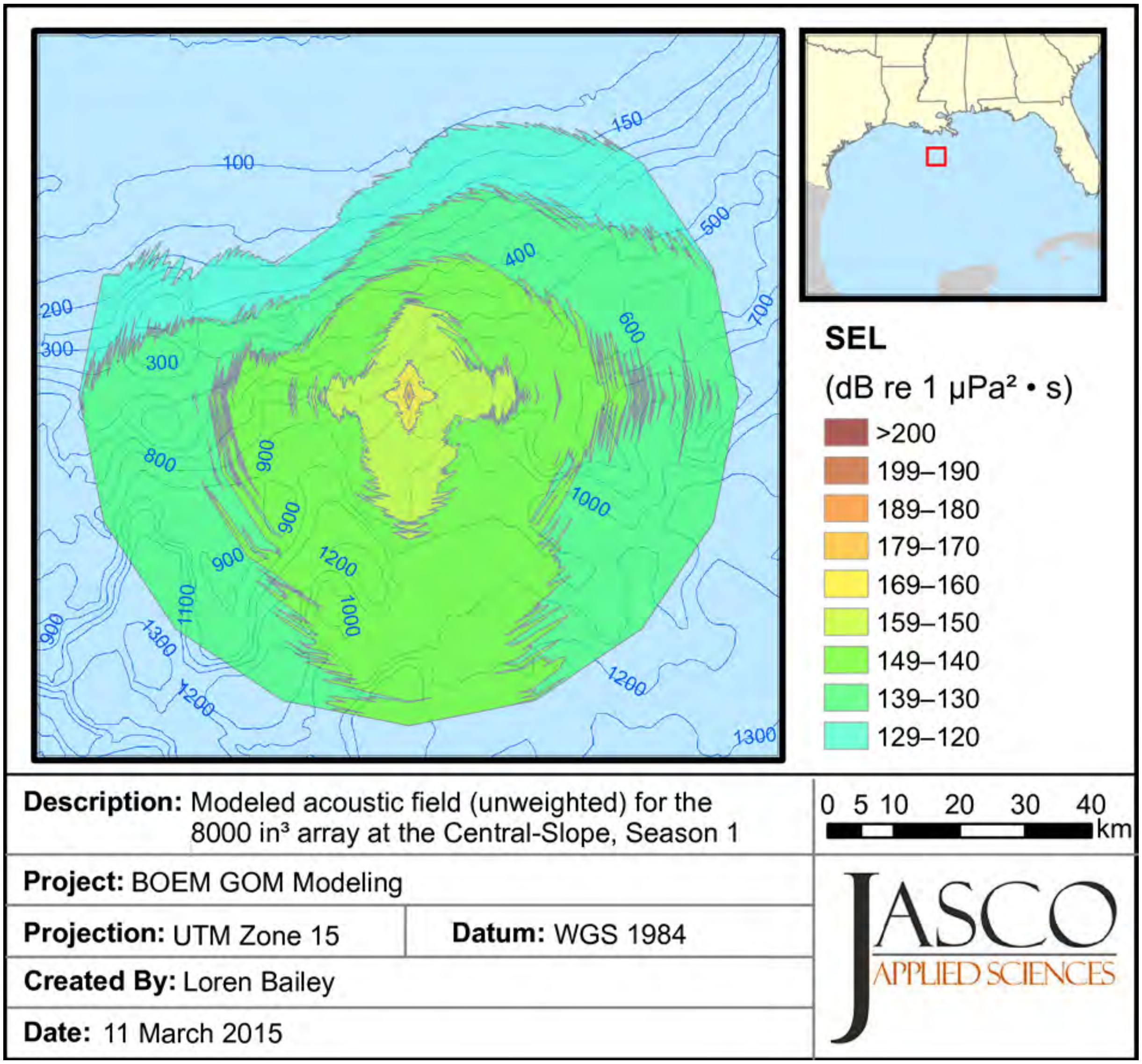

Figure E-1. 8000 in³ airgun array at the Central-Slope region (Site CM3), Season 1 (February): Broadband (10–5,000 Hz) maximum-over-depth per-pulse SEL field. Blue contours indicate water depth in meters.

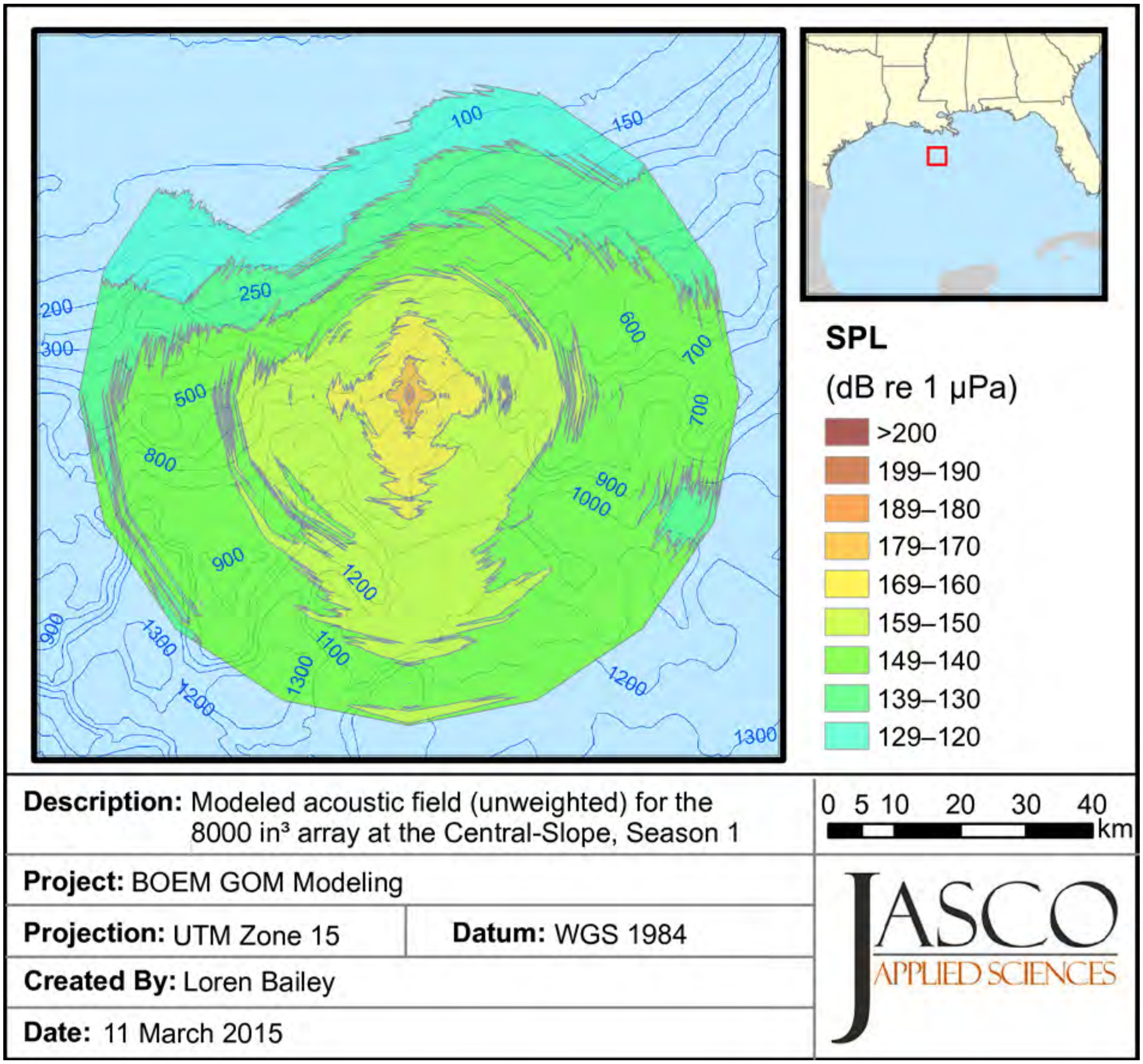

Figure E-2. 8000 in³ airgun array at the Central-Slope region (Site CM3), Season 1 (February): Broadband (10–5,000 Hz) maximum-over-depth rms SPL field. Blue contours indicate water depth in meters.

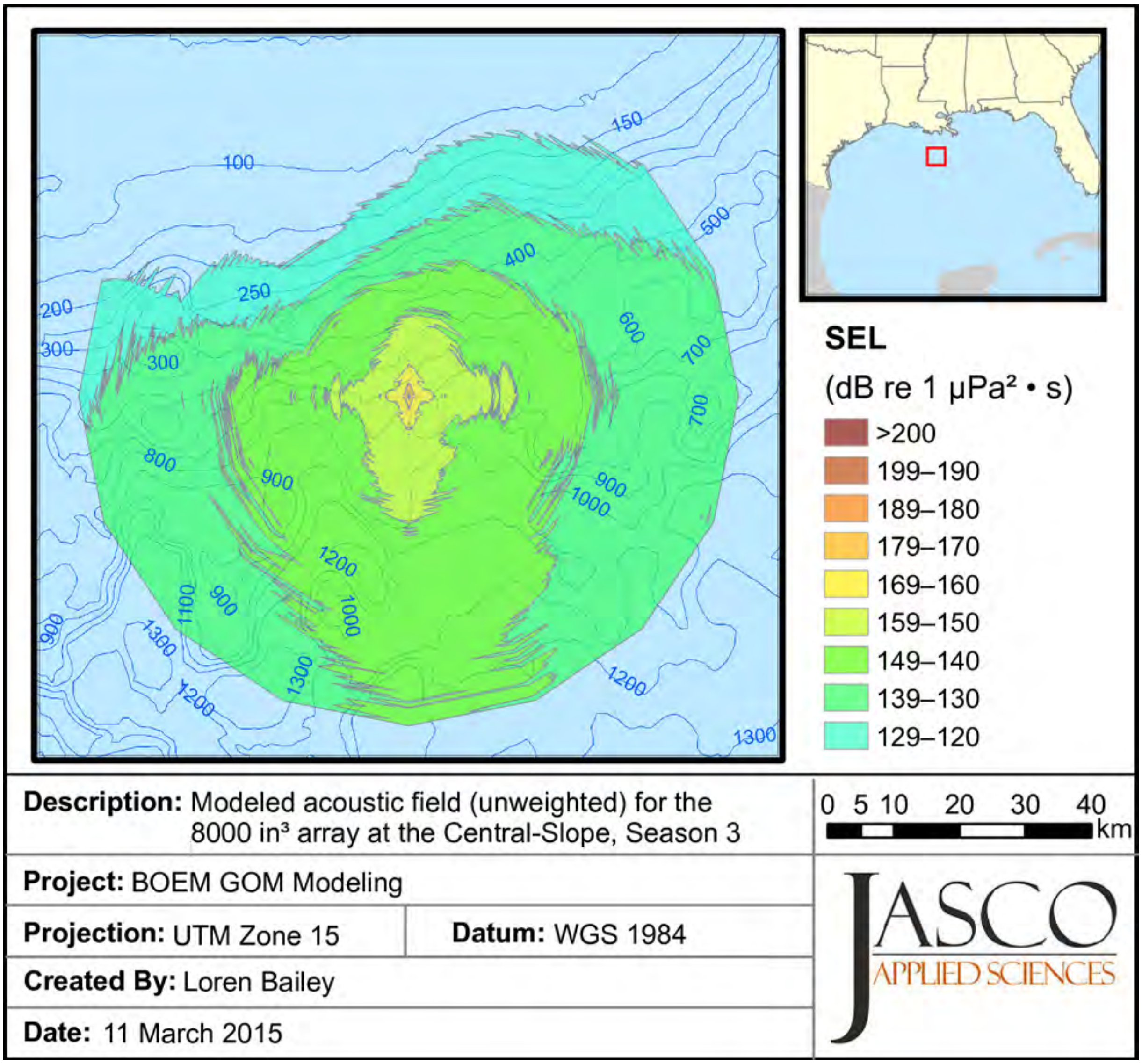

Figure E-3. 8000 in³ airgun array at the Central-Slope region (Site CM3), Season 3 (September) (February): Broadband (10–5,000 Hz) maximum-over-depth per-pulse SEL field. Blue contours indicate water depth in meters.

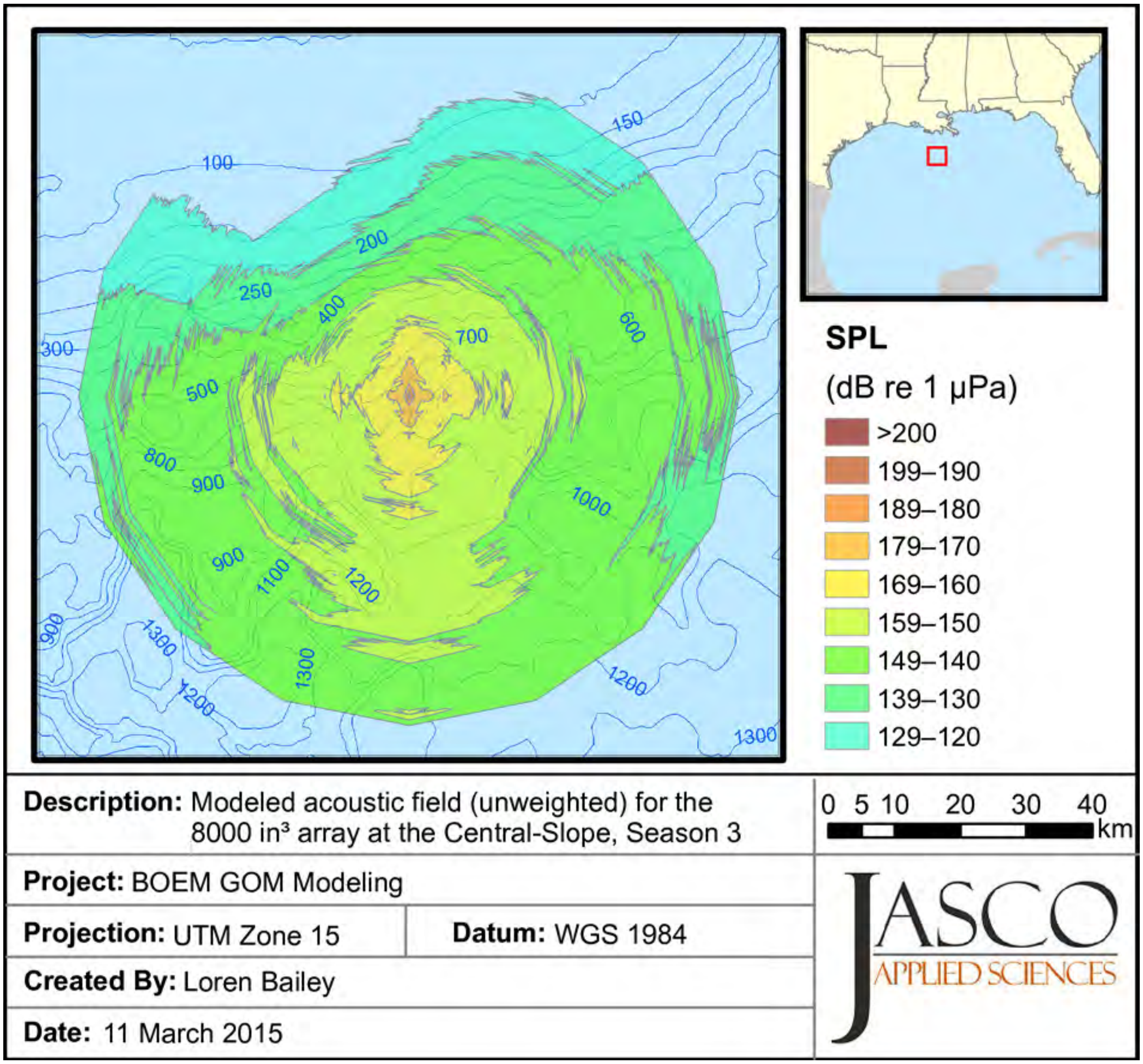

Figure E-4. 8000 in³ airgun array at the Central-Slope region (Site CM3), Season 3 (September) (February): Broadband (10–5,000 Hz) maximum-over-depth rms SPL field. Blue contours indicate water depth in meters.

Table E-1. 8000 in³ airgun array at Site CM3, Season 1 (February): Ranges to specific threshold levels (SEL).

SEL	Unweighted		Type I M-Weighting					
			LFC		MFC		HFC	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
210	10	10	10	10	< 10	< 10		
200	50	40	40	40	10	10	< 10	< 10
190	150	120	140	120	50	50	30	30
180	500	400	470	380	160	140	120	100
170	2100	1800	2000	1400	520	440	400	330
160	5900	4400	5400	4000	2900	1500	1300	1100
150	23000	17000	23000	16000	14000	9700	10000	9300
140	> 50000	> 50000	> 50000	> 50000	32000	21000	25000	18000
130					> 50000	> 50000	50000	36000
120							> 50000	> 50000
110								

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and
without auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC).
Units: rms SPL (dB re 1 µPa^2·s).

Table E-2. 8000 in³ airgun array at Site CM3, Season 1 (February): Ranges to specific threshold levels (rms SPL).

rms SPL	Unweighted		Type I M-Weighting					
			LFC		MFC		HFC	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
210	50	41	50	40	10	10	10	10
200	170	140	160	130	60	50	40	30
190	470	390	470	370	180	150	120	100
180	1900	1300	1500	1200	590	480	460	370
170	6700	5300	6400	4700	2400	1100	1200	900
160	19000	15000	18000	14000	11000	8500	9800	7200
150	50000	36000	50000	35000	26000	17000	23000	15000
140	> 50000	> 50000	> 50000	> 50000	47000	32000	43000	27000
130					> 50000	> 50000	> 50000	> 50000
120								
110								

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without
auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: rms SPL (dB re 1 µPa).

Table E-3. 8000 in³ airgun array at Site CM3, Season 3 (September): Ranges to specific threshold levels (SEL).

SEL	Unweighted		Type I M-Weighting					
			LFC		MFC		HFC	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
210	10	10	10	10	< 10	< 10		
200	50	40	40	40	10	10	< 10	< 10
190	150	120	140	120	50	50	30	30
180	490	400	470	380	160	140	120	100
170	2000	1700	1900	1400	510	430	390	330
160	5900	4200	5600	3900	2900	1700	1300	1100
150	21000	16000	19000	16000	15000	9300	9900	9100
140	> 50000	> 50000	> 50000	> 50000	23000	19000	23000	16000
130					48000	33000	40000	29000
120					> 50000	> 50000	> 50000	> 50000
110								

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and
without auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC).
Units: rms SPL (dB re 1 µPa^2·s).

Table E-4. 8000 in³ airgun array at Site CM3, Season 3 (September): Ranges to specific threshold levels (rms SPL).

rms SPL	Unweighted		Type I M-Weighting					
			LFC		MFC		HFC	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
210	50	41	50	40	10	10	10	10
200	170	140	160	130	60	50	40	30
190	470	390	470	370	180	150	120	100
180	1900	1300	1500	1200	590	470	460	370
170	6500	5300	6400	5000	2600	1200	1200	910
160	19000	15000	19000	14000	12000	9100	9700	7200
150	49000	35000	49000	34000	21000	16000	18000	15000
140	> 50000	> 50000	> 50000	> 50000	37000	28000	32000	26000
130					> 50000	> 50000	> 50000	> 50000
120								
110								

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without
auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: rms SPL (dB re 1 µPa).

E.2. High-resolution Sources

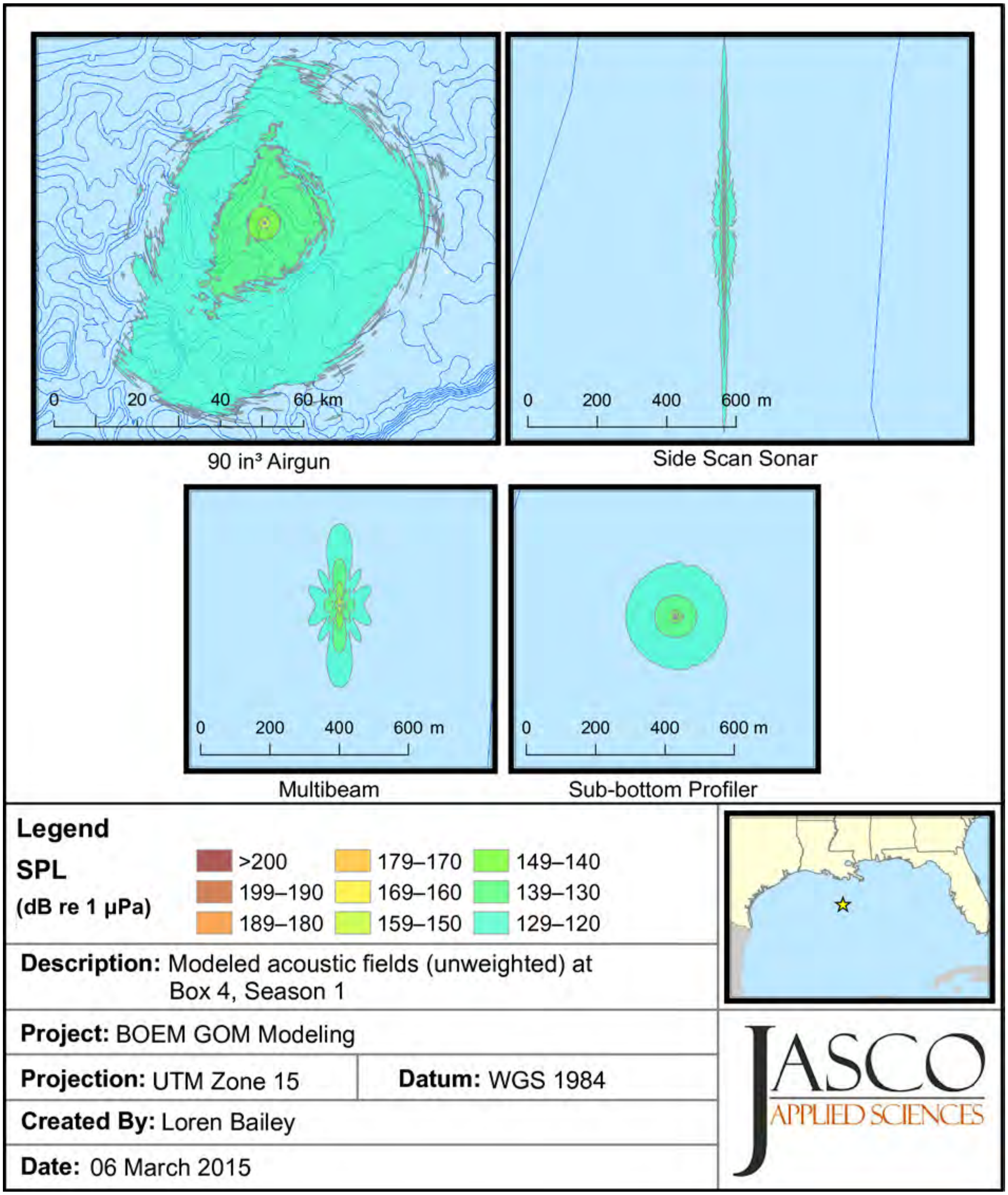

Figure E-5. Box 4 geotechnical sources: Maximum-over-depth sound pressure levels during Season 1 (February).

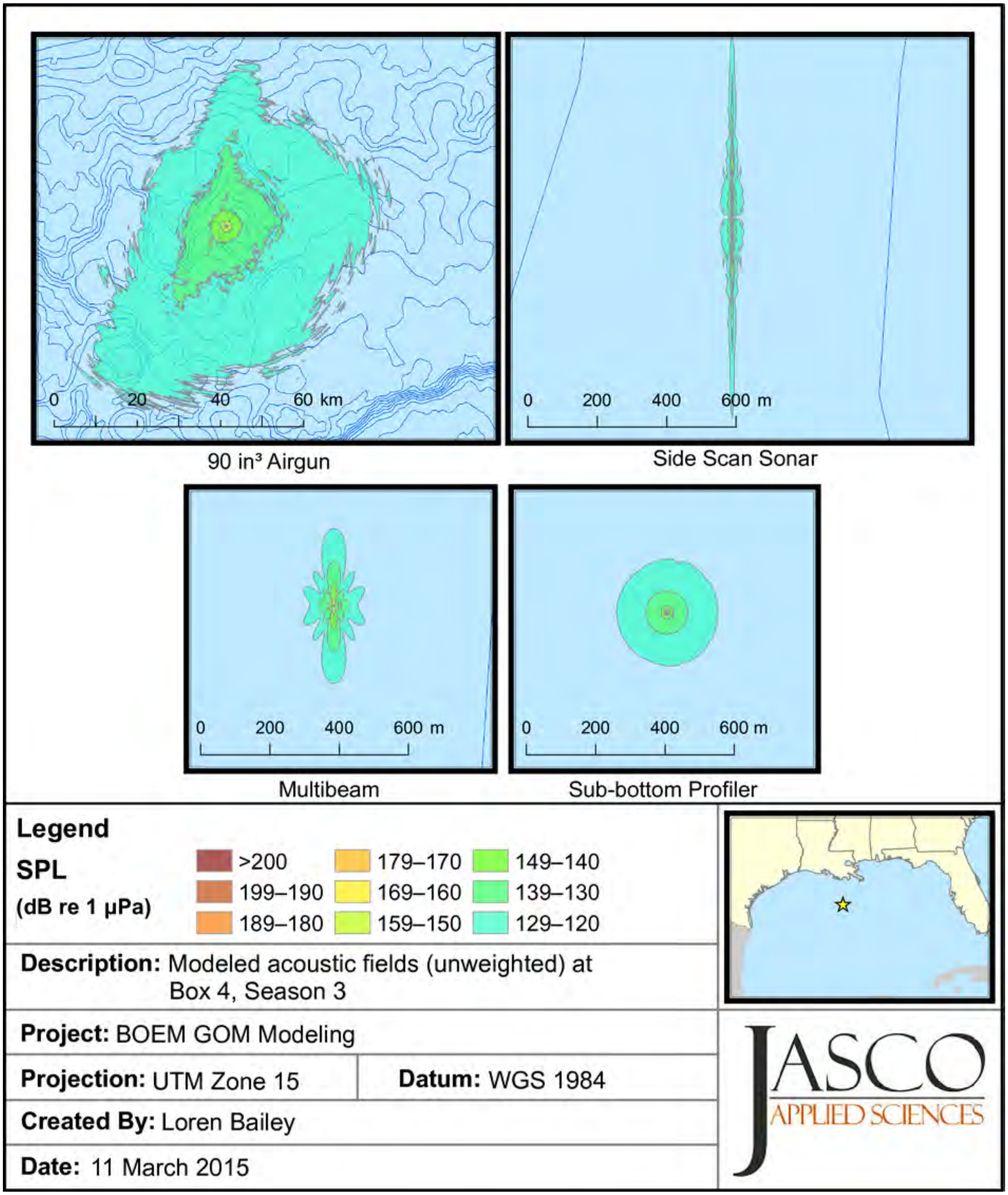

Figure E-6. Box 4 geotechnical sources: Maximum-over-depth sound pressure levels during Season 3 (September).

E.2.1. 90 in^3 Airgun/Boomer

Table E-5. Box 4, Season 1 (February), ranges to specific threshold levels for a 90 in³ single airgun.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	200	< 10	< 10	< 10	< 10				
180	190	14	14	14	14	< 10	< 10	< 10	< 10
170	180	45	42	42	42	14	14	14	14
160	170	120	110	110	110	54	54	45	45
150	160	370	360	360	350	160	160	130	130
140	150	1300	1300	1300	1200	500	490	410	390
130	140	8900	4800	8900	4200	1800	1700	1300	1300
120	130	28000	19000	28000	18000	17000	9400	17000	8300
110	120	> 50000	> 50000	> 50000	> 50000	35000	25000	35000	23000
100	110					> 50000	> 50000	> 50000	> 50000

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without
auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

Table E-6. Box 4, Season 3 (September), ranges to specific threshold levels for a 90 in³ single airgun.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
190	200	< 10	< 10	< 10	< 10				
180	190	14	14	14	14	< 10	< 10	< 10	< 10
170	180	42	42	41	41	14	14	14	14
160	170	120	110	110	110	54	54	45	45
150	160	370	360	360	350	160	160	130	130
140	150	1300	1300	1300	1200	500	490	410	400
130	140	8400	5200	8300	4000	1900	1700	1400	1300
120	130	27000	18000	25000	18000	14000	9100	13000	8300
110	120	> 50000	> 50000	50000	37000	35000	24000	35000	21000
100	110			> 50000	> 50000	> 50000	> 50000	> 50000	> 50000

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without
auditory frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

E.2.2. Multibeam Sonar

Table E-7. Box 4, Season 1 (February), ranges to specific threshold levels for a multibeam sonar.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
150	160	< 5	< 5			< 5	< 5	< 5	< 5
140	150	25	25			5	5	5	5
130	140	65	60			30	25	35	30
120	130	140	120	< 5	< 5	75	70	80	75
110	120	240	210	5	5	150	140	160	150
100	110	380	330	30	25	260	230	280	240

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without auditory
frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

Table E-8. Box 4, Season 3 (September), ranges to specific threshold levels for a multibeam sonar.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
150	160	< 5	< 5			< 5	< 5	< 5	< 5
140	150	25	25			5	5	5	5
130	140	65	60			30	25	35	30
120	130	130	120	< 5	< 5	75	70	80	70
110	120	220	200	5	5	150	130	160	140
100	110	350	300	30	30	240	220	260	230

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without auditory
frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

E.2.3. Side-scan Sonar

Table E-9. Box 4, Season 1 (February), ranges to specific threshold levels for a side-scan sonar.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
160	170	< 5	< 5			< 5	< 5	< 5	< 5
150	160	65	65			30	30	35	35
140	150	140	140			90	85	95	90
130	140	260	250	< 5	< 5	190	180	200	190
120	130	420	370	55	55	340	320	360	330
110	120	590	500	130	120	530	440	540	460
100	110	790	600	240	230	700	580	710	580

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without auditory
frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

Table E-10. Box 4, Season 3 (September), ranges to specific threshold levels for a side-scan sonar.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
160	170	< 5	< 5			< 5	< 5	< 5	< 5
150	160	65	65			30	30	35	35
140	150	140	130			90	85	95	90
130	140	240	230	< 5	< 5	190	180	190	180
120	130	410	350	55	50	330	310	350	330
110	120	580	480	130	120	520	430	520	430
100	110	760	580	240	230	680	560	700	570

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without auditory
frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

E.2.4. Sub-bottom Profiler

Table E-11. Box 4, Season 1 (February), ranges to specific threshold levels for a sub-bottom profiler.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
150	160	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
140	150	8	8	8	8	8	8	8	8
130	140	17	17	16	15	17	17	17	17
120	130	61	59	45	44	61	59	61	59
110	120	150	150	110	110	150	140	150	140
100	110	750	600	440	370	750	600	750	600

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without auditory
frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

Table E-12. Box 4, Season 3 (September), ranges to specific threshold levels for a sub-bottom profiler.

SEL	rms SPL	Unweighted		Type I M-Weighting					
				LFC		MFC		HFC	
		R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
150	160	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
140	150	8	8	8	8	8	8	8	8
130	140	17	17	16	15	17	17	17	17
120	130	61	59	45	44	61	59	61	59
110	120	160	150	110	110	150	140	150	140
100	110	770	610	440	370	750	600	750	600

Maximum (R_{max}, m) and 95% ($R_{95\%}$, m) horizontal distance from the source to modeled broadband maximum-over-depth sound level thresholds, with and without auditory
frequency weighting applied for low-frequency cetaceans (LFC), mid-frequency cetaceans (MFC), and high-frequency cetaceans (HFC). Units: SEL (dB re 1 µPa^2·s);
rms SPL (dB re 1 µPa).

Appendix F. Annual Exposure Estimates

F.1. Annual Totals for All Sources

Table F-1. 2016 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	331.1	33.5	40080.2	133426.8	201356.3
Beaked whales	51.7	2.9	6563.7	235614.8	57492.8
Common bottlenose dolphins	1974.6	151.7	212385.2	653404.8	891037.8
Bryde’s whales	0.4	15.1	77.4	731.8	860.9
Clymene dolphins	431.5	35.0	10240.0	110741.8	201187.1
False killer whales	111.4	10.7	3130.6	25510.6	45216.7
Fraser’s dolphins	52.0	3.2	3006.9	13858.3	22507.8
Killer whales	4.8	0.5	357.6	1492.9	2069.3
Kogia	4426.8	541.4	3824.5	16188.5	35585.5
Melon-headed whales	252.4	16.5	14115.5	68899.5	119722.0
Pantropical spotted dolphins	2550.3	134.2	64870.6	606728.6	947527.9
Pygmy killer whales	83.4	7.5	2281.5	18029.1	30429.7
Risso’s dolphins	105.9	14.5	2608.6	27061.9	48495.8
Rough-toothed dolphins	150.8	15.1	5401.8	37666.3	67023.8
Short-finned pilot whales	68.1	7.6	3426.8	19258.3	38823.6
Sperm whales	44.8	2.4	10872.7	43503.7	93979.5
Spinner dolphins	253.1	9.4	6328.8	82778.6	160968.7
Striped dolphins	174.2	11.1	4295.8	44037.5	75388.5

Table F-2. 2017 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	425.1	33.7	59630.6	175824.7	244098.4
Beaked whales	45.1	1.8	5870.3	204860.9	50231.7
Common bottlenose dolphins	2757.9	111.3	341522.1	966790.3	1283476.0
Bryde's whales	0.3	12.6	62.7	605.0	724.2
Clymene dolphins	360.6	21.3	8795.2	93767.5	165628.8
False killer whales	99.9	8.0	2879.5	22516.7	38959.8
Fraser's dolphins	47.1	2.3	2719.2	12240.7	19386.6
Killer whales	4.5	0.5	332.0	1351.6	1833.6
Kogia	3991.0	493.2	3488.7	14520.1	31629.3
Melon-headed whales	227.5	12.2	12607.0	60546.5	103396.1
Pantropical spotted dolphins	2319.6	98.6	59828.3	548764.4	843785.8
Pygmy killer whales	75.1	5.7	2055.5	15845.3	26126.8
Risso's dolphins	95.0	12.3	2309.0	23594.5	41516.2
Rough-toothed dolphins	142.0	11.8	5959.5	36133.7	61548.4
Short-finned pilot whales	54.0	4.8	2635.1	14972.4	29918.0
Sperm whales	40.4	1.4	9213.3	36832.3	79611.9
Spinner dolphins	244.7	8.5	6129.9	78708.7	153523.0
Striped dolphins	153.6	7.5	3862.8	38903.9	65281.2

Table F-3. 2018 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	290.2	25.5	36272.0	117295.4	173452.2
Beaked whales	44.4	2.7	5585.4	195022.1	47714.9
Common bottlenose dolphins	1784.9	90.3	198079.4	598127.8	804687.8
Bryde's whales	0.3	13.3	67.0	618.4	723.4
Clymene dolphins	376.4	32.7	8786.2	93293.4	171405.6
False killer whales	96.3	10.0	2687.6	21389.7	38221.2
Fraser's dolphins	45.3	3.0	2549.0	11575.0	18847.7
Killer whales	4.1	0.4	299.9	1229.9	1715.8
Kogia	3710.5	468.1	3226.1	13379.4	29285.6
Melon-headed whales	219.1	15.5	11957.0	57389.9	99683.7
Pantropical spotted dolphins	2157.9	116.7	54470.9	499090.9	786512.4
Pygmy killer whales	71.8	6.9	1945.2	15048.9	25668.9
Risso's dolphins	91.6	12.9	2226.9	22558.6	40690.5
Rough-toothed dolphins	131.1	13.9	4703.2	31907.1	56928.3
Short-finned pilot whales	61.3	7.4	3024.1	16718.6	33605.6
Sperm whales	38.1	2.1	9330.0	36576.4	78417.3
Spinner dolphins	212.1	7.9	5254.2	66746.3	129459.8
Striped dolphins	149.3	10.1	3637.0	36541.7	63137.2

Table F-4. 2019 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	423.0	40.2	61334.2	174705.4	237351.8
Beaked whales	38.0	1.6	4259.4	162134.0	39332.0
Common bottlenose dolphins	2833.4	161.0	352798.8	977108.3	1286763.9
Bryde’s whales	0.3	10.2	48.2	481.3	571.5
Clymene dolphins	282.8	19.7	6587.0	72912.8	132307.6
False killer whales	76.6	6.5	2175.1	17631.1	30853.9
Fraser’s dolphins	35.6	1.9	2010.0	9654.3	15405.2
Killer whales	3.4	0.4	240.9	1031.1	1429.7
Kogia	2889.2	380.6	2554.4	11427.6	24827.9
Melon-headed whales	171.2	9.5	9239.0	47547.6	81651.0
Pantropical spotted dolphins	1759.0	86.0	43742.7	419737.6	657701.8
Pygmy killer whales	56.9	4.5	1505.4	12277.6	20528.0
Risso’s dolphins	75.2	9.5	1761.0	18123.5	32923.3
Rough-toothed dolphins	114.5	10.2	5244.4	30192.3	51110.5
Short-finned pilot whales	42.6	4.1	2005.0	12154.5	24322.1
Sperm whales	28.9	1.3	6248.9	27270.6	56706.5
Spinner dolphins	188.1	7.5	4550.8	59622.5	119366.8
Striped dolphins	118.2	6.7	2855.3	29936.2	51432.8

Table F-5. 2020 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	290.5	23.4	36255.0	116698.1	171995.1
Beaked whales	46.7	1.7	5591.0	190777.4	46608.9
Common bottlenose dolphins	1788.3	81.9	198182.1	596824.1	801708.1
Bryde’s whales	0.3	12.4	61.3	565.8	672.5
Clymene dolphins	348.1	20.9	8468.2	87614.7	155501.5
False killer whales	95.4	7.6	2700.3	20828.4	36168.0
Fraser’s dolphins	43.9	2.1	2572.2	11393.8	17978.9
Killer whales	4.3	0.4	316.2	1258.4	1703.8
Kogia	3857.7	475.2	3346.4	13664.1	29421.3
Melon-headed whales	212.9	10.6	12084.1	56791.0	96371.0
Pantropical spotted dolphins	2215.8	94.3	57221.4	511036.9	789057.3
Pygmy killer whales	71.8	5.4	1975.1	14787.7	24406.7
Risso’s dolphins	93.7	11.4	2202.9	21914.2	38821.7
Rough-toothed dolphins	129.5	10.6	4704.1	31102.5	54226.7
Short-finned pilot whales	50.8	4.3	2546.7	14163.3	28103.6
Sperm whales	38.1	1.5	8517.9	33340.0	70032.5
Spinner dolphins	238.2	8.3	5935.9	73012.9	142804.9
Striped dolphins	147.6	7.3	3708.3	36266.5	61116.2

Table F-6. 2021 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	417.0	35.4	59474.2	171905.7	236363.4
Beaked whales	47.1	2.7	5398.0	187604.0	45590.3
Common bottlenose dolphins	2763.1	115.9	341320.6	955742.1	1266130.0
Bryde's whales	0.3	13.3	66.8	597.2	693.3
Clymene dolphins	369.8	32.7	8603.4	89618.0	166262.4
False killer whales	94.1	9.6	2708.4	20760.0	37075.3
Fraser's dolphins	43.3	2.8	2516.9	11279.5	18255.5
Killer whales	4.0	0.4	290.5	1176.3	1643.8
Kogia	3659.4	457.5	3153.7	12984.2	28092.0
Melon-headed whales	208.1	14.0	11669.4	55474.4	95823.2
Pantropical spotted dolphins	2096.5	116.1	52890.5	476698.9	757643.4
Pygmy killer whales	69.4	6.7	1895.4	14427.9	24697.5
Risso's dolphins	92.5	12.2	2171.1	21521.7	39337.2
Rough-toothed dolphins	136.0	14.0	5774.8	33915.3	58878.2
Short-finned pilot whales	58.9	7.0	2981.0	16327.5	32625.2
Sperm whales	36.3	2.3	8733.4	33804.8	69850.9
Spinner dolphins	209.9	8.1	5169.9	63322.2	124218.1
Striped dolphins	146.0	10.0	3547.6	34969.4	60995.9

Table F-7. 2022 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	302.4	30.4	38803.6	122141.9	177946.6
Beaked whales	41.9	1.7	5076.4	178787.5	43303.5
Common bottlenose dolphins	1890.0	134.3	210451.4	624454.4	835161.0
Bryde's whales	0.3	11.2	57.0	530.3	627.5
Clymene dolphins	315.9	20.6	7735.4	81413.5	145490.2
False killer whales	84.5	6.9	2452.5	19325.5	33630.0
Fraser's dolphins	39.0	1.9	2355.5	10607.9	16763.3
Killer whales	3.8	0.4	285.9	1162.9	1580.0
Kogia	3585.0	419.9	3054.8	12695.9	27371.7
Melon-headed whales	188.9	9.8	11040.9	52809.2	89767.1
Pantropical spotted dolphins	1998.7	93.2	51950.6	472822.4	732288.9
Pygmy killer whales	63.5	4.9	1780.6	13685.7	22634.5
Risso's dolphins	83.6	10.3	2012.3	20305.1	36265.7
Rough-toothed dolphins	117.1	10.1	4547.2	29545.9	51348.7
Short-finned pilot whales	46.0	4.1	2347.1	13294.3	26435.6
Sperm whales	33.6	1.5	7627.1	30668.4	63959.6
Spinner dolphins	212.0	8.0	5399.8	67309.9	132699.6
Striped dolphins	133.3	7.2	3375.6	33603.6	56934.9

Table F-8. 2023 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	397.5	32.7	58303.6	164824.3	221780.8
Beaked whales	36.5	1.6	4243.7	151708.3	37134.2
Common bottlenose dolphins	2687.0	102.8	339639.6	938321.5	1229214.3
Bryde's whales	0.3	9.9	47.0	454.3	540.4
Clymene dolphins	276.7	18.7	6501.2	69608.5	125034.2
False killer whales	75.9	6.5	2164.3	16774.1	29231.5
Fraser's dolphins	35.2	1.8	1991.4	9126.7	14537.6
Killer whales	3.4	0.4	240.0	984.3	1351.0
Kogia	2861.0	373.8	2526.2	10742.9	23321.6
Melon-headed whales	168.6	9.4	9148.2	44841.9	76892.5
Pantropical spotted dolphins	1719.9	78.8	43334.2	399580.5	621470.2
Pygmy killer whales	56.4	4.6	1504.2	11676.8	19464.7
Risso's dolphins	73.1	9.3	1710.1	17308.8	30955.1
Rough-toothed dolphins	112.5	9.9	5076.5	28662.8	48301.8
Short-finned pilot whales	41.8	4.0	1982.0	11522.5	23062.6
Sperm whales	29.6	1.3	6530.7	26650.9	56439.5
Spinner dolphins	182.7	6.6	4450.0	56546.1	111110.8
Striped dolphins	115.6	6.3	2821.3	28522.2	48514.8

Table F-9. 2024 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	269.3	22.6	35542.4	109856.5	157436.0
Beaked whales	37.7	1.7	4753.2	156583.6	38031.8
Common bottlenose dolphins	1721.5	74.9	196862.6	579403.1	766053.4
Bryde's whales	0.3	10.2	53.2	469.8	554.3
Clymene dolphins	288.4	19.0	7196.6	72741.3	129402.6
False killer whales	76.7	6.6	2296.8	17163.3	29795.7
Fraser's dolphins	35.3	1.7	2209.3	9391.4	14760.2
Killer whales	3.4	0.3	266.7	1035.8	1390.7
Kogia	3410.8	377.2	2858.4	11164.7	23941.2
Melon-headed whales	170.4	8.9	10344.7	46630.5	78841.0
Pantropical spotted dolphins	1814.1	82.8	48318.0	419823.7	647642.4
Pygmy killer whales	57.6	4.7	1668.1	12140.9	20053.1
Risso's dolphins	76.0	9.3	1830.2	18091.8	31995.2
Rough-toothed dolphins	106.3	9.4	4200.0	26314.7	45535.6
Short-finned pilot whales	42.0	3.9	2210.3	11900.0	23598.7
Sperm whales	31.6	1.5	7443.5	27656.6	57735.6
Spinner dolphins	189.4	6.6	4961.2	59253.3	115261.0
Striped dolphins	121.1	6.4	3136.7	29890.1	50373.1

Table F-10. 2025 annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	417.5	39.8	61360.8	172104.3	230498.1
Beaked whales	35.4	1.6	4314.1	146016.7	35545.7
Common bottlenose dolphins	2819.0	157.5	352480.7	970712.7	1269758.3
Bryde's whales	0.2	9.6	48.4	439.4	519.1
Clymene dolphins	269.9	18.4	6573.7	67663.6	121148.0
False killer whales	72.7	6.4	2189.7	16242.2	28188.8
Fraser's dolphins	33.5	1.7	2038.4	8848.8	13959.3
Killer whales	3.2	0.3	242.8	958.5	1298.3
Kogia	3036.5	355.7	2587.1	10383.1	22339.9
Melon-headed whales	160.4	8.7	9365.2	43386.6	73728.2
Pantropical spotted dolphins	1680.1	77.9	43875.2	388177.6	601739.4
Pygmy killer whales	54.0	4.5	1520.5	11291.9	18750.8
Risso's dolphins	71.0	8.8	1691.1	16794.8	29887.1
Rough-toothed dolphins	109.6	10.0	5256.8	28351.1	47408.9
Short-finned pilot whales	40.0	3.9	2024.0	11190.6	22263.7
Sperm whales	29.1	1.4	6721.2	25716.3	53768.8
Spinner dolphins	176.1	6.3	4499.6	54651.1	106767.8
Striped dolphins	112.7	6.2	2854.7	27700.9	46946.9

Table F-11. Decade annual exposure estimate totals for all sources.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	3563.5	317.2	487056.5	1458783.3	2052278.6
Beaked whales	424.6	20.1	51655.2	1809109.2	440985.8
Common bottlenose dolphins	23019.7	1181.6	2743722.5	7860889.1	10433990.6
Bryde's whales	3.0	117.8	588.8	5493.2	6487.0
Clymene dolphins	3320.1	239.0	79487.0	839375.0	1513368.0
False killer whales	883.5	78.8	25384.9	198141.7	347341.0
Fraser's dolphins	410.3	22.4	23968.9	107976.5	172402.1
Killer whales	38.8	4.1	2872.4	11681.7	16015.8
Kogia	35427.9	4342.6	30620.3	127150.4	275815.8
Melon-headed whales	1979.7	115.1	111570.8	534317.0	915875.8
Pantropical spotted dolphins	20311.8	978.5	520502.4	4742461.5	7385369.4
Pygmy killer whales	659.8	55.4	18131.6	139211.8	232760.7
Risso's dolphins	857.6	110.4	20523.1	207274.9	370887.7
Rough-toothed dolphins	1249.5	115.1	50868.4	313791.7	542311.0
Short-finned pilot whales	505.5	51.1	25182.1	141502.0	282758.8
Sperm whales	350.6	16.7	81238.9	322020.0	680502.4
Spinner dolphins	2106.2	77.1	52680.2	661951.7	1296180.6
Striped dolphins	1371.6	78.7	34095.0	340372.2	580121.5

F.2. Annual Exposure Estimates for Each Source

F.2.1. 2016

Table F-12. 2016 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	3.4	0.2	164.7	2667.7	6011.5
Beaked whales	1.8	0.1	186.4	15183.3	3562.4
Common bottlenose dolphins	7.3	0.6	396.6	7010.8	13939.6
Bryde's whales	0.0	0.3	2.4	41.2	50.6
Clymene dolphins	12.4	0.9	307.8	5925.8	10276.6
False killer whales	2.9	0.1	80.4	1363.4	2334.0
Fraser's dolphins	1.1	0.0	98.1	773.5	1330.2
Killer whales	0.1	0.0	12.4	87.5	123.4
Kogia	153.7	12.1	121.8	960.1	2319.9
Melon-headed whales	5.3	0.0	451.8	3911.0	7345.2
Pantropical spotted dolphins	93.0	7.7	2247.7	36435.7	54177.4
Pygmy killer whales	2.2	0.0	62.1	988.3	1580.3
Risso's dolphins	2.4	0.2	85.1	1530.8	2738.8
Rough-toothed dolphins	3.6	0.1	99.0	1775.4	3204.4
Short-finned pilot whales	1.1	0.0	77.6	864.2	1934.7
Sperm whales	1.4	0.2	327.0	2391.4	5749.3
Spinner dolphins	8.4	0.5	219.1	5464.7	11120.2
Striped dolphins	5.7	0.4	140.6	2542.7	4194.2

Table F-13. 2016 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	290.5	30.6	37123.8	114136.0	163006.9
Beaked whales	33.0	2.1	3289.8	141081.3	35503.2
Common bottlenose dolphins	1852.8	133.0	208355.1	603788.8	796124.2
Bryde’s whales	0.2	10.1	36.7	444.8	534.2
Clymene dolphins	278.5	26.4	5339.5	65882.6	123800.0
False killer whales	76.0	8.8	1710.2	15509.1	28278.4
Fraser’s dolphins	36.4	2.9	1463.8	8294.8	14018.2
Killer whales	3.3	0.4	182.0	853.8	1256.3
Kogia	1704.3	376.1	1827.1	9551.2	21540.5
Melon-headed whales	176.0	14.7	6772.6	40937.4	73612.3
Pantropical spotted dolphins	1541.9	84.9	32815.2	348649.0	560399.0
Pygmy killer whales	56.4	6.0	1202.0	10803.8	18880.2
Risso’s dolphins	67.4	10.6	1495.2	15913.9	29352.4
Rough-toothed dolphins	106.9	12.8	3633.2	24669.3	44010.9
Short-finned pilot whales	49.5	6.9	1725.8	12049.3	24878.6
Sperm whales	26.8	1.3	5337.1	26668.0	59889.8
Spinner dolphins	158.6	6.4	3179.1	47035.2	92654.6
Striped dolphins	108.7	7.8	2199.9	25673.0	45301.4

Table F-14. 2016 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	15.4	1.2	1948.8	13153.1	26634.9
Beaked whales	4.7	0.1	2347.0	63466.0	15214.7
Common bottlenose dolphins	34.7	0.9	2284.2	34068.7	68051.1
Bryde’s whales	0.1	1.1	30.9	200.9	229.3
Clymene dolphins	51.5	3.2	3108.5	31042.9	55785.4
False killer whales	11.2	1.0	847.6	6504.1	11321.1
Fraser’s dolphins	4.9	0.1	1119.1	3800.5	5931.0
Killer whales	0.5	0.1	118.3	437.5	556.7
Kogia	2149.2	40.1	1449.9	4496.0	9696.3
Melon-headed whales	24.3	0.6	5331.1	19034.4	32091.0
Pantropical spotted dolphins	311.8	7.5	20302.3	177190.6	274838.2
Pygmy killer whales	8.7	0.8	644.0	4698.6	7698.9
Risso’s dolphins	12.1	1.7	658.9	7710.5	13746.5
Rough-toothed dolphins	13.7	1.1	1055.3	8450.8	15393.5
Short-finned pilot whales	6.4	0.4	1249.2	4986.4	9964.0
Sperm whales	8.4	0.2	4068.0	11273.2	23183.1
Spinner dolphins	31.3	0.2	1984.1	24292.3	47726.1
Striped dolphins	21.1	0.8	1327.7	12638.6	21468.6

Table F-15. 2016 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	21.8	0.4	840.3	3454.1	5677.3
Beaked whales	12.3	0.5	740.4	15880.5	3212.4
Common bottlenose dolphins	79.9	6.4	1322.0	8454.5	12832.0
Bryde’s whales	0.1	3.7	7.5	44.8	46.9
Clymene dolphins	89.1	4.5	1484.1	7890.5	11325.0
False killer whales	21.3	0.9	492.4	2134.0	3283.1
Fraser’s dolphins	9.7	0.2	325.8	989.4	1228.4
Killer whales	1.0	0.1	44.8	114.1	132.8
Kogia	419.6	113.2	425.6	1181.3	2028.8
Melon-headed whales	46.8	1.1	1560.0	5016.7	6673.5
Pantropical spotted dolphins	603.6	34.1	9505.3	44453.4	58113.2
Pygmy killer whales	16.1	0.6	373.4	1538.5	2270.2
Risso’s dolphins	24.0	2.0	369.4	1906.7	2658.2
Rough-toothed dolphins	26.7	1.1	614.3	2769.6	4413.4
Short-finned pilot whales	11.1	0.3	374.2	1358.4	2046.4
Sperm whales	8.2	0.7	1140.7	3171.0	5157.4
Spinner dolphins	54.8	2.4	946.6	5986.4	9468.0
Striped dolphins	38.7	2.0	627.6	3183.2	4424.3

Table F-16. 2016 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	1.5	11.6	24.3
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	13.2	53.3	82.5
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.1	0.1
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.1	0.9	1.6
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-17. 2016 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-18. 2016 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	1.0	1.1	4.3	1.4
Beaked whales	0.0	0.1	0.1	3.7	0.0
Common bottlenose dolphins	0.0	10.9	14.1	28.7	8.3
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.2	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.2. 2017

Table F-19. 2017 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	1.8	0.0	98.3	1186.5	2811.6
Beaked whales	1.1	0.0	91.9	6722.8	1501.1
Common bottlenose dolphins	5.0	0.3	150.6	2883.8	7197.1
Bryde's whales	0.0	0.2	1.2	18.1	21.6
Clymene dolphins	5.9	0.5	146.0	2482.2	4989.7
False killer whales	1.1	0.0	40.7	604.5	1113.7
Fraser's dolphins	0.7	0.0	49.3	359.5	573.1
Killer whales	0.1	0.0	5.4	37.0	54.8
Kogia	80.5	6.3	66.3	450.9	1000.6
Melon-headed whales	3.5	0.1	236.3	1841.0	3166.7
Pantropical spotted dolphins	42.4	3.6	1025.4	15336.8	25861.0
Pygmy killer whales	0.9	0.0	30.5	436.0	748.4
Risso's dolphins	2.1	0.3	44.9	630.1	1325.3
Rough-toothed dolphins	1.4	0.1	51.4	790.5	1537.5
Short-finned pilot whales	0.9	0.0	45.7	418.6	834.9
Sperm whales	0.5	0.0	99.4	724.3	1020.7
Spinner dolphins	4.3	0.3	111.3	2275.5	5480.2
Striped dolphins	2.7	0.2	65.7	1066.9	2025.8

Table F-20. 2017 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	352.4	30.5	49497.1	142643.3	192650.5
Beaked whales	29.3	1.2	3051.9	128007.2	32312.8
Common bottlenose dolphins	2407.7	86.1	290214.0	812697.3	1039664.0
Bryde's whales	0.2	8.6	31.3	385.7	469.7
Clymene dolphins	237.8	16.8	4766.0	58336.4	106122.3
False killer whales	69.6	6.4	1615.6	14263.3	25295.6
Fraser's dolphins	33.4	2.1	1375.0	7624.2	12619.0
Killer whales	3.1	0.4	173.7	804.0	1158.3
Kogia	1578.4	348.0	1715.3	8894.0	19970.3
Melon-headed whales	160.5	11.1	6254.8	37393.8	66375.9
Pantropical spotted dolphins	1430.8	62.3	31083.7	328109.8	516513.5
Pygmy killer whales	51.8	4.4	1107.2	9874.8	16811.3
Risso's dolphins	61.2	9.0	1365.9	14505.6	26158.1
Rough-toothed dolphins	102.6	9.7	4022.8	24583.6	41975.2
Short-finned pilot whales	40.1	4.5	1425.8	9878.3	20237.6
Sperm whales	24.6	0.7	4681.1	23741.8	53770.0
Spinner dolphins	156.0	5.8	3137.8	46544.4	91603.8
Striped dolphins	97.7	5.3	2038.9	23633.7	40670.8

Table F-21. 2017 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	29.0	0.7	7890.2	25800.2	40335.2
Beaked whales	3.8	0.0	2074.1	56206.0	13558.4
Common bottlenose dolphins	121.1	4.3	41316.0	123526.4	204394.8
Bryde's whales	0.0	0.8	24.3	165.0	193.0
Clymene dolphins	40.0	0.0	2643.0	26420.6	45219.4
False killer whales	10.1	0.9	776.3	5771.4	9674.7
Fraser's dolphins	4.3	0.0	1004.7	3388.2	5118.5
Killer whales	0.4	0.1	110.9	405.4	498.7
Kogia	1950.8	36.6	1321.2	4103.9	8797.9
Melon-headed whales	21.2	0.0	4738.6	16924.7	27954.6
Pantropical spotted dolphins	280.9	0.0	18918.8	164513.4	248467.6
Pygmy killer whales	7.9	0.7	580.5	4172.5	6575.4
Risso's dolphins	10.4	1.2	582.4	6809.4	11737.3
Rough-toothed dolphins	13.1	1.0	1235.3	8147.1	13989.8
Short-finned pilot whales	4.6	0.0	898.6	3696.0	7297.5
Sperm whales	8.0	0.0	3481.2	9698.1	20342.7
Spinner dolphins	30.6	0.0	1951.1	23989.5	47094.8
Striped dolphins	18.0	0.0	1197.9	11386.2	18696.2

Table F-22. 2017 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	41.9	1.5	2142.5	6178.9	8275.4
Beaked whales	10.9	0.5	652.4	13921.0	2859.4
Common bottlenose dolphins	224.1	9.8	9814.4	27601.1	32129.4
Bryde's whales	0.1	3.0	5.8	36.3	39.9
Clymene dolphins	76.8	4.1	1240.3	6528.2	9297.4
False killer whales	19.1	0.8	447.1	1877.4	2875.7
Fraser's dolphins	8.8	0.2	290.1	868.8	1075.8
Killer whales	0.9	0.0	42.0	105.2	121.8
Kogia	381.2	102.3	385.9	1071.3	1860.5
Melon-headed whales	42.3	1.0	1377.3	4386.9	5898.9
Pantropical spotted dolphins	565.5	32.6	8800.4	40804.4	52943.6
Pygmy killer whales	14.5	0.6	337.3	1361.9	1991.7
Risso's dolphins	21.3	1.9	315.8	1649.3	2295.4
Rough-toothed dolphins	24.9	1.1	649.9	2611.4	4044.3
Short-finned pilot whales	8.4	0.2	265.0	979.6	1548.0
Sperm whales	7.4	0.6	951.6	2668.1	4478.6
Spinner dolphins	53.9	2.3	929.8	5899.2	9344.3
Striped dolphins	35.2	1.9	560.3	2817.1	3888.5

Table F-23. 2017 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	1.5	11.6	24.3
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	13.2	53.3	82.5
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.1	0.1
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.1	0.9	1.6
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-24. 2017 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-25. 2017 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	1.0	1.1	4.2	1.4
Beaked whales	0.0	0.1	0.1	3.9	0.0
Common bottlenose dolphins	0.0	10.8	14.0	28.3	8.1
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.2	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.3. 2018

Table F-26. 2018 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-27. 2018 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	258.5	23.0	33885.6	103132.0	145888.8
Beaked whales	30.0	2.1	2952.3	127359.3	32024.0
Common bottlenose dolphins	1686.8	73.7	194968.1	561859.9	735584.6
Bryde’s whales	0.2	9.2	33.6	406.2	486.1
Clymene dolphins	255.3	25.7	4840.8	59851.4	113381.4
False killer whales	68.6	8.4	1546.5	14014.8	25695.4
Fraser’s dolphins	32.9	2.7	1318.0	7489.7	12714.7
Killer whales	2.9	0.3	162.2	763.3	1129.6
Kogia	1530.4	337.9	1635.0	8564.4	19336.5
Melon-headed whales	158.7	13.9	6085.2	36890.6	66561.4
Pantropical spotted dolphins	1383.6	80.5	29282.7	311665.6	503795.1
Pygmy killer whales	50.8	5.7	1080.8	9734.3	17127.6
Risso’s dolphins	60.9	9.7	1348.2	14350.8	26624.2
Rough-toothed dolphins	96.7	12.0	3279.7	22320.9	39942.9
Short-finned pilot whales	45.9	6.7	1594.6	11153.1	23069.5
Sperm whales	24.1	1.3	4860.1	24193.1	54213.7
Spinner dolphins	140.0	5.7	2803.7	41449.0	81672.3
Striped dolphins	98.4	7.5	1974.7	23087.2	41008.4

Table F-28. 2018 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	13.1	1.1	1666.3	11199.8	22710.5
Beaked whales	4.0	0.1	2001.4	54098.3	12955.0
Common bottlenose dolphins	29.5	0.9	1952.6	28973.5	58068.6
Bryde's whales	0.0	0.9	26.8	173.5	197.1
Clymene dolphins	44.8	3.2	2668.0	26639.5	48248.8
False killer whales	9.5	0.8	721.9	5551.2	9719.5
Fraser's dolphins	4.2	0.1	953.1	3239.8	5082.9
Killer whales	0.4	0.1	99.8	370.0	473.7
Kogia	1824.1	34.0	1229.8	3812.2	8230.3
Melon-headed whales	20.7	0.6	4541.3	16213.6	27431.9
Pantropical spotted dolphins	265.0	7.5	17149.5	149772.4	233427.8
Pygmy killer whales	7.3	0.7	547.3	4003.2	6603.0
Risso's dolphins	10.4	1.5	562.0	6575.9	11790.6
Rough-toothed dolphins	11.6	0.9	899.9	7216.7	13211.7
Short-finned pilot whales	5.7	0.4	1099.4	4370.4	8747.7
Sperm whales	7.1	0.2	3487.8	9656.9	19792.6
Spinner dolphins	26.2	0.2	1658.9	20294.1	39876.9
Striped dolphins	18.1	0.8	1128.1	10740.9	18352.6

Table F-29. 2018 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	18.6	0.4	717.5	2947.3	4825.6
Beaked whales	10.4	0.4	631.7	13560.3	2735.9
Common bottlenose dolphins	68.6	5.4	1131.1	7210.2	10938.4
Bryde's whales	0.1	3.2	6.5	38.7	40.2
Clymene dolphins	76.3	3.8	1277.4	6802.5	9775.5
False killer whales	18.1	0.7	419.2	1823.6	2806.2
Fraser's dolphins	8.2	0.2	277.9	845.5	1050.0
Killer whales	0.8	0.0	37.8	96.6	112.5
Kogia	356.1	96.1	361.3	1002.8	1718.7
Melon-headed whales	39.8	1.0	1330.5	4285.6	5690.4
Pantropical spotted dolphins	509.3	28.7	8038.6	37652.8	49289.5
Pygmy killer whales	13.7	0.5	317.2	1311.5	1938.3
Risso's dolphins	20.4	1.7	316.8	1631.9	2275.7
Rough-toothed dolphins	22.7	1.0	523.5	2368.3	3772.0
Short-finned pilot whales	9.7	0.3	330.1	1195.1	1788.4
Sperm whales	7.0	0.6	982.1	2726.3	4411.0
Spinner dolphins	45.8	2.0	791.6	5003.2	7910.6
Striped dolphins	32.8	1.7	534.2	2713.7	3776.2

Table F-30. 2018 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	1.6	12.4	26.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	14.1	57.1	88.4
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.1	0.1
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.1	1.0	1.7
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-31. 2018 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-32. 2018 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.9	1.0	3.9	1.3
Beaked whales	0.0	0.1	0.1	4.1	0.0
Common bottlenose dolphins	0.0	10.4	13.4	27.1	7.7
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.2	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.4. 2019

Table F-33. 2019 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	5.3	0.1	278.9	3706.9	8628.9
Beaked whales	3.0	0.1	277.0	21037.3	4783.3
Common bottlenose dolphins	13.7	0.9	499.5	9273.0	21363.9
Bryde's whales	0.0	0.5	3.6	56.8	68.5
Clymene dolphins	18.0	1.4	445.8	7927.3	15117.6
False killer whales	3.7	0.1	121.5	1890.8	3394.4
Fraser's dolphins	1.9	0.0	147.7	1105.7	1811.4
Killer whales	0.2	0.0	17.0	117.7	171.2
Kogia	237.9	18.8	193.5	1381.8	3161.1
Melon-headed whales	9.7	0.2	698.5	5637.5	10006.1
Pantropical spotted dolphins	131.2	11.1	3174.7	48891.3	78810.7
Pygmy killer whales	2.9	0.1	92.1	1366.3	2286.9
Risso's dolphins	5.3	0.6	132.4	2025.6	4020.0
Rough-toothed dolphins	4.6	0.2	152.4	2468.8	4677.2
Short-finned pilot whales	2.3	0.1	130.2	1269.2	2637.2
Sperm whales	1.7	0.1	362.3	2644.3	4916.0
Spinner dolphins	12.8	0.9	332.1	7283.4	16520.5
Striped dolphins	8.2	0.7	201.7	3405.1	6148.7

Table F-34. 2019 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	360.2	37.5	51987.7	145156.3	192048.7
Beaked whales	26.0	1.2	2364.2	100180.1	25095.0
Common bottlenose dolphins	2513.7	139.3	302326.3	832539.5	1058082.9
Bryde’s whales	0.2	7.2	26.1	307.3	369.5
Clymene dolphins	194.7	15.6	3812.4	45827.6	85313.6
False killer whales	55.5	5.4	1317.1	11237.1	20096.9
Fraser’s dolphins	26.1	1.7	1093.4	6036.2	9991.7
Killer whales	2.4	0.3	134.2	617.0	898.6
Kogia	1253.7	277.0	1345.5	6982.0	15495.4
Melon-headed whales	124.2	8.7	4916.8	29368.5	52043.7
Pantropical spotted dolphins	1126.0	54.5	24137.8	251515.9	402878.2
Pygmy killer whales	40.8	3.7	871.8	7677.1	13240.5
Risso’s dolphins	50.8	7.1	1082.0	11204.0	20701.3
Rough-toothed dolphins	86.5	8.7	3806.3	21030.5	35439.8
Short-finned pilot whales	32.6	3.9	1178.1	8121.9	16564.8
Sperm whales	18.9	0.8	3487.9	17766.7	38593.6
Spinner dolphins	123.5	4.9	2455.8	34951.0	69804.6
Striped dolphins	78.3	4.8	1603.9	18273.9	32084.1

Table F-35. 2019 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	23.0	0.4	7216.1	20946.0	30581.8
Beaked whales	2.3	0.0	1232.9	32845.5	7811.7
Common bottlenose dolphins	108.7	4.3	40554.0	110805.1	179899.5
Bryde's whales	0.0	0.5	14.9	96.3	110.9
Clymene dolphins	23.8	0.1	1586.7	15424.4	26555.0
False killer whales	6.0	0.5	471.0	3409.5	5700.4
Fraser's dolphins	2.5	0.0	595.4	2005.5	2987.9
Killer whales	0.2	0.0	65.1	235.6	290.0
Kogia	1169.6	22.0	783.2	2434.9	5115.3
Melon-headed whales	12.3	0.0	2799.5	9992.7	16250.3
Pantropical spotted dolphins	165.5	0.4	11220.9	95897.8	145622.4
Pygmy killer whales	4.7	0.4	344.0	2445.2	3852.8
Risso's dolphins	6.3	0.7	354.0	3957.5	6893.5
Rough-toothed dolphins	8.2	0.6	860.3	5093.7	8580.2
Short-finned pilot whales	2.6	0.0	535.7	2194.0	4242.7
Sperm whales	4.5	0.0	1899.3	5432.1	10919.1
Spinner dolphins	18.4	0.1	1196.3	14031.9	27709.5
Striped dolphins	10.7	0.0	715.8	6643.8	10972.3

Table F-36. 2019 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	34.5	1.5	1848.0	4872.8	6049.0
Beaked whales	6.7	0.3	385.2	8066.9	1642.0
Common bottlenose dolphins	197.3	7.2	9384.0	24373.8	27267.1
Bryde's whales	0.0	1.9	3.6	20.9	22.6
Clymene dolphins	46.3	2.6	742.1	3733.5	5321.4
False killer whales	11.3	0.4	265.4	1093.6	1662.0
Fraser's dolphins	5.2	0.1	173.6	506.9	614.2
Killer whales	0.5	0.0	24.6	60.8	69.8
Kogia	228.1	62.9	232.2	628.9	1056.0
Melon-headed whales	25.0	0.6	824.1	2548.9	3351.0
Pantropical spotted dolphins	336.2	19.9	5209.2	23432.5	30390.4
Pygmy killer whales	8.6	0.3	197.5	789.1	1147.8
Risso's dolphins	12.7	1.1	192.6	936.4	1308.4
Rough-toothed dolphins	15.3	0.7	425.4	1597.6	2410.7
Short-finned pilot whales	5.0	0.1	161.0	569.3	877.4
Sperm whales	3.8	0.3	499.4	1427.4	2277.9
Spinner dolphins	33.4	1.6	566.6	3356.2	5332.2
Striped dolphins	21.1	1.2	333.9	1613.4	2227.7

Table F-37. 2019 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	1.7	13.4	28.2
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	15.3	61.7	95.7
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.1	0.1
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.1	1.0	1.8
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-38. 2019 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.9	6.7	14.1
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	7.7	31.0	48.1
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.1
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.5	0.9
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-39. 2019 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.8	0.9	3.3	1.1
Beaked whales	0.0	0.1	0.1	4.1	0.0
Common bottlenose dolphins	0.0	9.3	12.0	24.1	6.8
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.2	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.5. 2020

Table F-40. 2020 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-41. 2020 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	257.3	21.5	33820.5	101931.8	143334.9
Beaked whales	32.0	1.2	2864.4	120588.4	30188.2
Common bottlenose dolphins	1689.3	64.7	195029.7	558752.9	730436.3
Bryde’s whales	0.2	8.6	31.1	364.5	439.5
Clymene dolphins	231.2	16.8	4583.2	54661.0	100979.0
False killer whales	66.4	5.9	1506.3	13247.4	23695.8
Fraser’s dolphins	31.0	1.9	1288.4	7165.0	11819.3
Killer whales	3.0	0.3	163.4	748.1	1083.6
Kogia	1526.0	336.4	1639.5	8489.6	18763.7
Melon-headed whales	149.4	9.6	5966.5	35476.4	62512.8
Pantropical spotted dolphins	1369.3	61.7	29494.0	305690.7	487609.9
Pygmy killer whales	49.4	4.1	1057.1	9252.6	15838.7
Risso’s dolphins	62.0	8.3	1305.4	13456.6	24789.6
Rough-toothed dolphins	93.7	8.7	3226.7	21288.3	37285.2
Short-finned pilot whales	37.8	4.1	1382.8	9487.1	19257.1
Sperm whales	22.8	0.9	4084.4	20970.2	45203.6
Spinner dolphins	153.7	6.0	3053.5	43120.3	86362.0
Striped dolphins	94.4	5.3	1949.4	22061.1	38529.1

Table F-42. 2020 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	13.8	0.7	1695.3	11719.6	23546.6
Beaked whales	3.8	0.0	2074.1	56206.0	13558.4
Common bottlenose dolphins	31.1	0.0	1989.5	30571.2	59895.0
Bryde’s whales	0.0	0.8	24.3	165.0	193.0
Clymene dolphins	40.0	0.0	2643.0	26420.6	45219.4
False killer whales	10.0	0.8	754.2	5717.3	9609.3
Fraser’s dolphins	4.2	0.0	995.6	3364.5	5088.1
Killer whales	0.4	0.1	110.8	405.1	498.3
Kogia	1950.4	36.6	1320.6	4102.6	8796.0
Melon-headed whales	21.2	0.0	4738.5	16924.4	27954.2
Pantropical spotted dolphins	280.9	0.0	18917.1	164509.3	248462.5
Pygmy killer whales	7.9	0.7	580.5	4172.4	6575.2
Risso’s dolphins	10.4	1.2	581.6	6807.6	11735.1
Rough-toothed dolphins	12.1	0.9	932.4	7404.4	13091.1
Short-finned pilot whales	4.6	0.0	898.5	3695.9	7297.5
Sperm whales	8.0	0.0	3481.2	9698.1	20342.7
Spinner dolphins	30.6	0.0	1951.1	23989.5	47094.8
Striped dolphins	18.0	0.0	1197.9	11386.1	18696.1

Table F-43. 2020 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	19.4	0.3	737.0	3041.0	5110.1
Beaked whales	10.9	0.5	652.4	13921.0	2859.3
Common bottlenose dolphins	68.0	6.1	1145.4	7466.0	11361.6
Bryde’s whales	0.1	3.0	5.8	36.3	39.9
Clymene dolphins	76.8	4.1	1240.3	6528.2	9297.4
False killer whales	19.0	0.8	439.4	1862.6	2861.4
Fraser’s dolphins	8.7	0.2	287.8	863.6	1070.5
Killer whales	0.9	0.0	41.9	105.2	121.7
Kogia	381.1	102.2	385.8	1071.0	1860.2
Melon-headed whales	42.3	1.0	1377.3	4386.9	5898.9
Pantropical spotted dolphins	565.5	32.6	8800.1	40803.5	52942.7
Pygmy killer whales	14.5	0.6	337.3	1361.9	1991.7
Risso’s dolphins	21.3	1.9	315.6	1648.9	2295.0
Rough-toothed dolphins	23.7	1.0	544.5	2408.3	3848.4
Short-finned pilot whales	8.4	0.2	265.0	979.6	1548.0
Sperm whales	7.4	0.6	951.6	2668.1	4478.6
Spinner dolphins	53.9	2.3	929.8	5899.2	9344.3
Striped dolphins	35.2	1.9	560.3	2817.1	3888.4

Table F-44. 2020 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.7	1.2	1.3
Beaked whales	0.0	0.0	0.0	34.8	1.8
Common bottlenose dolphins	0.0	0.0	2.0	3.5	4.4
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	1.0	2.9	3.4
False killer whales	0.0	0.0	0.2	0.7	0.9
Fraser's dolphins	0.0	0.0	0.2	0.4	0.6
Killer whales	0.0	0.0	0.0	0.1	0.1
Kogia	0.1	0.0	0.3	0.5	0.9
Melon-headed whales	0.0	0.0	1.1	2.0	3.1
Pantropical spotted dolphins	0.0	0.0	6.1	20.0	25.3
Pygmy killer whales	0.0	0.0	0.1	0.5	0.7
Risso's dolphins	0.0	0.0	0.2	0.7	1.1
Rough-toothed dolphins	0.0	0.0	0.2	0.8	1.2
Short-finned pilot whales	0.0	0.0	0.6	0.4	0.7
Sperm whales	0.0	0.0	0.4	2.1	4.6
Spinner dolphins	0.0	0.0	1.0	2.3	2.3
Striped dolphins	0.0	0.0	0.4	1.3	1.6

Table F-45. 2020 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.5	0.8	0.9
Beaked whales	0.0	0.0	0.0	23.2	1.2
Common bottlenose dolphins	0.0	0.0	1.3	2.3	2.9
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.7	1.9	2.3
False killer whales	0.0	0.0	0.1	0.4	0.6
Fraser's dolphins	0.0	0.0	0.2	0.3	0.4
Killer whales	0.0	0.0	0.0	0.0	0.1
Kogia	0.1	0.0	0.2	0.4	0.6
Melon-headed whales	0.0	0.0	0.7	1.3	2.0
Pantropical spotted dolphins	0.0	0.0	4.1	13.3	16.8
Pygmy killer whales	0.0	0.0	0.1	0.3	0.5
Risso's dolphins	0.0	0.0	0.1	0.5	0.8
Rough-toothed dolphins	0.0	0.0	0.2	0.6	0.8
Short-finned pilot whales	0.0	0.0	0.1	0.3	0.4
Sperm whales	0.0	0.0	0.3	1.4	3.1
Spinner dolphins	0.0	0.0	0.6	1.5	1.5
Striped dolphins	0.0	0.0	0.3	0.9	1.0

Table F-46. 2020 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.9	1.0	3.8	1.3
Beaked whales	0.0	0.1	0.1	3.9	0.0
Common bottlenose dolphins	0.0	11.0	14.2	28.2	7.8
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.2	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.6. 2021

Table F-47. 2021 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-48. 2021 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	347.6	31.8	49489.2	140536.8	188872.3
Beaked whales	32.7	2.1	2764.9	119940.7	29899.4
Common bottlenose dolphins	2418.9	92.0	290228.9	806443.3	1031848.6
Bryde's whales	0.2	9.2	33.4	385.0	455.9
Clymene dolphins	248.7	25.7	4658.0	56176.1	108238.1
False killer whales	66.3	8.0	1537.5	13316.3	24469.9
Fraser's dolphins	30.9	2.4	1274.5	7165.3	12086.8
Killer whales	2.8	0.3	152.7	709.2	1057.1
Kogia	1478.7	327.3	1561.8	8167.6	18140.7
Melon-headed whales	147.6	12.4	5797.4	34974.8	62700.4
Pantropical spotted dolphins	1322.3	79.8	27700.2	289268.8	474920.2
Pygmy killer whales	48.4	5.4	1030.9	9113.0	16156.0
Risso's dolphins	61.7	9.0	1291.4	13311.6	25268.3
Rough-toothed dolphins	99.4	12.0	3943.0	23384.3	40799.8
Short-finned pilot whales	43.6	6.3	1551.5	10762.0	22089.1
Sperm whales	22.3	1.5	4263.5	21421.5	45647.3
Spinner dolphins	137.8	5.9	2719.4	38024.9	76430.6
Striped dolphins	95.1	7.5	1885.3	21514.8	38867.0

Table F-49. 2021 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	28.4	1.1	7861.1	25280.4	39499.1
Beaked whales	4.0	0.1	2001.4	54098.4	12955.0
Common bottlenose dolphins	119.5	5.1	41279.1	121928.8	202568.4
Bryde’s whales	0.0	0.9	26.8	173.5	197.1
Clymene dolphins	44.8	3.2	2668.0	26639.5	48248.8
False killer whales	9.6	0.8	744.0	5605.3	9785.0
Fraser’s dolphins	4.2	0.1	962.3	3263.5	5113.4
Killer whales	0.4	0.1	100.0	370.4	474.1
Kogia	1824.5	34.0	1230.4	3813.5	8232.2
Melon-headed whales	20.7	0.6	4541.4	16213.9	27432.3
Pantropical spotted dolphins	265.0	7.5	17151.2	149776.5	233432.8
Pygmy killer whales	7.3	0.7	547.3	4003.3	6603.2
Risso’s dolphins	10.4	1.5	562.7	6577.7	11792.8
Rough-toothed dolphins	12.6	1.0	1202.8	7959.4	14110.5
Short-finned pilot whales	5.7	0.4	1099.4	4370.4	8747.7
Sperm whales	7.1	0.2	3487.8	9656.9	19792.6
Spinner dolphins	26.2	0.2	1658.9	20294.1	39876.9
Striped dolphins	18.1	0.8	1128.1	10740.9	18352.7

Table F-50. 2021 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	41.1	1.6	2122.9	6085.2	7990.8
Beaked whales	10.4	0.4	631.7	13560.3	2735.9
Common bottlenose dolphins	224.7	9.0	9800.1	27345.3	31706.3
Bryde's whales	0.1	3.2	6.5	38.7	40.2
Clymene dolphins	76.3	3.8	1277.4	6802.5	9775.5
False killer whales	18.2	0.7	426.9	1838.4	2820.4
Fraser's dolphins	8.3	0.2	280.1	850.7	1055.3
Killer whales	0.8	0.0	37.8	96.7	112.6
Kogia	356.2	96.2	361.5	1003.1	1719.1
Melon-headed whales	39.8	1.0	1330.5	4285.7	5690.4
Pantropical spotted dolphins	509.3	28.7	8039.0	37653.7	49290.4
Pygmy killer whales	13.7	0.5	317.2	1311.5	1938.3
Risso's dolphins	20.4	1.7	317.0	1632.3	2276.1
Rough-toothed dolphins	24.0	1.0	628.9	2571.4	3967.8
Short-finned pilot whales	9.7	0.3	330.1	1195.1	1788.4
Sperm whales	7.0	0.6	982.1	2726.3	4411.0
Spinner dolphins	45.8	2.0	791.6	5003.2	7910.6
Striped dolphins	32.8	1.7	534.2	2713.7	3776.2

Table F-51. 2021 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-52. 2021 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-53. 2021 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.8	0.9	3.3	1.1
Beaked whales	0.0	0.1	0.1	4.6	0.0
Common bottlenose dolphins	0.0	9.8	12.6	24.7	6.7
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.2	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.1	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.7. 2022

Table F-54. 2022 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	3.5	0.1	180.6	2520.4	5817.3
Beaked whales	1.9	0.1	185.1	14314.5	3282.3
Common bottlenose dolphins	8.7	0.6	348.9	6389.2	14166.9
Bryde’s whales	0.0	0.4	2.4	38.7	46.9
Clymene dolphins	12.1	0.9	299.9	5445.1	10128.0
False killer whales	2.6	0.1	80.9	1286.2	2280.7
Fraser’s dolphins	1.2	0.0	98.4	746.2	1238.2
Killer whales	0.1	0.0	11.6	80.7	116.5
Kogia	157.3	12.4	127.2	930.9	2160.5
Melon-headed whales	6.2	0.1	462.2	3796.5	6839.3
Pantropical spotted dolphins	88.9	7.5	2149.3	33554.6	52949.7
Pygmy killer whales	2.0	0.0	61.6	930.2	1538.5
Risso’s dolphins	3.3	0.4	87.5	1395.5	2694.7
Rough-toothed dolphins	3.2	0.1	100.9	1678.2	3139.7
Short-finned pilot whales	1.4	0.0	84.5	850.7	1802.3
Sperm whales	1.2	0.1	262.9	1920.0	3895.3
Spinner dolphins	8.5	0.5	220.8	5007.9	11040.3
Striped dolphins	5.5	0.4	136.0	2338.2	4122.9

Table F-55. 2022 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	268.1	28.5	36347.7	106098.2	145899.1
Beaked whales	26.0	1.2	2364.2	100180.1	25094.9
Common bottlenose dolphins	1788.4	119.4	207103.8	583275.6	755337.1
Bryde's whales	0.2	7.2	26.1	307.3	369.5
Clymene dolphins	194.7	15.6	3812.4	45827.6	85313.6
False killer whales	55.1	5.4	1267.0	11078.4	19909.7
Fraser's dolphins	25.8	1.7	1071.8	5968.8	9905.8
Killer whales	2.4	0.3	133.9	616.1	897.5
Kogia	1253.3	276.6	1344.1	6978.2	15490.0
Melon-headed whales	124.2	8.7	4916.5	29367.7	52042.6
Pantropical spotted dolphins	1126.0	54.5	24134.2	251504.8	402863.9
Pygmy killer whales	40.8	3.7	871.7	7676.6	13240.0
Risso's dolphins	50.8	7.1	1080.1	11199.1	20695.0
Rough-toothed dolphins	80.7	8.2	3076.6	18851.2	32666.3
Short-finned pilot whales	32.6	3.9	1178.1	8121.9	16564.8
Sperm whales	18.9	0.8	3487.9	17766.7	38593.6
Spinner dolphins	123.5	4.9	2455.8	34951.0	69804.6
Striped dolphins	78.3	4.8	1603.8	18273.8	32084.0

Table F-56. 2022 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	12.3	0.7	1586.3	10771.9	21642.0
Beaked whales	3.6	0.0	1924.3	51580.8	12331.2
Common bottlenose dolphins	29.1	0.0	1890.8	28040.3	55364.6
Bryde's whales	0.0	0.8	23.1	151.3	175.3
Clymene dolphins	37.1	0.1	2467.6	24231.2	41628.1
False killer whales	9.3	0.8	700.4	5261.2	8838.1
Fraser's dolphins	3.9	0.0	918.1	3103.3	4653.5
Killer whales	0.4	0.1	101.9	370.3	455.7
Kogia	1819.3	34.1	1222.9	3801.1	8045.4
Melon-headed whales	19.4	0.0	4378.9	15633.9	25568.0
Pantropical spotted dolphins	259.2	0.4	17524.9	150730.2	228438.3
Pygmy killer whales	7.3	0.7	537.4	3835.8	6044.4
Risso's dolphins	9.8	1.1	547.2	6224.9	10803.0
Rough-toothed dolphins	11.3	0.8	868.1	6819.1	12045.1
Short-finned pilot whales	4.2	0.0	835.2	3426.0	6675.2
Sperm whales	7.1	0.0	3059.7	8664.8	17700.0
Spinner dolphins	28.6	0.1	1846.7	22028.4	43407.8
Striped dolphins	16.7	0.0	1115.1	10439.1	17204.3

Table F-57. 2022 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	18.5	0.4	688.1	2748.5	4587.1
Beaked whales	10.3	0.4	602.7	12707.2	2595.1
Common bottlenose dolphins	63.8	5.6	1096.8	6727.3	10286.4
Bryde's whales	0.1	2.9	5.5	33.0	35.8
Clymene dolphins	72.0	3.9	1155.6	5909.5	8420.5
False killer whales	17.6	0.7	404.2	1699.6	2601.6
Fraser's dolphins	8.0	0.2	267.3	789.6	965.7
Killer whales	0.8	0.0	38.5	95.8	110.3
Kogia	355.1	96.8	360.6	985.6	1675.8
Melon-headed whales	39.1	1.0	1283.2	4011.1	5317.2
Pantropical spotted dolphins	524.7	30.8	8142.2	37032.7	48037.0
Pygmy killer whales	13.4	0.5	309.9	1243.0	1811.7
Risso's dolphins	19.8	1.8	297.6	1485.6	2073.0
Rough-toothed dolphins	21.9	0.9	501.5	2197.3	3497.6
Short-finned pilot whales	7.8	0.2	249.3	895.8	1393.4
Sperm whales	6.3	0.5	816.6	2316.8	3770.7
Spinner dolphins	51.4	2.4	876.5	5322.6	8447.0
Striped dolphins	32.8	1.8	520.6	2552.4	3523.8

Table F-58. 2022 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-59. 2022 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-60. 2022 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.7	0.8	3.0	1.0
Beaked whales	0.0	0.1	0.1	5.0	0.0
Common bottlenose dolphins	0.0	8.7	11.1	22.0	6.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.1	0.1	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.1	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.1	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.8. 2023

Table F-61. 2023 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	1.2	0.0	60.2	840.1	1939.1
Beaked whales	0.6	0.0	61.7	4771.5	1094.1
Common bottlenose dolphins	2.9	0.2	116.3	2129.7	4722.3
Bryde’s whales	0.0	0.1	0.8	12.9	15.6
Clymene dolphins	4.0	0.3	100.0	1815.0	3376.0
False killer whales	0.9	0.0	27.0	428.7	760.2
Fraser’s dolphins	0.4	0.0	32.8	248.7	412.7
Killer whales	0.0	0.0	3.9	26.9	38.8
Kogia	52.4	4.1	42.4	310.3	720.2
Melon-headed whales	2.1	0.0	154.1	1265.5	2279.8
Pantropical spotted dolphins	29.6	2.5	716.4	11184.9	17649.9
Pygmy killer whales	0.7	0.0	20.5	310.1	512.8
Risso’s dolphins	1.1	0.1	29.2	465.2	898.2
Rough-toothed dolphins	1.1	0.0	33.6	559.4	1046.6
Short-finned pilot whales	0.5	0.0	28.2	283.6	600.8
Sperm whales	0.4	0.0	87.6	640.0	1298.4
Spinner dolphins	2.8	0.2	73.6	1669.3	3680.1
Striped dolphins	1.8	0.1	45.3	779.4	1374.3

Table F-62. 2023 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	336.5	30.1	49020.7	136922.4	180782.4
Beaked whales	26.0	1.2	2364.2	100180.1	25095.0
Common bottlenose dolphins	2371.9	81.9	289426.7	797721.2	1011713.9
Bryde's whales	0.2	7.2	26.1	307.2	369.5
Clymene dolphins	194.7	15.6	3812.4	45827.6	85313.6
False killer whales	55.5	5.4	1311.9	11223.3	20077.8
Fraser's dolphins	26.1	1.7	1091.6	6030.3	9983.3
Killer whales	2.4	0.3	134.1	616.8	898.3
Kogia	1253.7	277.0	1345.4	6981.9	15495.1
Melon-headed whales	124.2	8.7	4916.8	29368.5	52043.6
Pantropical spotted dolphins	1126.0	54.5	24137.6	251515.4	402877.4
Pygmy killer whales	40.8	3.7	871.8	7677.0	13240.4
Risso's dolphins	50.8	7.1	1081.8	11203.7	20700.8
Rough-toothed dolphins	85.4	8.4	3649.9	20615.6	34867.5
Short-finned pilot whales	32.6	3.9	1178.1	8121.9	16564.8
Sperm whales	18.9	0.8	3487.9	17766.7	38593.6
Spinner dolphins	123.5	4.9	2455.8	34951.0	69804.6
Striped dolphins	78.3	4.8	1603.9	18273.9	32084.1

Table F-63. 2023 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	24.4	0.5	7325.1	21893.7	32486.3
Beaked whales	2.5	0.0	1382.7	37470.7	9039.0
Common bottlenose dolphins	110.7	4.3	40652.8	113336.0	184429.8
Bryde's whales	0.0	0.6	16.2	110.0	128.7
Clymene dolphins	26.7	0.0	1762.0	17613.7	30146.3
False killer whales	6.7	0.6	524.9	3865.6	6471.6
Fraser's dolphins	2.9	0.0	672.9	2266.7	3422.5
Killer whales	0.3	0.0	74.0	270.4	332.6
Kogia	1300.7	24.4	881.0	2736.4	5865.9
Melon-headed whales	14.2	0.0	3159.1	11283.2	18636.5
Pantropical spotted dolphins	187.3	0.0	12613.1	109677.0	165646.7
Pygmy killer whales	5.2	0.5	387.0	2781.7	4383.7
Risso's dolphins	6.9	0.8	388.5	4540.2	7825.6
Rough-toothed dolphins	9.0	0.7	924.5	5679.0	9626.2
Short-finned pilot whales	3.0	0.0	599.0	2464.0	4865.0
Sperm whales	5.3	0.0	2320.8	6465.4	13561.8
Spinner dolphins	20.4	0.0	1300.7	15993.0	31396.5
Striped dolphins	12.0	0.0	798.6	7590.8	12464.1

Table F-64. 2023 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	35.4	1.4	1896.8	5165.2	6572.0
Beaked whales	7.3	0.3	434.9	9280.7	1906.2
Common bottlenose dolphins	201.4	7.7	9432.6	25112.5	28342.2
Bryde’s whales	0.1	2.0	3.9	24.2	26.6
Clymene dolphins	51.2	2.7	826.9	4352.2	6198.3
False killer whales	12.8	0.5	300.6	1256.5	1921.9
Fraser’s dolphins	5.9	0.1	194.2	580.9	719.0
Killer whales	0.6	0.0	28.0	70.2	81.2
Kogia	254.2	68.2	257.3	714.3	1240.4
Melon-headed whales	28.2	0.7	918.2	2924.6	3932.6
Pantropical spotted dolphins	377.0	21.7	5867.1	27203.2	35296.1
Pygmy killer whales	9.7	0.4	224.9	908.0	1327.8
Risso’s dolphins	14.2	1.3	210.6	1099.7	1530.4
Rough-toothed dolphins	17.0	0.8	468.4	1808.7	2761.5
Short-finned pilot whales	5.6	0.2	176.7	653.0	1032.0
Sperm whales	4.9	0.4	634.4	1778.7	2985.7
Spinner dolphins	35.9	1.6	619.8	3932.8	6229.5
Striped dolphins	23.5	1.3	373.5	1878.1	2592.3

Table F-65. 2023 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-66. 2023 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-67. 2023 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.7	0.8	3.0	1.0
Beaked whales	0.0	0.1	0.1	5.3	0.0
Common bottlenose dolphins	0.0	8.7	11.1	22.0	6.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.1	0.1	0.1	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.1	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.1	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.9. 2024

Table F-68. 2024 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-69. 2024 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	236.1	20.9	33109.3	95093.0	128778.3
Beaked whales	23.0	1.2	2026.6	86451.3	21614.1
Common bottlenose dolphins	1622.5	60.1	193716.6	541343.9	694790.8
Bryde’s whales	0.2	6.4	23.0	268.6	321.4
Clymene dolphins	171.5	14.9	3313.3	39792.5	74885.7
False killer whales	47.7	5.0	1103.2	9583.5	17325.0
Fraser’s dolphins	22.3	1.5	925.9	5163.3	8601.5
Killer whales	2.1	0.2	114.0	525.6	770.7
Kogia	1079.3	238.4	1151.9	5991.1	13285.1
Melon-headed whales	106.9	7.8	4228.9	25319.1	44988.0
Pantropical spotted dolphins	967.6	50.1	20600.8	214510.8	346237.1
Pygmy killer whales	35.2	3.4	750.4	6606.7	11486.2
Risso’s dolphins	44.3	6.2	933.0	9635.2	17965.1
Rough-toothed dolphins	70.5	7.4	2723.1	16501.8	28596.1
Short-finned pilot whales	29.0	3.7	1046.7	7224.5	14753.3
Sperm whales	16.2	0.8	3010.7	15290.3	32914.3
Spinner dolphins	104.9	4.2	2080.4	29364.5	58821.9
Striped dolphins	67.9	4.5	1378.6	15686.9	27788.5

Table F-70. 2024 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	13.8	0.7	1695.3	11719.6	23546.6
Beaked whales	3.8	0.0	2074.1	56206.0	13558.4
Common bottlenose dolphins	31.1	0.0	1989.5	30571.2	59895.0
Bryde’s whales	0.0	0.8	24.3	165.0	193.0
Clymene dolphins	40.0	0.0	2643.0	26420.6	45219.4
False killer whales	10.0	0.8	754.2	5717.3	9609.3
Fraser’s dolphins	4.2	0.0	995.6	3364.5	5088.1
Killer whales	0.4	0.1	110.8	405.1	498.3
Kogia	1950.4	36.6	1320.6	4102.6	8796.0
Melon-headed whales	21.2	0.0	4738.5	16924.4	27954.2
Pantropical spotted dolphins	280.9	0.0	18917.1	164509.3	248462.5
Pygmy killer whales	7.9	0.7	580.5	4172.4	6575.2
Risso’s dolphins	10.4	1.2	581.6	6807.6	11735.1
Rough-toothed dolphins	12.1	0.9	932.4	7404.4	13091.1
Short-finned pilot whales	4.6	0.0	898.5	3695.9	7297.5
Sperm whales	8.0	0.0	3481.2	9698.1	20342.7
Spinner dolphins	30.6	0.0	1951.1	23989.5	47094.8
Striped dolphins	18.0	0.0	1197.9	11386.1	18696.1

Table F-71. 2024 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	19.4	0.3	737.0	3041.0	5110.1
Beaked whales	10.9	0.5	652.4	13921.0	2859.3
Common bottlenose dolphins	68.0	6.1	1145.4	7466.0	11361.6
Bryde's whales	0.1	3.0	5.8	36.3	39.9
Clymene dolphins	76.8	4.1	1240.3	6528.2	9297.4
False killer whales	19.0	0.8	439.4	1862.6	2861.4
Fraser's dolphins	8.7	0.2	287.8	863.6	1070.5
Killer whales	0.9	0.0	41.9	105.2	121.7
Kogia	381.1	102.2	385.8	1071.0	1860.2
Melon-headed whales	42.3	1.0	1377.3	4386.9	5898.9
Pantropical spotted dolphins	565.5	32.6	8800.1	40803.5	52942.7
Pygmy killer whales	14.5	0.6	337.3	1361.9	1991.7
Risso's dolphins	21.3	1.9	315.6	1648.9	2295.0
Rough-toothed dolphins	23.7	1.0	544.5	2408.3	3848.4
Short-finned pilot whales	8.4	0.2	265.0	979.6	1548.0
Sperm whales	7.4	0.6	951.6	2668.1	4478.6
Spinner dolphins	53.9	2.3	929.8	5899.2	9344.3
Striped dolphins	35.2	1.9	560.3	2817.1	3888.4

Table F-72. 2024 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-73. 2024 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-74. 2024 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.7	0.8	3.0	1.0
Beaked whales	0.0	0.1	0.1	5.3	0.0
Common bottlenose dolphins	0.0	8.7	11.1	22.0	6.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.1	0.1	0.1	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.1	0.1
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.1	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

F.2.10. 2025

Table F-75. 2025 annual exposure estimate totals for 2-D survey (8000 in^3 airgun array, 1 vessel).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.3	0.0	16.4	197.8	468.6
Beaked whales	0.2	0.0	15.3	1120.5	250.2
Common bottlenose dolphins	0.8	0.1	25.1	480.6	1199.5
Bryde's whales	0.0	0.0	0.2	3.0	3.6
Clymene dolphins	1.0	0.1	24.3	413.7	831.6
False killer whales	0.2	0.0	6.8	100.8	185.6
Fraser's dolphins	0.1	0.0	8.2	59.9	95.5
Killer whales	0.0	0.0	0.9	6.2	9.1
Kogia	13.4	1.1	11.0	75.1	166.8
Melon-headed whales	0.6	0.0	39.4	306.8	527.8
Pantropical spotted dolphins	7.1	0.6	170.9	2556.1	4310.2
Pygmy killer whales	0.1	0.0	5.1	72.7	124.7
Risso's dolphins	0.3	0.0	7.5	105.0	220.9
Rough-toothed dolphins	0.2	0.0	8.6	131.8	256.2
Short-finned pilot whales	0.1	0.0	7.6	69.8	139.2
Sperm whales	0.1	0.0	16.6	120.7	170.1
Spinner dolphins	0.7	0.1	18.5	379.3	913.4
Striped dolphins	0.4	0.0	10.9	177.8	337.6

Table F-76. 2025 annual exposure estimate totals for 3-D NAZ survey (8000 in^3 airgun array, 2 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	351.8	37.2	51716.5	142385.1	186194.2
Beaked whales	23.0	1.2	2026.6	86451.4	21614.1
Common bottlenose dolphins	2489.5	137.4	301838.7	825426.1	1043905.6
Bryde's whales	0.2	6.4	23.0	268.6	321.4
Clymene dolphins	171.5	14.9	3313.3	39792.5	74885.7
False killer whales	48.2	5.0	1158.6	9756.0	17531.3
Fraser's dolphins	22.5	1.5	949.3	5236.5	8695.8
Killer whales	2.1	0.2	114.4	526.7	772.1
Kogia	1079.7	238.9	1153.3	5995.0	13290.8
Melon-headed whales	106.9	7.8	4229.2	25320.0	44989.1
Pantropical spotted dolphins	967.7	50.1	20604.6	214522.5	346252.3
Pygmy killer whales	35.2	3.4	750.6	6607.1	11486.8
Risso's dolphins	44.3	6.2	935.0	9640.5	17971.8
Rough-toothed dolphins	77.4	8.2	3609.2	19096.1	31941.8
Short-finned pilot whales	29.0	3.7	1046.8	7224.6	14753.3
Sperm whales	16.2	0.8	3010.7	15290.3	32914.3
Spinner dolphins	104.9	4.2	2080.4	29364.5	58821.9
Striped dolphins	67.9	4.5	1378.6	15687.0	27788.7

Table F-77. 2025 annual exposure estimate totals for 3-D WAZ survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	26.7	0.6	7607.6	23846.9	36410.8
Beaked whales	3.2	0.0	1728.4	46838.4	11298.7
Common bottlenose dolphins	115.9	4.3	40984.4	118431.2	194412.3
Bryde's whales	0.0	0.7	20.3	137.5	160.9
Clymene dolphins	33.4	0.0	2202.5	22017.2	37682.9
False killer whales	8.4	0.7	650.6	4818.5	8073.2
Fraser's dolphins	3.6	0.0	838.8	2827.5	4270.5
Killer whales	0.4	0.1	92.5	337.9	415.6
Kogia	1625.7	30.5	1101.1	3420.2	7331.9
Melon-headed whales	17.7	0.0	3948.8	14104.0	23295.6
Pantropical spotted dolphins	234.1	0.0	15765.9	137095.2	207057.2
Pygmy killer whales	6.5	0.6	483.8	3477.1	5479.5
Risso's dolphins	8.7	1.0	485.5	5674.8	9781.5
Rough-toothed dolphins	11.0	0.8	1079.9	6913.0	11808.0
Short-finned pilot whales	3.8	0.0	748.8	3080.0	6081.3
Sperm whales	6.7	0.0	2901.0	8081.8	16952.3
Spinner dolphins	25.5	0.0	1625.9	19991.3	39245.7
Striped dolphins	15.0	0.0	998.2	9488.5	15580.1

Table F-78. 2025 annual exposure estimate totals for Coil survey (8000 in^3 airgun array, 4 vessels).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	38.7	1.4	2019.7	5672.1	7423.7
Beaked whales	9.1	0.4	543.7	11600.8	2382.8
Common bottlenose dolphins	212.8	8.8	9623.5	26356.8	30235.8
Bryde's whales	0.1	2.5	4.8	30.2	33.2
Clymene dolphins	64.0	3.4	1033.6	5440.2	7747.8
False killer whales	15.9	0.7	373.8	1566.9	2398.8
Fraser's dolphins	7.3	0.2	242.1	724.9	897.4
Killer whales	0.8	0.0	35.0	87.7	101.5
Kogia	317.7	85.3	321.6	892.8	1550.5
Melon-headed whales	35.3	0.8	1147.7	3655.8	4915.8
Pantropical spotted dolphins	471.3	27.2	7333.7	34003.8	44119.9
Pygmy killer whales	12.1	0.5	281.1	1135.0	1659.7
Risso's dolphins	17.8	1.6	263.2	1374.5	1912.9
Rough-toothed dolphins	21.0	0.9	559.1	2210.0	3402.9
Short-finned pilot whales	7.0	0.2	220.9	816.3	1290.0
Sperm whales	6.1	0.5	793.0	2223.4	3732.1
Spinner dolphins	44.9	2.0	774.8	4916.0	7786.9
Striped dolphins	29.3	1.6	466.9	2347.6	3240.4

Table F-79. 2025 annual exposure estimate totals for 90 in^3 airgun.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-80. 2025 annual exposure estimate totals for boomer.

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.0	0.0	0.0	0.0
Beaked whales	0.0	0.0	0.0	0.0	0.0
Common bottlenose dolphins	0.0	0.0	0.0	0.0	0.0
Bryde’s whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser’s dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.0	0.0	0.0	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso’s dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.0	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.0	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

Table F-81. 2025 annual exposure estimate totals for side-scan sonar, sub-bottom profiler, and multibeam scanner).

Species	Number of Level A exposures			Number of Level B exposures	
	peak SPL	SEL	180 rms SPL	Step fxn	160 rms SPL
Atlantic spotted dolphins	0.0	0.6	0.7	2.4	0.8
Beaked whales	0.0	0.1	0.1	5.6	0.0
Common bottlenose dolphins	0.0	7.0	9.0	17.9	5.0
Bryde's whales	0.0	0.0	0.0	0.0	0.0
Clymene dolphins	0.0	0.0	0.0	0.0	0.0
False killer whales	0.0	0.0	0.0	0.0	0.0
Fraser's dolphins	0.0	0.0	0.0	0.0	0.0
Killer whales	0.0	0.0	0.0	0.0	0.0
Kogia	0.0	0.0	0.0	0.0	0.0
Melon-headed whales	0.0	0.0	0.0	0.0	0.0
Pantropical spotted dolphins	0.0	0.1	0.1	0.1	0.0
Pygmy killer whales	0.0	0.0	0.0	0.0	0.0
Risso's dolphins	0.0	0.0	0.0	0.0	0.0
Rough-toothed dolphins	0.0	0.0	0.0	0.1	0.0
Short-finned pilot whales	0.0	0.0	0.0	0.0	0.0
Sperm whales	0.0	0.0	0.0	0.1	0.0
Spinner dolphins	0.0	0.0	0.0	0.0	0.0
Striped dolphins	0.0	0.0	0.0	0.0	0.0

The Department of the Interior Mission

The Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The Bureau of Ocean Energy Management Mission

The Bureau of Ocean Energy Management (BOEM) is responsible for managing development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way.