Request for an Incidental Harassment Authorization under the Marine Mammal Protection Act

CGG Atlantic 2D Seismic Program

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ABBREVIATIONS

°	Degrees
µ	Micro
2-D	Two - dimensional
AASM	Airgun Array Source Model
AFAST	Atlantic Fleet Active Sonar Training
AMAPPS	Atlantic Marine Assessment Program for Protected Species
BIA	Biologically Important Area
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CetMap	Cetacean Density and Distribution Mapping Working Group
CetSound	Cetacean and Sound Mapping
CV	Coefficient of variation
D	Depleted
DD	Data Deficient
DSM	Density surface modeling
DMA	Dynamic Management Areas
dB	Decibel
e.g.	Exempli gratia
ECS	Extended Continental Shelf
EEZ	Economic Exclusion Zone
EN	Endangered
ESA	Endangered Species Act
GAM	Generalized additive model
G&G	Geological & Geophysical
HESS	High Energy Seismic
Hz	Hertz
i.e.	Id est
IHA	Incidental Harassment Authorization
in^3	Cubic inch
kHz	Kilohertz
km	Kilometer
km^2	Square kilometer
kn	Knot
m	Meter
MASOMO	Marine Source Modeling Module
MGEL	Marine Geospatial Ecology Lab
MMPA	Marine Mammal Protection Act
MONM	Marine Operations Noise Model
N	North
NARW	North Atlantic right whale
NASA	National Aeronautics and Space Administration
NEFSC	Northeast Fisheries Science Centers

NOAA	National Oceanographic Atmospheric Administration
NRC	National Resource Council
NC	Not classified
NL	Not listed
NJDEP	New Jersey Department of Environment
NOAA	National Ocean Atmospheric Administration
NTL	Notice to Lessees
NMFS	National Marine Fisheries Service
OCS	Outer Continental Shelf
Pa	Pascal
PAM	Passive acoustic monitoring
PEIS	Programmatic Environmental Impact Statement
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
RAM	Range-dependent Acoustic Model
RMS	Root mean square
SEFSC	Southeast Fisheries Science Centers
SMA	Seasonal Management Areas
TNASS	Trans-North Atlantic Survey
TTS	Temporary Threshold Shift
US	United States
USCG	United States Coast Guard
SAR	Stock assessment report
SE	Southeast
SPL	Sound pressure level
UNCW	University of North Carolina–Wilmington

OVERVIEW OF THE ACTIVITY

CGG, a geophysical company, proposes to conduct a two-dimensional (2D) seismic survey in the federal waters of the Mid- and South Atlantic Ocean region within the 350 nautical mile (nm) US Extended Continental Shelf (ECS) boundary. The proposed survey area is located a minimum of 84 kilometers (km) (50 miles (mi)) from shore and extends from Georgia to Virginia. Water depths in the survey area range from 100 meters (m) (328 feet (ft)) to over 4,000 m (13,123 ft). The proposed 2D seismic survey consists of 53 lines totaling 28,670 line-km.

The purpose of CGG's program is to acquire geophysical data using traditional 2D seismic survey methodology. The operational activity will consist of a seismic research vessel travelling along a pre-determined survey line for several hours at an average speed of 4.5 knots (kn). A seismic acoustic source towed behind the vessel releases an energy pulse that is directed vertically to the sea floor. The energy reflects or refracts from the surface and sub-surface of the seafloor based on the density of the geological composition layer. Hydrophones contained in a streamer towed behind the seismic acoustic source record the reflected and refracted signals. The recorded data will be used to render a high resolution image of the Earth's subsurface geologic structures and identify potential oil and gas reserves.

The energy generated by the seismic acoustic source has the potential to disturb or harass marine mammals (i.e., cetaceans) in the survey area. Harassment is a form of "take" as defined under the Marine Mammal Protection Act (MMPA), and is subject to governance under the MMPA. Incidental and unintentional harassment takes are permitted with the issuance of an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS). The NMFS will only authorize the incidental taking of marine mammals by an activity that is not likely to have more than a negligible impact. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of survival or recruitment (i.e., offspring survival, birth rates) (see C.F.R§ 216.103). A mitigation and monitoring plan is included in CGG's IHA application to ensure any potential effect of the proposed activity on marine mammals and their habitat will be negligible. The plan includes a defined mitigation zone and acquisition boundaries between concurrent surveys. A soft start, shut down, power down, or delayed activation of the seismic acoustic source will also be observed. Monitoring will be carried out using Protected Species Observers (PSO) and Passive Acoustic Monitoring (PAM).

Takes of marine mammals by injury or disturbance associated with vessel collisions are unlikely because vessel strike avoidance measures and visual monitoring will be in place. In addition, the seismic research vessel will be traveling at a travel average speed of 4.5 kn while acquiring seismic data. A reduced vessel speed lowers the chances of an animal strike and has been shown to be effective at reducing right whale deaths (Laist et al. 2001). Therefore, only the activities associated with acoustic impacts that have the potential to result in Level B takes of marine mammals are included in CGG's IHA mitigation and monitoring plan.

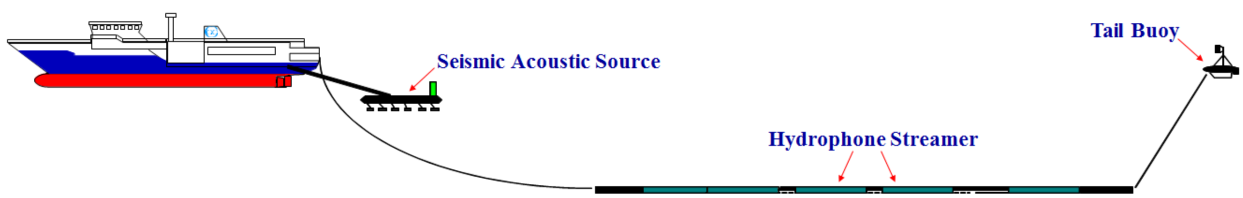
This IHA application uses the best available science to assess and minimize the potential for acoustic impacts associated with CGG's proposed activity on marine mammals and their habitat. Any effects on marine mammals which result from the proposed seismic survey are expected to be short-term and localized.

1.0 DESCRIPTION OF SPECIFIED ACTIVITY

CGG's proposed Atlantic 2D Seismic Program consists of 53 survey lines in a 20 km (12 mi) by 20 km (12 mi) orthogonal grid totaling an area of 28,670 line-km. A single seismic research vessel, operating 24 hours a day, will travel along the survey lines to acquire seismic data. The line length will be 300 km (186 mi) to 750 km (466 mi) in length and take approximately 36 to 90 hours to complete. Upon reaching the end of a survey line, the vessel will take four to six hours to turn around and start another line. The seismic acoustic source will be silent during line changes.

The layout of the seismic research vessel and towed seismic acoustic source and hydrophone streamer cable is shown in Figure 1. The towed seismic equipment will remain deployed for the duration of the survey with the exception of necessary maintenance or repair work.

Figure 1 2D seismic research vessel layout. **Figure is not to scale.**



1.1 Aircraft

Offshore operations will be serviced by helicopter(s) operating from an onshore support base location. The helicopter(s) will primarily be used to carry out crew changes but may also be used for personnel medical evacuations. Depending on the severity of the emergency, a helicopter operated by the United States Coast Guard (USCG) may be necessary. Harassment of marine mammals from aircraft operations are not expected to occur due to the flight elevation and minimal duration on the vessel helideck.

1.2 Vessels

A typical seismic research vessel averages 100 m (328 ft) in length and has a crew capacity of about 55 persons. The vessel is expected to remain in the survey area and operate continuously for the duration of the survey. During this time, the vessel will be traveling at speeds ranging between 3.7 kn and 5.4 kn to maintain a safe towing speed for the seismic equipment. The vessel will transit at an average speed of 8.1 kn prior to mobilization and after demobilization from the survey area.

There will be two additional vessels, each on approximately 50 m (164 ft) in length, used during the proposed survey for operational support and maintaining safe conditions. An escort vessel will be used to maintain safe navigation by informing the seismic research vessel of marine debris which may pose a risk to deployed gear. The escort vessel will also communicate a mariners notice to ensure vessels in the area maintain a safe distance from the deployed seismic equipment. A supply vessel will be present in the survey area to supply fuel, groceries, and general supplies to the seismic research vessel. Both vessels will make port calls to re-supply and change its onboard crew. The supply and escort vessel speed will average ten knots during transits to and from port.

Vessel strikes on Endangered Species Act (ESA)-listed species, strategic stocks, or other marine mammals are not expected to occur due to the slow vessel operating speed of three to five knots and adherence to vessel strike avoidance measures as described in Section 11.1 of this IHA.

1.2.1 Vessel noise

Vessel noise associated with CGG's proposed seismic survey activity will temporarily increase ambient noise levels by a small amount in the general vicinity. The operation is transient in nature and the seismic research vessel, when in production, covers about 1 km (.6 mi) in seven minutes. The survey lines are spaced 20 km (12 mi) apart which reduces the likelihood of multiple interactions with the same marine mammal individuals. A recent study concluded that vessel speed is a significant predictor of noise levels (Houghton et al. 2015). The study, conducted on killer whales, found that reduced vessel speeds resulted in lower levels of received noise. In 2014, the Bureau of Ocean Energy Management (BOEM) released the 'Programmatic Environmental Impact Statement for Proposed G&G Activities on the Mid- and South Atlantic Outer Continental Shelf' (BOEM PEIS 2014). The PEIS concludes that individuals or groups of marine mammals in the study area would be familiar with various vessel-related noises, particularly within frequented shipping lanes. Although the vessel will produce continuous sounds within the marine environment, the noise is not expected to affect marine mammals to a level which constitutes a take. Long-term habitat degradation as a result of vessel noise is not likely to occur due to the slow transit speed of the seismic research vessel and the mitigation measures described in Section 11.

1.3 Description of seismic equipment

1.3.1 Hydrophone streamer

A hydrophone streamer approximately 10 km (10,000 m) to 12 km (12,000 m) in length will be used to record the refracted and reflected acoustic signals generated by the seismic acoustic source. Aside from the hydrophone sections, the streamer cable is filled with solid polyurethane foam to ensure its floatability. Positioning equipment called 'Birds' will be attached along the length of the streamer cables to maintain the streamer depth.

The towed hydrophone streamer cable is not expected to result in any form of marine mammal harassment. Entanglements are not expected due to the rigidity of the hydrophone streamer cable. The seismic research vessel has a slow operating speed and injury is not expected to occur if a marine mammal makes contact with the hydrophone streamer.

1.3.2 Seismic acoustic source

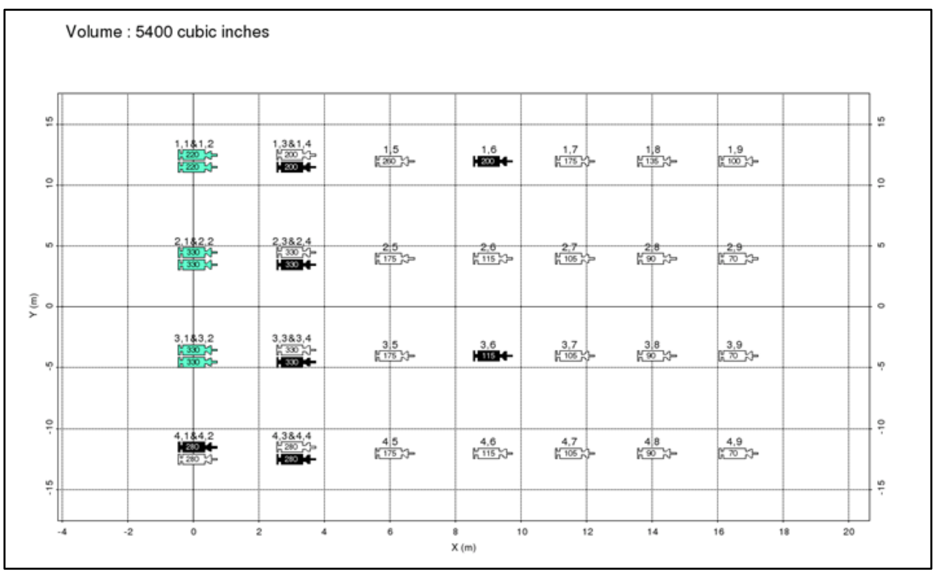
A BOLT 1900/1500 impulsive seismic acoustic source comprised of 36 acoustic elements which total 5,400 cubic inches (in^3) will be used to carry out seismic acquisition operations during the proposed 2D seismic survey. The impulsive seismic acoustic source functions by releasing a controlled, compressed air bubble from the acoustic elements at a pre-planned interval (impulse interval). The air bubble forms, expands, and collapses over a period of one second, resulting in the propagation of acoustic energy into the water column.

The seismic acoustic source is designed to maximize subsurface illumination by focusing energy propagation vertically towards the sea floor with minimal horizontal propagation. Physical characteristics of the marine environment (e.g., water column stratification, water depth, sea floor composition) in the survey area are considered when determining the seismic acoustic source configuration and minimum volume needed to meet the objectives of the proposed survey. The technical specifications for the seismic acoustic source are shown in Table 1 and the seismic acoustic source layout is illustrated in Figure 2.

Table 1 BOLT 1900/1500 seismic acoustic source array specifications

Width	24 m (78.74 ft)
Depth	7 m (22.97 ft)
Length	16.5 m (54.13 ft)
Number of sub arrays	4
Sub array separation	8 m (26.25 ft)
Number of acoustic elements	36
Total Volume	5,400 in^3
Impulse interval	25 m (65.61 ft)
Impulse duration	1 second

Figure 2 BOLT 1900/1500 seismic acoustic source array configuration



CGG undertook an acoustic modeling study of the proposed 5,400 in^3 seismic acoustic source to assess sound levels and estimate the distance from the source at which received sound levels could have the potential to impact marine mammals. The total sound energy output (source level) of a seismic acoustic source impulse was assessed with source modeling. The source level was combined with site-specific environmental data to simulate the sound propagating from the seismic acoustic source and predict the distance at which sound levels could result in marine mammal harassment.

1.3.2.1 Seismic acoustic source modeling assessment

The source levels and directivity of the 36 acoustic elements, or components, that comprise the seismic acoustic were predicted with Nucleus+ modeling software. The seismic acoustic source specifications and area-specific environmental data were input to the Marine Source Modeling Module (MASOMO) algorithm to model the full-waveform signature of a seismic pulse at a standard reference distance of 1 m (3.2 ft) below the source. The peak-to-peak pressure signature, or total source level output, of the seismic acoustic source was determined to be 259 dB re 1 μPa (137.7 bar-m) at 1 m (3.2 ft).

Nucleus+ software is currently among the most utilized and accepted seismic acoustic source modelling software in the Geological and Geophysical (G&G) industry. The MASOMO algorithm in Nucleus+ defines the pressure signature of a source based on the Kirkwood & Bethe (1942) theory of the oscillating spherical bubble. MASOMO incorporates the Ziolkowski method (1970) for the forward-calculation of source pressure pulses. The software is based on a multi-method approach to design seismic acoustic sources with optimal sound output[1].

1.3.2.2 Sound propagation modeling assessment of the 5,400 in^3 seismic source

Sound propagation modeling was used to understand the directional spreading and intrinsic attenuation characteristics (the acoustic field) of a 5,400 in^3 seismic acoustic source impulse as it relates to the proposed survey area. Then, the radial distances from the seismic acoustic source where received sound levels ≥160 dB and ≥180 dB re 1 μPa rms were predicted. The current National Marine Fisheries Service (NMFS) acoustic threshold criteria states that a marine mammal exposed to impulsive broadband sounds can be injured (180 dB rms) or experience disturbance resulting in behavioral shifts (160 dB rms) (NMFS 2000; 2005). The threshold radii for marine mammals were thus predicted using sound propagation modeling. Based on the similar characteristics and configuration between the seismic acoustic source elements, as it relates to the directivity and propagation in water, it is reasonable to assume the acoustic propagation assessment of a 5,400 in^3 acoustic array carried out for the BOEM PEIS 2014 (Appendix D) will realistically portray the sound propagation results for CGG's proposed seismic acoustic source. The BOEM acoustic propagation modeling methodology is summarized in the following paragraph.

BOEM selected 15 specific geographic sites within the Mid- and South Atlantic OCS to assess the potential effects of oil and gas exploration surveys. JASCO's Marine Operations Noise Model (MONM), based on Range dependent Acoustic Model (RAM) code was used to estimate the acoustic fields for a 5,400 in^3 seismic acoustic source at each site. MONM-RAM has been validated in multiple sound source verification tests (Hannay et al. 2009; Aerts 2008; O'Neill et al. 2010; Warner et al. 2010) and uses a wide-

[1] Dragoset 1990, 2000; Laws et al. 1990; Langhammer 1994; Landrø 1992; Parkes et al. 1986; Strandenes et al. 1992.

angle parabolic equation method to calculate the acoustic wave equation in range-varying environments (Collins 1993). The 5,400 in^3 seismic acoustic source level, derived from JASCO's Airgun Array Source Model (AASM), was input into MONM-RAM and combined with transmission loss to predict the acoustic field, or threshold radii distance. The software estimated the transmission loss of the seismic acoustic source as a function of range and depth at each site using specific acoustic inputs associated with the environment:

- Water column sound speed profiles
- Bathymetric grid of the modeled area
- Geoacoustic profile based on seafloor composition

Multiple scenarios were run at each site to account for the attenuation of sound in changing water properties with different seasons. ArcGIS (ESRI 2012), a geographic information system, was used to geo-reference the 15 sites over CGG's proposed 2D area. Only the 13 modeling sites which occurred in or near the survey area were considered for CGG's site-specific assessment. Water depths of the selected modeling sites ranged between 100 m (328 ft) to 4,300 m (14,108 ft).

The modeling assessment indicated that the largest acoustic field for a 5,400 in^3 seismic acoustic source array is typically associated with sites in intermediate water depths between 200 m (820 ft) to 900 m (2,953 ft). Table 2 shows the distances at which the 160 dB and 180 dB rms sound levels are expected to be received for a 5,400 in^3 seismic acoustic source array. The mean radial distance from the seismic acoustic source at which received sound levels are ≥160 dB rms is 6,751 m (22,149 ft). The mean radial distance at which received sound levels are ≥180 dB rms is 907 m (2,976 ft) from the seismic acoustic source. Based on the average 180 dB rms threshold criteria, a 907 m (2,976 ft) mitigation zone was established for shut down and power down procedures. The mean radius for 160 dB rms levels was incorporated into the marine mammal exposure modeling (Section 6) to assess the number of individuals which may be disturbed by the seismic acoustic source. Marine mammals are not reasonably likely to be exposed to sound levels associated with CGG's activity that exceed the injury threshold criteria because the mitigation and monitoring plan is designed to avoid such events.

Table 2 Radial distance from the seismic acoustic source at which received SPL are 160 dB rms and 180 dB rms. Estimated distance from the source at which sound levels are ≥160 dB or ≥180 dB re 1µ Pa rms. Water depths range from 100 m (328 ft) to 4,300 m (14,108 ft).

NMFS criteria threshold levels	**Predicted ensonification radii**
180 dB (Level A harassment)	737 m (2,418 ft) – 1,094 m (3,589 ft)
160 dB (Level B harassment)	5,013 m (16,447 ft) – 8,593 m (28,192 ft)

1.3.3 Gravity and magnetic passive equipment

Gravity and magnetic data is used to identify and assess geologic formations and can assist in seismic modeling and processing parameters. A Gravity Meter will be used to passively measure minute fractional changes of the Earth's gravitational field and identify variations in rock density. A Magnetometer will be used to measure the Earth's magnetic field at a specific point in space and detect geological anomalies. A sensor will be towed from either a fixed point on the seismic research vessels stern or from one of the seismic acoustic source sub arrays.

Marine mammal entanglement or injury with the magnetometer is not anticipated because of the structure and positioning of the equipment in addition to the seismic research vessels slow operating speed. There will be no acoustic impact on the marine environment because the equipment is passive.

2.0 DATES, DURATION, AND REGION OF ACTIVITY

CGG proposes to conduct a 2D seismic survey in the federal waters of the Mid- and South Atlantic region extending from Georgia and Virginia (see Figure 3). Seismic activities will be carried out a minimum of 80 km (50 mi) from shore in water depths ranging between 100 m (328 ft) to over 5,000 m (16,404 ft). The survey is planned to take place from July through December 2016. The actual starting date of the survey is subject to vessel availability and the timeliness of the regulatory review process. The commencement of the survey should not be effected by the 120 day IHA regulatory review process required to receive an approved G&G operational permit (MMPA 101(a)(5)D)(iii)). However, there is a possibility that the proposed survey will not start in accordance with the proposed dates. As a precaution, the three modeling analyses (i.e., seismic acoustic source model, sound propagation model, individual acoustic exposure model) and the species distribution described in our IHA account for the entire year rather than the stipulated six month period. The duration of the survey is contingent on weather, mobilization, demobilization, marine life mitigation action, and other potential technical maritime or seismic associated down time. The survey area is located well outside of the defined North Atlantic right whale (NARW) Southeast (SE) and Mid-Atlantic Seasonal Management Areas (SMA) (see Figure 3).

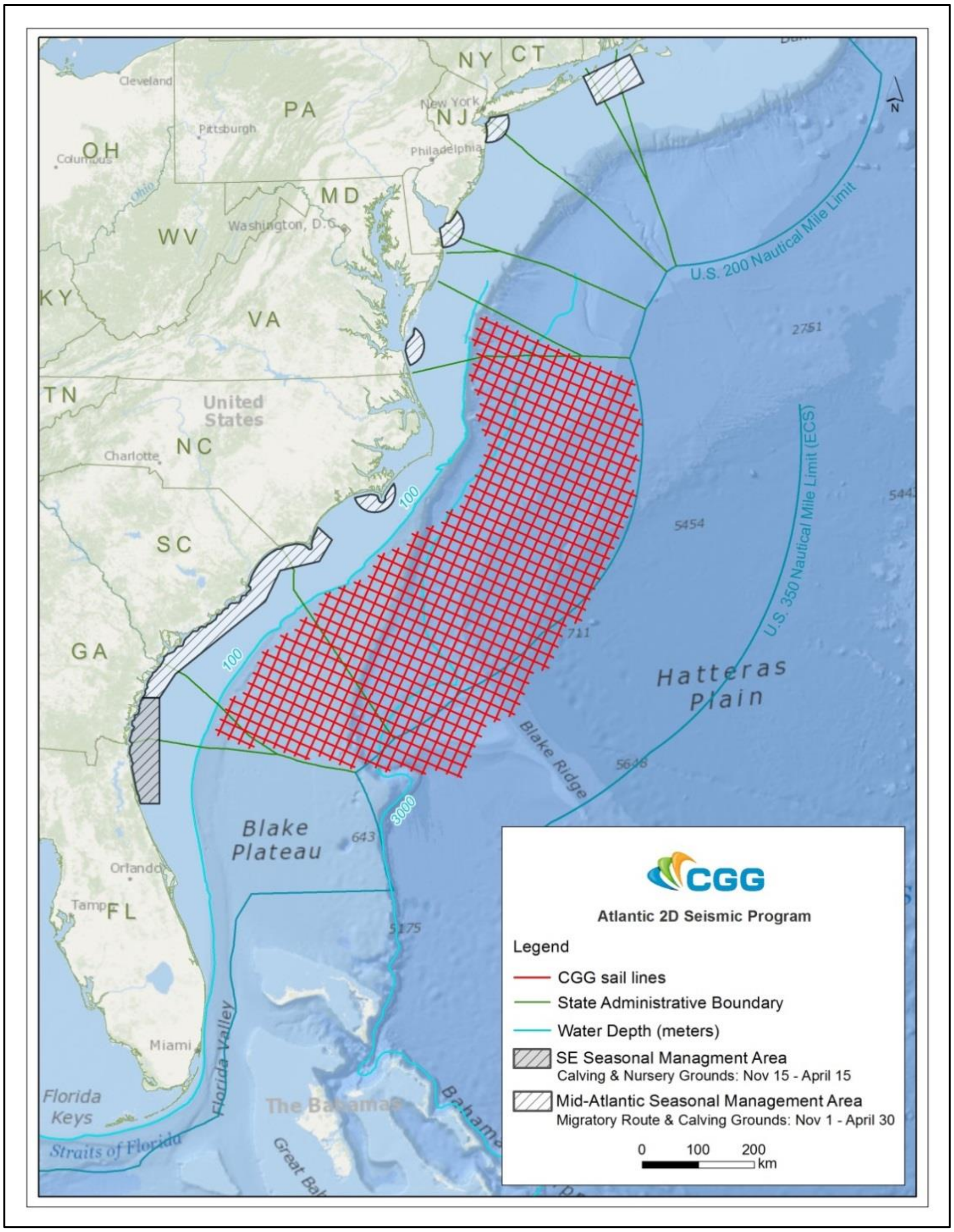


Figure 3 CGG's proposed 2D Atlantic Seismic Program

3.0 MARINE MAMMALS IN THE PROPOSED SURVEY AREA

There are 32 species represented by two sub-orders of cetaceans (Mysticeti and Odontoceti) that have been known to inhabit the proposed seismic survey area. All marine mammal species are under NMFS jurisdiction and protected by the MMPA of 1972. Of the 32 species, six are protected under the ESA. These cetaceans are considered endangered and comprise five species of baleen whale (blue whale, North Atlantic right whale, fin whale, humpback whale, sei whale) and one species of toothed whale (sperm whale). Pinnipeds (seals) are not addressed in this section because they are not expected to be near CGG's proposed seismic survey area.

Table 3 provides a general summary of each marine mammal species status, occurrence, and abundance. The species stock abundance estimates are based on the NOAA 2014 Stock Assessment Report (SAR) (Waring et al. 2015), unless otherwise cited. The MMPA defines the term stock as a group of marine mammals of the same species or smaller taxa in a common spatial arrangement that interbreed when mature (50 CFR 216.3). Section 4 describes each species distribution and behaviors in detail.

Table 3 Marine mammal species known to occur in the proposed survey area.

Species	ESA Status[1]	MMPA Status[2]	Occurrence (in survey area)	Habitat	Predicted Seasonality (in survey area)	Stock Abundance[3]	Population Trend
Suborder Mysticeti							
Family Balaenidae (right whales)							
North Atlantic right whale (*Eubaleaena glacialis)*	EN	D	Uncommon	Coastal to deep water	Fall to spring	476[4]	Increasing
Family Balaenopteridae (roquals)							
Blue whale *(Balaenoptera musculus)*	EN	D	Rare	Coastal to deep water	DD	DD	DD
Bryde's whale (Balaenoptera edeni)	NL	NC	Rare	Coastal to continental shelf edge	DD	DD	DD
Fin whale *(Balaenoptera physalus)*	EN	D	Common	Continental shelf and slope	Mid-winter to mid-summer	1,618[5]	DD
Minke whale *(Balaenoptera acutorostrata)*	NL	NC	Uncommon	Coastal to deep water	Possible spring to winter	20,741[6]	DD
Humpback whale *(Megaptera novaeangliae)*	EN	D	Common	Coastal to deep water	Possible year-round presence	823[7]	Increasing

Sei whale *(Balaenoptera borealis)*	EN	D	Rare	Continental shelf edge to deep water	Fall to winter	237[8]	DD
Suborder Odontoceti (toothed whales)							
Family Ziphiidae (beaked whales)							
Blainville's beaked whale *(Mesoplodon densirostris)*	NL	NC	Common	Continental shelf to slope	DD	7,092[9]	DD
Sowerby's beaked whale *(Mesoplodon bidens)*	NL	NC	Uncommon	Continental shelf edge to oceanic	DD		DD
Gervais' beaked whale *(Mesoplodon europaeus)*	NL	NC	Common	Continental shelf to oceanic	DD		DD
True's beaked whale *(Mesoplodon mirus)*	NL	NC	Uncommon	Continental shelf slope	DD		DD
Cuvier's beaked whale *(Ziphius cavirostris)*	NL	NC	Common	Continental shelf edge and slope	DD	6,532[10]	DD
Family Physeteridae (sperm whale)							
Sperm whale *(Physeter macrocephalus)*	EN	D	Common	Continental shelf edge to deep water	DD	2,288[11]	DD
Family Delphinidae (dolphins)							
Atlantic spotted dolphin *(Stenella frontalis)*	NL	NC	Common	Continental shelf to deep water	Year-round	44,715	DD
Atlantic white-sided dolphin *(Lagenorhynchus acutus)*	NL	NC	Uncommon	Continental shelf to deep water	Year-round	48,819[12]	DD

Bottlenose dolphin *(Tursiops truncatus)*	NL	D	Common	Coastal to deep water	Year-round	77,532[13]	DD
Clymene dolphin *(Stenella clymene)*	NL	NC	Uncommon	Coastal to deep water	DD	DD	DD
False killer whale *(Psudorca crassidens)*	NL	NC	Rare	Coastal to deep water	DD	442	DD
Fraser's dolphin (*Lagenodelphis hosei)*	NL	NC	Rare	Shallow to deep water	DD	DD	DD
Killer whale (*Orcinus orca)*	NL	NC	Rare	Coastal to deep water	DD	DD	DD
Pygmy sperm whale (*Kogia breviceps)*	NL	NC	Common	Continental shelf edge to deep water	Year-round	3,785[14]	DD
Dwarf sperm whale *(Kogia sima)*	NL	NC	Common	Continental shelf	Year-round		DD
Melon-headed whale *(Peponocephala electra)*	NL	NC	Rare	Continental shelf edge to deep water	DD	DD	DD
Long-finned pilot whale (*Globicephala melas*)	NL	NC	Common	Continental shelf edge to deep water	Year-round	5,636[15]	DD
Short-finned pilot whale (*Globicephala macrorhynchus*)	NL	NC	Common	Continental shelf edge to deep water	Year-round	21,515[16]	DD
Pantropical spotted dolphin *(Stenella attenuata)*	NL	NC	Common	Coastal to continental shelf slope	Year-round	4,439[17]	DD

Risso's dolphin *(Grampus griseus)*	NL	NC	Common	Continental shelf to deep water	Year-round	18,250[18]	DD
Rough-toothed dolphin *(Steno bredanensis)*	NL	NC	Rare	Continental shelf edge to deep ocean	DD	271	DD
Short-beaked common dolphin (*Delphinus delphis*)	NL	NC	Common	Continental shelf to deep ocean	Year-round	173,486	DD
Spinner dolphin (*Stenella longirostris*)	NL	NC	Rare	Continental shelf edge to deep water	DD	DD	DD
Striped dolphin (*Stenella coeruleoalba*)	NL	NC	Common	Continental shelf edge to deep water	Year-round	54,807[19]	DD
Family Phocoenidae (porpoise)							
Harbor porpoise[20] *(Phocoena phocoena)*	NL	NC	Uncommon	Coastal to continental shelf edge	Winter to spring	79,883	DD

1 US Endangered Species Act: EN = Endangered, T = Threatened, DL = Delisted, NL = Not listed.

2 US Marine Mammal Protection Act: D = Depleted, NC = Not Classified.

3 DD = Data Deficient

4 Best abundance estimate based for the Western Atlantic stock (Waring et al. 2015b)

5 Best abundance estimate based for the Western Atlantic stock (Waring et al. 2015b)

6 Best abundance estimate for the Canadian East Coast stock (Waring et al. 2015b)

7 Best abundance estimate for Gulf of Maine stock (Waring et al. 2015b)

8 Best abundance estimate for Nova Scotia stock (Waring et al. 2015b)

9 Best abundance estimate for all Mesoplodon spp. beaked whales (Waring et al. 2015)

10 Best abundance estimate for Cuvier's beaked whale (Waring et al. 2015)

11 Best abundance estimate based on Palka (2012) is likely underestimated because it does not consider whales under the surface (Waring et al. 2014)

12 Best abundance estimate for Western North Atlantic stock (Waring et al. 2015b)

13 Western North Atlantic offshore stock (Waring et al. 2015)

14 Best abundance estimate include both dwarf and pygmy sperm whales (Waring et al. 2014)

15 Best abundance estimate for western North Atlantic stock based on Palka (2012)

16 Best abundance estimate for western North Atlantic stock (Waring et al. 2015b)

17 Best abundance estimate for western North Atlantic stock (Waring et al. 2007)

18 Best abundance estimate for western North Atlantic stock (Waring et al. 2015b)

19 Best abundance estimate for western North Atlantic stock (Waring et al. 2014)

20 Gulf of Maine/Bay of Fundy stock

4.0 DESCRIPTION OF MARINE MAMMALS IN THE PROPOSED SURVEY AREA

This section provides detailed information for the 32 species, listed in Section 3, that are known to occur in the US Mid- and South Atlantic Ocean and could be present in the proposed survey area. This section also discusses the northern bottlenose dolphin that is considered extralimital in the survey area but was identified in the marine mammal exposure estimates. An extensive literature review based on multiple sighting survey programs and other data resources was undertaken to assess each species' seasonal and spatial distribution throughout the year. The literature includes the Atlantic Marine Assessment Program for Protected Species (AMAPPS) 2010 to 2014 vessel and aerial sighting surveys, preliminary marine mammal habitat-based density models for the Northwest Atlantic (Roberts et al. 2015a), BOEM 2014 PEIS, NOAA SAR, Department of the Navy (DoN) training operations, OBIS-NODES, historical stranding records (Byrd et al. 2014; Schmidly 1981), and other species-specific research reports.

Cetacean distribution in the US East Coast Atlantic may be influenced by different variables such as sea surface temperature, water depth, and topography. Seasonal shifts in cetacean distribution can be attributed to prey availability in nutrient-rich upwelling areas of high sea floor relief for animals such as sperm whales, bottlenose dolphins, and baleen whales. Many cetacean species, such as the Atlantic spotted dolphins and Clymene dolphins, favor warm productive waters along the Gulf Stream and North Atlantic Drift.

LaBrecque et al. (2015) published an expert review identifying 18 Biologically Important Areas (BIA) for cetaceans within US waters along the East Coast. The review identifies the migratory, feeding, and reproductive areas for small and resident populations of minke whales, sei whales, fin whales, North Atlantic right whales (NARW), humpback whales, harbor porpoises, and bottlenose dolphins. All BIA are located north of the survey area with the exception of the NARW which has established calving grounds and migratory corridor in the Florida to Virginia continental shelf waters.

4.1 Mysticeti (Baleen whales)

4.1.1 Blue whale (*Balaenoptera musculus*)

Blue whales inhabit the deep ocean, and less often coastal areas, between sub-polar and sub-tropical latitudes (Yochem & Leatherwood 1985). Blue whales are prey-driven, preferring areas rich in krill, and make poleward movements in the spring and summer to feed (NOAA OPR 2015e; Kenney et al. 1985). Migration related to reproduction is unknown; however, winter calving likely occurs in warmer tropical waters (Reeves et al. 2002).

In the waters of the US Atlantic 200 nm Economic Exclusion Zone (EEZ), historical records of blue whale observations most often occur above 40^0 N during all seasons (Roberts et al. 2015g; AMAPPS 2014, 2013; Deibich 2014; Waring et al. 2011; DoN 2008). There is not enough data for the North Atlantic to ascertain seasonal migration routes and distribution for the western North Atlantic stock. The actual southern limit of the blue whale is unknown (Waring et al. 2011). Blue whales are expected to be rare in the proposed survey area.

4.1.2 Bryde's whale (*Balaenoptera edeni*)

Bryde's whales prefer highly productive tropical to warm temperate waters worldwide. This species is known to associate along continental shelf breaks (Davis et al. 2002) and coastal upwelling areas (Siciliano et al. 2004). Bryde's whales are typically sighted individually or in pairs, although larger groups have been reported in feeding areas (NOAA OPR 2015b). Like other baleen whales, some populations of Bryde's whale are thought to migrate to higher latitudes in the summer and southern latitudes in the winter (NOAA OPR 2015b). There is no known geographical or seasonal distribution pattern for this species along the US East Coast Atlantic.

Bryde's whales are considered rare in the western North Atlantic and are not classified within a management stock (BOEM PEIS 2014). Historical stranding and sighting records indicate Bryde's whales infrequently inhabit waters from Florida to Virginia (Roberts et al. 2015i; Waring et al. 2013; DoN 2008; Schmidly 1981; Cummings 1985). Information regarding the distribution of Bryde's whales along the US East Coast is gleaned mostly from stranding records. Bryde's whales are not likely to be encountered in the proposed seismic survey area but are included in our take requests as a precautionary measure.

4.1.3 Fin whale (*Balaenoptera physalus*)

The western North Atlantic stock of fin whale is the most abundant along the continental shelf waters extending northward from Cape Hatteras (GMI 2010; Lawson et al. 2009). Major feeding grounds have been identified north of the survey area from New York to Maine during late spring to early fall (LaBrecque et al. 2015; Waring et al. 2015a). Previous studies suggest that the western North Atlantic population has a dominant presence year-round and plays a significant role in the ecosystem processes (Hain et al. 1992; Kenney et al. 1997). Research from Hain et al. (1992) predicts a fin whale calving period in the Mid-Atlantic between the months of October to January. However, this assumption is based on stranded cow and calf pair observations and has not been verified. Although there is no defined migration corridor for fin whales within the US East Coast Atlantic EEZ, a report by Clark (1995) suggests fin whales migrate south to the West Indies in the fall (LaBrecque et al. 2015).

Based on the available literature, fin whales are most likely to inhabit waters northward of South Carolina from mid-winter through summer months. Abundance is anticipated to be the most concentrated along the continental shelf and slope north of Cape Hatteras (Hain et al. 1992; CETAP 1982). The Roberts et al. (2015e) habitat-model for fin whales in the survey area predicts the highest presence will be along in water depths less than 200 m (656 ft) from January to May. The model predictions are consistent with AMAPPS data that recorded multiple sightings of fin whales as far south as North Carolina during 2011 to 2014 ship and aerial surveys. The 2013 summer AMAAPS survey recorded fin whales in deep oceanic waters off the coast of North Carolina.

4.1.4 Minke whale (*Balaenoptera acutorostrata*)

Minke whales are believed to be the most abundant of the *Balaenopteridae* family and occur in polar, temperate, and tropical waters throughout the world (NAMMCO 2015). In the western North Atlantic, minke whales migrate to the warmer waters of the Gulf Stream along the continental shelf in the spring and travel farther offshore in autumn; abundant detections were found off the southeastern US and the Caribbean during winter (Risch et al. 2014). Minke whales are thought to be present year-round in latitudes north of 40° N, with the highest densities during summer and autumn (Roberts et al. 2015q). A feeding ground BIA was defined off the coast of New York to Maine from spring to late autumn (LaBrecque et al. 2015).

Sightings of the Canadian East Coast stock of Minke whale are expected to be infrequent within the proposed survey area. There is no known BIA within or near CGG's proposed survey area. Minke whales are predominantly distributed along the continental shelf or in waters <100 m (328 ft) deep.

4.1.5 North Atlantic right whale *(Eubalaena glacialis)*

The western Atlantic stock of North Atlantic right whales (NARW) resides in coastal or shelf waters but has been known to travel into deep water (Whitt et al. 2013). NARW are considered one of the most endangered whale species because of historical over-exploitation by commercial whaling (NOAA OPR 2015d; Clapham et al. 1999). Right whales have been listed as endangered under the Endangered Species Conservation Act since 1970 and are also protected under the MMPA. Current threats include ship collisions, entanglement with fishing gear and habitat degradation. NMFS has taken steps to reduce the threats from ship strikes and fishing gear. The 2014 Atlantic Right Whale Consortium report suggests a positive and slowly accelerating population recovery (Pettis and Hamilton 2014).

A report by LaBrecque et al. (2015) based on a comprehensive literature analysis outlines migratory, feeding, and reproductive corridor BIA for NARW in the US East Coast Atlantic. NARW feed on copepods and other zooplankton from February through December in shallow waters from New England to Canada. Beginning in November, NARW individuals migrate south to nursery areas in the shallow coastal waters from Florida to North Carolina. Individuals consist primarily of pregnant females although non-pregnant females have been observed (Schulte & Taylor 2012; New England Aquarium 2015). Right whales return to feeding grounds north of the survey area in March and April. Individual NARW migration to offshore waters outside of calving areas has been observed on occasion (Waring et al. 2015b). However, there is insufficient research to understand the extent of the migration. Non-calving right whales remain north of the survey area, and travel further offshore to mating areas in the Gulf of Maine from late autumn to early winter (Cole et al. 2013).

The proposed survey area is located well outside of any National Oceanographic Atmospheric Administration (NOAA) designated NARW critical habitat areas. The likelihood of encountering a NARW is low as the western-most boundary of the proposed survey area is located along the continental shelf edge in water depths no less than 100 m (328 ft) deep. The most likely time that a NARW could be within range of our proposed operations is during periods of migration and calving from November to April.

It is highly unlikely a ship strike will be caused by the seismic research vessel during the operation due to the slow vessel speed. Precautions will be taken nonetheless during the proposed survey to reduce the likelihood of ship strikes or disturbance from the acoustic source (see Section 11).

4.1.6 Humpback whale (*Megaptera novaeangliae*)

Humpback whales have a broad seasonal distribution and occur in all oceans from the Artic to Antarctic (Reeves 2002). The Gulf of Maine stock of humpback whale is thought to migrate in the open ocean and along the continental shelf (Barco et al. 2002; GMI 2010). Humpback whales feed on Atlantic herring and sandlace in the cold, productive waters of the Gulf of Maine from as early as March until as late as December (LaBrecque et al. 2015). Payne et al. (1986) suggests a relationship between humpback whale feeding strategies and areas of high bathymetric variation. Beginning in late October, most humpbacks migrate south to the breeding and calving grounds in the West Indies until returning north in July (Waring et al. 2015b; LaBrecque et al. 2015). Research suggests that some juvenile and adult humpback whales may not migrate as far south as other whales, but instead spend time feeding in the US Mid-Atlantic (Wiley et al. 1995; Clapham et al. 1993; Kraus et al. 2005).

Humpback whales are most likely to occur in the survey area during early winter and late spring to early summer months. The Roberts et al. (2015n) habitat-based density model for the humpback whale predicts that the highest population density in the proposed survey area is along North Carolina's continental shelf edge. An acoustic monitoring study conducted from November to April in Onslow Bay, North Carolina, recorded humpback vocalizations along the shelf edge (Hodge and Read 2014). AMAPPS sighting and acoustic surveys conducted between 2011 to 2014 recorded humpbacks south of the survey area in the winter. A few sightings of humpback whales were recorded from late winter through late summer along the Virginia and North Carolina continental shelf.

4.1.7 Sei whale (*Balaenoptera borealis*)

Sei whales typically inhabit temperate to subpolar waters on the continental shelf edge and slope (NOAA OPR 2012a). NOAA SAR has adopted the IWC's stock definition "Nova Scotia Stock" in the absence of available species data for sei whales in the western North Atlantic (Waring et al. 2015b). Population densities are most prevalent from the Gulf of Maine to the Labrador Sea (AMAPPS 2010-2013; Roberts et al. 2015w). In addition to sightings surveys, abundance and distribution information for sei whales are derived from acoustic surveys (Cholewiak et al. 2013; Debich et al. 2014; Hodge and Read 2014), genetically validated bycatch (Wenzel et al. 2013), and stranding reports (Byrd et al. 2014). Prieto et al. (2012) estimates the present population in certain areas of the North Atlantic may exceed 10,000 animals. However, Roberts et al. (2015w) predicted a habitat-density model for sei whales with an estimated a population abundance of 2,600 in the US East Coast EEZ.

The Nova Scotia population is thought to be prey driven and associated with copepod-rich and euphasid-rich feeding areas north of the survey area from spring to autumn (LaBrecque et al. 2015; Prieto et al. 2014). During the winter season, Mitchell & Chapman (1977) suggests that sei whales migrate along the shelf-break to unidentified grounds in lower latitudes. However, Prieto et al. (2014) reported findings that the sei whales inhabiting North Atlantic waters migrate from feeding grounds to wintering grounds off northwestern Africa. There is not enough information to define a migration corridor or reproduction grounds within the US East Coast Atlantic EEZ (LaBrecque et al. 2015).

Sei whales are anticipated to be rare in the survey area. The continental shelf break, where this species typically inhabits, represents only a small portion of the proposed survey area. Historical sightings and acoustic recordings in the survey area are few in number and infrequent when compared to latitudes north of Cape Cod. Sei whale presence in the survey area will most likely be near the continental shelf edge from North Carolina to Virginia during the fall and winter seasons. Sei whale vocalizations have been recorded in Florida waters (Norris et al. 2014; Debich et al. 2013) and Onslow Bay, North Carolina during the autumn and winter months (Debich et al. 2014; 2013; Hodge and Read 2014). Byrd et al. (2014) reported a single sei whale stranding in North Carolina during the month of February.

4.2 Odontoceti (dolphins, toothed whales, porpoise)

4.2.1 Atlantic white-sided dolphin *(Lagenorhynchus acutus)*

Atlantic white-sided dolphins are found primarily in temperate to sub-polar waters along the continental shelf and slope and in deep waters (Hammond et al. 2008; Palka et al. 1997). Like many other cetaceans, this species is associated with areas of high seabed relief (Reeves et al. 2002). White-sided dolphin densities are greatest north of the survey area, from George’s Bank to the Gulf of Maine. Infrequent sightings have occurred along the Mid-Atlantic Bight to South Carolina during the winter and spring months (Roberts et al. 2015bb; Waring et al. 2015b; Selzer and Payne 1988). In the late spring, the western North Atlantic stock is thought to migrate north to areas associated with the Gulf Stream (Waring et al. 2015b).

Atlantic white-sided dolphins are considered uncommon in the general area of the proposed seismic survey. Habitat-based models produced by Roberts et al. (2015bb) included only one sighting in the survey area off the coast of Virginia in over 23 years of line transect sighting surveys. There were no recordings of white-sided dolphins in the survey area in four years of aerial and shipboard AMAPPS data. A few sightings were recorded off the coast of Virginia in the summer and fall (DoN 2008). This suggests that the known seasonal distribution of Atlantic white-sided dolphins may be broader than generally thought.

4.2.2 Atlantic spotted dolphin *(Stenella frontalis)*

The population distribution of the western North Atlantic stock of Atlantic spotted dolphins is primarily located along the continental shelf within or near the 200 m (656 ft) isobath (Hammond et al. 2012). Research suggests their shallow water presence is to pursue migratory fish (Perrin et al. 1994*).* Atlantic spotted dolphins are present from Florida to Virginia during all seasons (AMAPPS 2010 to 2014; Waring et al. 2014; Griffin & Griffin 2004). A majority of sightings have been made in shallow waters less than 200 m (720 ft) in the survey area. However, sightings are also common in deep oceanic waters.

According to the Roberts et al. (2015) prediction models, spotted dolphin abundance in the survey area will be lowest during winter months and highest in spring and summer months. Data from the 23 years of sighting surveys used in the models indicates that Atlantic spotted dolphins are most concentrated in the continental shelf and slope waters of North Carolina and Virginia.

4.2.3 Beaked whales

There are six species of beaked whales which may be present in the proposed survey area. These include one species of the genus *Ziphius*, four species of the genus *Mesoplodon*, and one species of the genus *Hyperoodon*. There is much unknown about the spatial and seasonal distribution of the beaked whale family due to this species' inconspicuous nature and the difficulty of differentiating visually between species at sea. Hence, data is commonly acquired through stranding records. Roberts et al. (2015f) predict that all beaked whale species are distributed along the continental shelf out to deep waters. This is consistent with research that suggests that this deep-diving species feeds primarily on fish and mesopelagic squid (Culik et al. 2004). Based on historical sighting survey data along the US East Coast and Canada, beaked whale sightings are most common in late spring to summer (Waring et al. 2014). Due to the difficulty in distinguishing confidently between species, the NOAA SAR predicts an abundance estimate of 7,092 (Waring et al. 2014) for all *Mesoplodon sp.*

4.2.3.1 Blainville's beaked whale *(Mesoplodon densirostris)*

The North Atlantic stock of Blainville's beaked whales are most commonly observed in intermediate to deep temperate and tropical waters between Caribbean to Nova Scotia (MarineBio 2013). *M. densirostris* is believed to be one of the most common of all the species of *Mesoplodon* (Pitman 2009). Two previous studies report that the Blainesville's beaked whale tends to carry out deep foraging dives in water greater than 835 m (2,723 ft) during the night and remain closer to the surface during the day (Tyack et al. 2006; Baird et al. 2008). There is not enough research available to show distinct seasonal migration and movement (NOAA OPR 2012b).

It is possible that Blainesville's beaked whale could be present in the survey area during the proposed survey. During the 2013 AMAPPS spring survey, Blainville's beaked whales were sighted between North Carolina to Maryland in waters 60 m (196 ft) to over 1,219 m (4,000 ft) in depth.

4.2.3.2 Cuvier's beaked whale *(Ziphius cavirostris)*

The western North Atlantic stock of Cuvier's beaked whales are typically sighted in late spring to summer along the continental shelf edge and steep depth gradients in the US East Coast Mid-Atlantic region (Waring et al. 2014). Cuvier's beaked whales are distributed in tropical to temperate waters worldwide. However, there is little data available to get a clear understanding of seasonal and migratory patterns. *Ziphius cavisostris* typically travel alone or in small groups of around seven individuals (Reeves et al. 2002). This species is seemingly prone to mass stranding[2] (Taylor et al. 2004).

Cuvier's beaked whales were sighted during the 2012 to 2014 AMAPPS surveys. Sightings were reported from February through May in water depths between 200 m (650 ft) to over 4,000 m (13,123 ft) off the coast of North Carolina and north of CGG's proposed survey area. Based on the available sighting records, the Cuvier's beaked whale will likely be the most commonly observed beaked whale species during our proposed seismic survey.

[2] A mass stranding is an event where two or more dolphins or whales (other than a mother/calf pair) strand at the same time in close proximity to one another (IFAW 2015).

4.2.3.3 Gervais' beaked whale *(Mesoplodon europaeus)*

Gervais' beaked whales in the western Atlantic Ocean have been known to occur along the continental shelf edge and oceanic waters from Florida to Cape Cod (Waring et. al 2013). Aside from preferring deep, warmer waters there is no seasonal distribution data available due to the difficulty in distinguishing between species. The Gervais' beaked whale is thought to be relatively common in the waters along the US East Coast (IUCN 2014).

4.2.3.4 Sowerby's beaked whale (*Mesoplodon bidens*)

In the North Atlantic, Sowerby's beaked whales inhabit temperate waters between 200 m (650 ft) to 1,500 m (5,000 ft) deep (Reeves et al. 2002). Species data available for the Sowerby's beaked whales is taken from acoustical surveys (Cholewiak et al. 2013), bycatch records (Wenzel et al. 2013), and visual surveys (Palka 2012).

The summer AMAPPS 2014 survey reported Sowerby's beaked whale sightings north of the proposed survey area. Stranding records are primarily north of the survey area except for two stranding considered as vagrant in Florida and Georgia (Carwardine 1995; DoN 2008). It is unlikely that Sowerby's beaked whales will be encountered because they are predominantly located north of the survey area.

4.2.3.5 True's beaked whale *(Mesoplodon mirus)*

True's beaked whales are a pelagic species (Buffrenil 1995) that reside in temperate North Atlantic waters from the Bahamas to Nova Scotia (Waring et al. 2014). In 1993, a pod was observed during a survey off the coast of North Carolina along the continental shelf slope in waters around 1,097 m (3,600 ft) deep (Tove 1995). According to OBIS-SEAMAP (Halpin et al. 2009), there is only one record of True's beaked whale in the survey area. The single record was a stranding record by the Virginia Aquarium in autumn of 2003. A few strandings were also recorded on the coastline of North Carolina to New York over the last ten years. The True's beaked whale is expected to be uncommon in the survey area.

4.2.3.6 Northern bottlenose whale *(Hyperoodon ampullatus)*

The Northern bottlenose whale is the largest beaked whale in the North Atlantic. This species is believed to inhabit deep, cold to subarctic waters in the North Atlantic. The southernmost record available for this species is a stranding record in Rhode Island (Mead 1989; Reyes 1991). Based on extensive literature research, the Northern bottlenose whale is considered an extralimital species in CGG's proposed survey area. Only one individual was found in a longline net survey towed from Florida to Massachusetts (Garrison 2007).

4.2.4 Bottlenose dolphin (*Tursiops truncatus*)

Bottlenose dolphins are distributed throughout the world in temperate and tropical seas (Culik 2004). In the North Western Atlantic, bottlenose dolphins exist in two genetically and morphologically distinct forms: coastal and offshore (Waring et al. 2015b). The coastal morphotype will not be discussed in great detail because it is unlikely that these dolphins will occur in the survey area. There is evidence that some bottlenose dolphin populations make small-scale migratory movements northward of New Jersey during summer and fall months and southward to Virginia and North Carolina during the winter and spring months

(DoN 2008). However, other stocks are known to inhabit the same geographical range year-round (Waring et al. 2015b). Group size generally ranges from individuals to large herds of several hundred (Roberts et al. 2015). Mesopelagic fish and squid serve as the primary food source for bottlenose dolphins (Wynne & Schwartz 1999; Reyes 1991). Bottlenose dolphins are known to associate with pilot whales and right whales (NOAA OPR 2015c).

In the survey area, bottlenose dolphins are anticipated to occur commonly throughout the year along the continental shelf break out to waters beyond the EEZ (Waring et al. 2015b; AMAAPS 2010, 2011, 2012, 2013, 2014). Habitat-based density models (Roberts et al. 2015) for the US East Coast Atlantic show the highest densities are offshore of North Carolina and Virginia for all seasons. The models also predict a greater latitudinal distribution, and overall abundance, in the survey area to occur in late winter. Bottlenose dolphin presence in the survey area is anticipated to be slightly lower from April to June.

Although bottlenose dolphins are historically known to strand individually or in large groups (Schmidly 1981) there has been an abnormally high number of reported stranding events along the US East Coast Atlantic since July 2013 (1,827 as of July 2015; NOAA OPR 2015a). A NOAA research team has proposed viral infection as the tentative cause of the "Unusual Mortality Event" (NOAA OPR 2015a).

4.2.5 Clymene dolphin (*Stenella clymene*)

Clymene dolphins are native to the tropical and sub-tropical waters of the Atlantic Ocean (Jefferson & Curry 2003). Clymene dolphins are considered to occur routinely in the western North Atlantic despite the fact that sightings have been historically rare (Waring et al. 2014). This species is known to associate with the continental shelf edge and Gulf Stream (Fertl et al. 2003) feeding on fish and squid (Culik 2004). There is not enough available data to be able to predict confidently a geographical or temporal distribution pattern for this species. Sightings and strandings of Clymene dolphins have been infrequently reported from Florida to Virginia over the last 23 years (Roberts et al. 2015j; AMAPPS 2013; AMAPPS 2011; DoN 2008). This species occurrence in the general survey area is anticipated to be the most concentrated along the continental shelf slope between North Carolina and Virginia. All sightings have been made from March to October, peaking in July and August. However, it should be noted that only off-shelf sighting surveys occurred during these months and a distribution pattern cannot be determined with certitude due to the lack of survey coverage. Clymene dolphin can also be difficult to distinguish between other dolphin species such as the spinner dolphin. Other evidence implies Clymene dolphins occur year round in the Southwest Atlantic (DoN 2008).

4.2.6 False killer whale (*Pseudorca crassidens*)

False killer whales are broadly distributed in tropical to cooler temperate waters (NOAA OPR 2013). This species is predominantly found in deep waters greater than 3,000 m (1,000 ft) but has also been observed in shallow coastal waters (Baird 2002). Abundance and distribution data has been acquired through sighting, stranding, and bycatch records (Waring et al. 2014). There is not enough data or research to estimate the population size or determine a seasonal distribution pattern for this stock. The western North Atlantic stock is considered separate from the northern Gulf of Mexico stock despite no evidence of genetic differentiation (Waring et al. 2014). This species is known for mass stranding (Schmidly 1981).

False killer whales are expected to be rare in the proposed survey area. Only a handful of false killer whales have been recorded during marine mammal sighting surveys; periodic stranding events have also been known to occur (Roberts et al. 2015k; Waring et al. 2014; AMAPPS 2014, 2011). Based on available information, the western North Atlantic population of false killer whales ranges from Florida to Maine.

4.2.7 Fraser's dolphin (*Lagenodelphis hosei*)

The distribution and abundance of the western North Atlantic stock of Fraser's dolphin is highly uncertain and migratory behaviors are unknown (Waring et al. 2014). However, this species is known to associate with upwelling areas (NOAA OPR 2015f). Fraser's dolphins reside mainly in deep, tropical waters over 1,000 m (3,000 ft), although shallow water observations have occurred on occasion (Culik 2004). Their diet consists of squid, deep water fish, and shrimp (Wynne and Shwartz 1999; Carwardine 1995). Fraser's dolphins are notorious for actively schooling in large herds and have been associated with other species including melon-headed whales, Risso's dolphins, bottlenose dolphins, and sperm whales (Culik 2004). A population estimate is not available for the North Atlantic stock due to lack of data.

The likelihood of encountering Fraser's dolphins during the proposed seismic survey is rare. Decades of sighting survey data has yielded only two sightings in the US East Coast Atlantic. A group sighting of 75 Fraser's dolphins was observed along the continental edge of North Carolina during the spring 2011 AFAST Hatteras Aerial Survey. The other sighting occurred during the same survey in late summer when a group of 250 individuals was sighted offshore of North Carolina in waters 3,300 m (10,826 ft) deep (NMFS 1999).

4.2.8 Harbor porpoise (*Phocoena phocoena*)

The Gulf of Maine/Bay of Fundy harbor porpoise (*Phocoena phocoena*) is the only porpoise species that occurs in the Atlantic. As the stock name implies, this species is most often found in sub-polar to cool-temperature waters remaining less than 63º F (17º C) (Read 1999). Harbor porpoises are typically concentrated along the coastal and continental shelf but are known to occur in deeper waters (Palka et al. 1996). According to Waring et al. (2015a), their geographical range extends from North Carolina to Canada throughout the winter and until early spring. This is consistent with the stranding data from North Carolina that indicates that most strandings take place during migration periods between January and April (Webster et al. 1995; Byrd et al. 2014). As water temperatures increase, species abundance is most prevalent north of Delaware until the temperature drops in the fall season (Waring et al. 2015b).

The presence of harbor porpoises in the survey area is expected to be uncommon because there is only a small percentage of the survey area for which water depths are less than 200 m (656 ft) isobath, where they are known to occur. Based on extensive literature review, sightings are unlikely to occur in the proposed seismic survey area before December and after May (AMAPPS 2013; 2014; Roberts et al. 2015m; Waring et al. 2015). The likelihood of sightings is further reduced as harbor porpoises are not inclined to bow ride and typically avoid vessels (Wynne and Schwartz 1999).

4.2.9 Killer whale (*Orcinus orca*)

Killer whales are considered to have the most cosmopolitan distribution of all marine mammal species (Culik 2004). They can be found in coastal and pelagic ecosystems from the tropics to the Arctic (Morin et al. 2015). Although the western North Atlantic stock of killer whale is considered rare in the US EEZ (Lawson & Stevens 2014; Forney & Wade 2006), there is evidence of seasonal distribution patterns which coincide with prey availability (Waring et al. 2015a; Foote et al. 2014). NOAA SAR does not estimate population abundance for the western North Atlantic stock of killer whale due to insufficient data. Group size tends to be small (NOAA OPR 2015g).

Killer whales are anticipated to be rare in CGG's proposed survey area. Historical sighting records dating from 1758 to 2012 conclude that killer whales are present year-round in the coastal and deep waters of the northwest Atlantic Ocean, north of 40^0 N (Lawson & Stevens 2014). This study also reported that killer whales are most abundant in Canada from June to September and less prevalent in the US EEZ territory. Only four sightings were recorded in 23 years of sighting survey data used in the Roberts et al. (2015k) predicted density model for killer whales. All four sightings occurred well north of the proposed seismic survey area. However, the spring 2014 AMAPPS aerial survey recorded a single group of 12 animals in waters less than 100 m (328 ft) deep off the coast of North Carolina.

4.2.10 Melon-headed whale (*Peponocephala electra*)

Melon-headed whales have a pantropical distribution and prefer deep oceanic waters beyond the continental shelf (Perryman 2002; Waring et al. 2007). There is no population abundance estimate or known seasonal distribution for the western North Atlantic stock due to insufficient data. Melon-headed whales are often confused with pygmy killer whales because they share similar behavioral and physical characteristics. A distinguishing factor is that melon-headed whales are highly social and more likely to be seen in large, tightly packed pods (Culik 2004).

Sightings in the proposed survey area are expected to be rare. Roberts et al. (2015p) reported only four sightings of melon-headed whales in 23 years of line transect sighting survey data. All sightings were in the deep offshore waters of North Carolina and Virginia. A single melon-headed whale or pygmy killer whale (a confident species identification was not possible) was recorded in waters near the EEZ around 34^0 N during the summer AMAPPS 2011 GU-11-02 survey. It should be noted that this species is known to mass strand (NOAA OPR 2012d).

4.2.11 Pantropical spotted dolphin *(Stenella attenuata)*

Pantropical spotted dolphins inhabit the tropical to temperate waters of the western North Atlantic Ocean (BOEM PEIS 2014). Like other *Stenella*, the pantropical spotted dolphin is found predominantly along the continental shelf and slope. This pelagic species feeds in shallower waters during the day and moves into deeper waters at night (NOAA OPR 2014a). At sea, pantropical spotted dolphins can be difficult to distinguish from other long-beaked oceanic dolphin, particularly the Atlantic spotted dolphin (Jefferson et al. 1993). Pantropical spotted dolphins are gregarious and known to school in large groups (Culik 2004). Calving and mating occurs throughout the year (NOAA OPR 2014a).

There is not a substantial amount of sighting and acoustic records for pantropical spotted dolphins along the US East Coast. However, there is enough information to identify waters from Florida to Maine as a potential year-round pantropical spotted dolphin habitat (Roberts et al. 2015s; AMAPPS 2011; Halpin et al. 2009; Waring et al. 2007). The NOAA SAR population estimate for the western North Atlantic stock is 4,439 individuals (Waring et al. 2007). Pantropical dolphins could be common in the proposed survey area.

4.2.12 Pilot whales (*Globicephala sp*.)

The genus *Globicephala* encompasses two subspecies: the long-finned pilot whale *(Globicephala melas)* and short-finned pilot whale (*Globicephala macrorhynchus*). Globally, the latitudinal range of *Globicephala sp.* varies (Reeves et al. 2002). However, both species are known to associate with the Gulf Stream and thermal fronts (Waring et al. 2015b). Movement from shallow to deep waters is thought to be in response to seasonal prey availability (Culik 2004). The primary food sources for pilot whales include squid, mackerel, and cod (Olson & Reilly 2002; Abend & Smith, 1997; Jefferson et al. 1993). In the US Atlantic EEZ, there is some overlap in species distribution between 35^{0} N and 40^{0} N. In addition, both *G. melas and G. macrorhynchus* have been observed stranded beyond their typical habitat (Waring et al. 2015b). Assessing density and abundance estimates is challenging due to the uncertainty of range distribution and the difficulty in differentiating between species at sea.

Pilot whales are susceptible to both individual and group stranding. Stranding events have been recorded from Florida to Maine over several decades (Waring et al. 2015b). In most cases the cause is unknown, but some events have been linked to fisheries interaction and pollution (Waring et al. 2015b). The risk of a mass stranding is compounded by the fact that pilot whales have herding tendencies and may travel in large tight-knit pods (Culik 2004).

Long-finned pilot whales have a cool temperate to subpolar distribution (Reeves et al. 2002). Calving periods occur between late spring and autumn in areas north of the survey area (Reeves et al. 2002). Long-finned pilot whales are highly social and have been known to associate with other marine mammal species, particularly with Atlantic white-sided dolphins (Culik 2004). In the survey area, long-finned pilot whales are expected to be present north of 42^{0} N.

Short-finned pilot whales are more broadly distributed in warm temperate and tropical waters (Jefferson et al. 1993). This species appears to be nomadic (Culik 2004). The Northwest Atlantic population of short-finned pilot whales is anticipated to be most common species occurring south of 42^{0} N, along the continental shelf from Virginia to Florida (Baird 2015; Waring et al. 2015b).

Pilot whales are expected to be common in the survey area. Based on the known distribution, most sightings are expected to be short-finned pilot whales. The Roberts et al. (2015t) habitat-based density model for pilot whales predicts continental shelf abundance to build from late winter into summer, peaking in July. Species distribution is the most concentrated along the northwest portion of the survey area throughout the year. However, their distribution also extends, to a lesser extent, southward to Florida. During the spring and summer month's pilot whales become more concentrated in oceanic waters from 1,000 m (3,600 ft) to 4,000 m (14,400 ft). Abundance drops steadily from late summer to winter as pilot whales move north and south of the survey area.

4.2.13 Pygmy and dwarf sperm whales (*Kogia sp.*)

Pygmy sperm whales (*Kogia breviceps*) and dwarf sperm whales (*Kogia sima*) comprise the family Kogiidae in the US East Coast Atlantic. *Kogia spp.* inhabits temperate and tropical waters seaward of the continental shelf throughout the world (Waring et al. 2014). Their diet consists primarily of deep-sea cephalopods and fish (Staudinger et al. 2014). *K. breviceps* and *K. sima* are inconspicuous and generally difficult to distinguish at sea although they are known to log on the water surface (Jefferson et al. 1993). The ability to differentiate between *Kogia* species and speculate distribution or migration patterns has largely been acquired through stranding records (McAlpine 2002). Culik (2004) suggests that migration can occur from shallow to deep waters during summer months. Historical records indicate that Kogia are present year-round from Florida to Maine (Roberts et al. 2015o; Byrd et al. 2014; AMAPPS 2013; AMAPPS 2011). Research by Byrd et al. (2014) reports that individual and group (mostly cow-calf pairs) stranding events occur year-round on the North Carolina coast; stranding is highest mid-winter and mid-spring. Dwarf sperm whales were reported to be stranded most commonly. Byrd's report concludes that the stranding numbers are disproportionate with respect to previously recorded *Kogia spp.* population estimates and biostatistical assumptions used in some studies could underestimate actual population size.

In the Northern Hemisphere, pygmy sperm whale mating and calving seasons peak from March to August (NOAA OPR 2014b). This species travels in a group size averaging less than six individuals (Culik 2004). The western North Atlantic stock of pygmy sperm whales is the most often sighted of the Kogia species. The pygmy sperm whale is considered to have a more oceanic distribution than dwarf sperm whales (Reeves 2002).

Dwarf sperm whales are the smallest of the whale species. Like *K. breviceps*, they are typically sighted in calmer conditions. This species is believed to be distributed in shallower waters than pygmy sperm whales as sightings occur more often on the continental shelf edge (Wynne & Schwartz 1999). Group size is slightly larger than *K. breviceps*, comprising groups of up to ten animals (Culik 2004).

*Kogia spp. s*ightings are likely to be infrequent in the survey area as this species is generally inconspicuous and has been known to shy away from vessels (Berini 2009).

4.2.14 Risso's dolphin (*Grampus griseus*)

The western North Atlantic stock of Risso's dolphin associates with the continental shelf break, sea mounts, and upwelling areas year-round. Crustaceans, fish, and cephalopods are the primary food source for this pelagic species (Jefferson et al. 1993; NOAA OPR 2012c). Risso's dolphins carry out seasonal shifts in distribution, associating with areas of primary productivity (Culik 2004). From spring to fall, their geographic distribution extends from Florida to Massachusetts (Waring et al. 2015b; CETAP 1982; AMAPPS 2011, 2012, 2013, 2014). The population is generally distributed along the mid-Atlantic Bight and into oceanic waters during winter months (Payne et al. 1984).

Risso's dolphins typically travel in group sizes between five and 30 individuals and have been observed with other cetaceans including porpoises, sperm whales, pilot whales, and bottlenose dolphins (NOAA OPR 2012c; Culik 2004). Behaviorally, they tend to shy away from vessels and, at times, may exhibit acrobatic, active swimming (Wynne & Schwartz 1999). This dolphin species is not known to bow ride.

Risso's dolphins are expected to be common throughout the survey area year-round.

4.2.15 Rough-toothed dolphin *(Steno bredanensis)*

Rough-toothed dolphins are a pelagic species that prefer warmer temperate to tropical waters (Reeves 2002). This species is well-known for fast, acrobatic swimming and occasional bow-riding (Wynne & Schwartz 1999). There is not enough available data to ascertain the seasonal distribution and abundance of the western North Atlantic stock of rough-toothed dolphins. Based on shipboard and aerial sighting and acoustic surveys from 1998 through 2013, the western North Atlantic stock of rough-toothed dolphins is broadly distributed from the coast to beyond the EEZ (Robert et al. 2015; Waring et al. 2014; AMAPPS 2013, 2011). Sightings have occurred from Florida to New York. There is no data available for autumn and winter surveys.

There is a possibility that rough-toothed dolphins will be present in the survey area during the proposed survey. However, sightings are expected to be rare.

4.2.16 Short-beaked common dolphin *(Delphinus delphis)*

Along the US East Coast, the western North Atlantic stock of common dolphin generally inhabits waters northward of 32º N and associates with the Gulf Stream features (Waring et al. 2015a; Jefferson et al. 2009). Population distribution is concentrated along the continental shelf edge between 100 m (328 ft) to 2,000 m (6,560 ft) deep (BOEM PEIS 2014). Squid and small schooling fish are a typical food source for common dolphins (Pusineri et al. 2007). Group size ranges from just a few individuals to several thousand (Culik 2010). Common dolphins have been known to associate with other species and exhibit highly active swimming and bow-riding (Wynne & Schwartz 1999; Palka et al. 2005).

Common dolphins were recorded in the survey area in all seasons during the 2010 to 2014 AMAPPS sighting surveys. Sightings were most frequent from mid-winter to mid-summer as far south as North Carolina. Most sightings were between 100 m (328 ft) to 200 m (656 ft). Beginning in mid-summer, the majority of observations were recorded in deeper waters north of the survey area. AMAPPS records are generally consistent with large-scale sighting surveys used in the NMFS 2014 SAR for the western North Atlantic stock of short-beaked common dolphins and a recent marine mammal tagging research survey (Baird 2015).

4.2.17 Sperm whale (*Physeter macrocephalus*)

Sperm whales inhabit every ocean in the world and associate with areas of high primary and secondary productivity (Wong et al. 2014). In the western North Atlantic, the geographic distribution of sperm whales may be driven by social structure (Waring et al. 2015a). Females and juveniles generally inhabit tropical and subtropical waters whereas males have a broad seasonal distribution into higher latitudes (Waring et al. 2015a). Male sperm whales have been known to associate with deep canyons in the summer and then broaden their distribution in the winter, possibly due to changes in prey (Jaquet et al. 2000). Historical sighting data from 1780 to 1920 provide evidence of a seasonal distribution pattern of sperm whales in the northwest Sargasso Sea during the spring and summer months (Smith et al. 2012).

Sperm whales are expected to be present in the survey area year-round. The majority of sightings are likely to be along the continental shelf and edge and oceanic waters from North Carolina to Virginia. During the winter, population abundance is generally concentrated offshore Cape Hatteras in water depths between 100 m (328 ft) to over 2,000 m (6,561 ft) (AMAPPS 2014, 2013, 2011). In the spring and summer, sperm whale population density and distribution extends northward with the warming currents along the continental shelf and into deep waters along the Mid-Atlantic Bight to George's Bank (Waring et al. 2015a). As autumn approaches, the main distribution moves to lower latitudes around the Mid-Atlantic Bight. The 2014 NOAA SAR predicts that the western North Atlantic stock population estimate of 2,288 individuals is underestimated because dive-times were not incorporated into the assessment (Waring et al. 2015a).

4.2.18 Spinner dolphin (*Stenella longirostris*)

Spinner dolphins are found in coastal and oceanic tropical waters around the world (Roberts et al. 2015z). The western North Atlantic stock is presumed to inhabit deep waters seaward of the continental shelf (Waring et al. 2015a). Spinner dolphins may dive to depths of over 300 m (984 ft) to feed on mesopelagic fish, squid, and shrimp (Culik 2004). Like other *Stenella* species, spinner dolphins are gregarious and may travel in large schools of mixed species (NOAA OPR 2014c). There is no population estimate or known seasonal distribution for Spinner dolphins in the US Atlantic EEZ due to the paucity of sightings (Waring et al. 2014).

Spinner dolphin sightings have occurred infrequently in the proposed survey area (Waring et al 2015; AMAPPS 2010; CETAP 1982). Sightings are from North Carolina to Virginia in water depths greater than 1,000 m (3,280 ft). All sightings occurred in spring and summer months, the latter being the most prevalent. Other sightings were recorded north of the survey area during AMAPPS surveys. Stranding records show a potential presence from Florida to North Carolina (Waring et al. 2015a). This species is not expected to be common in the proposed survey area.

4.2.19 Striped dolphin (*Stenella coeruleoalba*)

Striped dolphins inhabit productive tropical and warmer temperate waters worldwide (Jefferson et al. 2008). The US western North Atlantic stock is typically found along the continental shelf to the Gulf Stream from North Carolina to Maine (Waring et al. 2014). Striped dolphins are gregarious and have been known to travel in pods of more than 20 individuals (BOEM PEIS 2014; Mullin et al. 2004).

Striped dolphins are expected to be in the survey area year-round. Based on the Roberts et al. (2015aa) habitat-models for striped dolphins, abundance is anticipated to be most prevalent from spring to early summer, peaking in April and May. The models also predict density distribution to extend into deep oceanic waters northward of South Carolina during summer. These predictions are consistent with spring and summer AMAPPS (2011; 2013; 2014) aerial and shipboard surveys. Striped dolphins are anticipated to be most prevalent north of the survey area from autumn through mid-winter (Roberts et al. 2015aa). Only one sighting occurred as far south as Florida during a Southeast Cetacean Aerial Survey (SEFSC) in February of 1995 (OBIS-SEAMAP).

5.0 TYPE OF INCIDENTAL HARASSMENT AUTHORIZATION REQUESTED

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (1) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (2) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment].

CGG requests the issuance of an IHA pursuant to Section 101(a) (5) of the MMPA for incidental harassment of a small number of marine mammals by exposure to underwater sound during the proposed exploration survey in 2016. The impulsive sound generated by the seismic acoustic source has the potential to take marine mammals by Level B harassment. The behavioral response will depend on the individual marine mammal, the received sound level, and the activity the animal is engaged in at the time of exposure. The seismic acoustic source is not expected to disturb more than a small number of marine mammals or have more than a negligible effect on their populations based on the mitigation and monitoring plan described in Sections 11 and 13. Effects of the proposed seismic survey activity on whales and dolphins are expected to be temporary and localized. Takes by mortality or injury (Level A harassment) are not requested in CGG's IHA application because they are expected to be avoided to the extent practicable when the mitigation and monitoring measures prescribed in Section 11 and 13 are applied.

6.0 ESTIMATED NUMBER OF MARINE MAMMAL HARRASSMENTS

This section addresses the estimated number of marine mammals that could be exposed to sound levels generated by the impulsive seismic acoustic source that are ≥160 dB re 1 µPa rms (hereafter referred to as 160 dB rms). NMFS has stated that a marine mammal exposed to sounds within this threshold could experience behavioral shifts significant enough to constitute a "take by harassment" (NMFS 2001). NMFS does not provide specific guidance or requirements for IHA applicants for the development of take estimates and multiple exposure analysis. CGG's method for quantifying the predicted number of exposures (harassments) is explained below and is based on (1) marine mammal habitat-based density data; (2) sound propagation modeling results; (3) the survey duration and coverage area; and (4) species stock population data. The estimated number of exposures, the requested take authorizations by Level B harassments (160 dB rms), and the associated population impact are shown in Table 7.

Level A takes are not requested in this IHA application because they are expected to be avoided to the extent practicable when the mitigation and monitoring measures prescribed in Section 11 and 13 are applied. These measures are focused on effectively minimizing takes and represent a best practice approach. The short duration of acoustic exposures to marine mammals during the proposed survey are unlikely to result in any long-term deleterious consequences to either individuals or species populations.

NMFS has required that our IHA application address "unadulterated" (unmitigated) Level A exposures estimates for marine mammals in order for the agency to conduct a complete analysis. CGG strongly opposes addressing a potential impact that does not consider the role of mitigation and monitoring described in this IHA application. Regardless, the estimates shown in Table 4, are based on BOEM's Alternative A (no mitigation) scenario that calculates the number of Level A exposures for all projected seismic acoustic source surveys from 2012- 2020 (BOEM PEIS 2014; p. E-86). CGG's proposed 28,670 line-km survey area comprises 14% of BOEM's projected 28,670 line-km area of effort for all seismic acoustic source surveys in 2015. This is the year proposed in our G&G permit application (E14-005) that was incorporated into BOEM's analysis (BOEM PEIS 2014; p. E-57). CGG's total coverage was multiplied by the predicted Level A take value for all surveys to predict the number of individual Level A exposures (based on no mitigation) for our proposed survey area. It should be noted that the modeling conducted by BOEM is purposely developed to be conservative and should not be considered as expected levels of actual take.

Table 4 No mitigation scenario: estimated number of individual Level A exposures using Southall et al. (2007) criteria. Southall's acoustic criteria is based on total received sound energy, or sound exposure level (SEL), and is considered a better metric for the prediction of injury onset than rms (BOEM PEIS 2014; p. H-12). Level A exposures are not expected to occur with applied mitigation measures.

Species[1]	BOEM's Level A exposure estimates for all seismic acoustic source surveys in 2016[2]	Level A exposures estimates based on CGG's line-km area
Family Balaenidae (right whales)		
North Atlantic right whale[2]	0	0
Family Balaenopteridae (roquals)		
Blue whale	2	0
Bryde's whale	1	0
Fin whale	0	0
Minke whale	0	0
Humpback whale	6	1
Sei whale	0	0
Suborder Odontoceti (toothed whales)		
Family Ziphiidae (beaked whales)		
Blainville's beaked whale	3	0
Cuvier's beaked whale	20	3
Gervais' beaked whale	3	0
Northern bottlenose whale	0	0
Sowerby's beaked whale	0	0
True's beaked whale	2	0
Family Physeteridae (sperm whales)		
Sperm whale	0	0
Family Delphinidae (dolphins)		
Atlantic spotted dolphin	1,504	211
Atlantic white-sided dolphin	3	0
Bottlenose dolphin	31	4
Clymene dolphin	126	18
Dwarf sperm whale	6	1
False killer whale	0	0
Fraser's dolphin	0	0
Killer whale	0	0
Long-finned pilot whale	118	16
Melon-headed whale	0	0
Pantropical spotted dolphin	264	37
Pygmy killer whale	0	0

Pygmy sperm whale	0	0
Risso's dolphin	734	103
Rough-toothed dolphin	0	0
Short-beaked common dolphin	231	32
Short-finned pilot whale	23	3
Spinner dolphin	1	0
Striped dolphin	1,021	143
Family Phocoenidae (porpoise)		
Harbor porpoise	4	1

1 Species in italics are ESA-listed.
2 Projected seismic acoustic source surveys in Mid and South Atlantic in 2016 (BOEM PEIS 2014; Table Attachment E-4)

6.1 Habitat-based density models

At the time of this analysis, the best available habitat-based density models for understanding the spatial and temporal distribution of marine mammals in CGG's 2D Seismic Program area was determined to be the Roberts et al. (2015a) preliminary model predictions. The models were developed by the Duke University Marine Geospatial Ecology Laboratory (MGEL) in partnership with the NOAA Cetacean & Sound Mapping (CETSound) project, National Aeronautics and Space Administration (NASA), and the US Navy. The models will be used for NOAA's Cetacean Density and Distribution Mapping (CetMap).The Duke MGEL marine mammal density database for the US and Canada Northwest Atlantic 200 nm EEZ was built on 23 years of shipboard and aerial line transect survey data provided by five institutions. A summary of the survey programs and surveyors in the database is shown in Table 4. It should be noted that additional surveys may have been added or information from existing survey data may have been updated since we conducted our analysis.

Table 5 Line transect surveys used for the Duke MGEL cetacean habitat-based density models in the Northwest Atlantic models (Roberts et al. 2015b).

Survey Program	Duration	Coverage Area (km)	Effort Hours	# of Surveys
NEFSC[1] Aerial Surveys	1995 - 2008	70,000	412	8
NEFSC NARWSS[2] Harbor Porpoise Survey	1999 - 1999	6,000	36	1
NEFSC NARWSS	1999 - 2013	438,000	2,330	24
NEFSC Shipboard Surveys	1995 - 2004	16,000	1,143	6
NJDEP[3] Aerial Surveys	2008 - 2009	11,000	60	2
NJDEP Shipboard Surveys	2008 - 2009	14,000	836	2
SEFSC[4] Atlantic Shipboard Surveys	1992- 2005	29,000	1,731	6
SEFSC Mid Atlantic Tursiops Aerial Surveys	1995 - 2005	35,000	196	7
SEFSC Southeast Cetacean Aerial Surveys	1992 -1995	8,000	42	2
UNCW[5] Cape Hatteras Aerial Surveys (Navy)	2011 - 2013	38,000	250	4
UNCW Early Marine Mammal Aerial Surveys	2002 - 2002	18,000	98	1
UNCW Jacksonville Aerial Surveys (Navy)	2009 - 2013	132,000	805	10
UNCW Onslow Bay Aerial Surveys (Navy)	2007 - 2011	98,000	563	6
UNCW Right Whale Aerial Surveys	2005 - 2008	114,000	586	3
Virginia Aquarium Aerial Surveys	2012 – 2014	19,000	106	1
Total		1,046,000	9,194	83

[1]Northeast Fisheries Science Centers

[2] North Atlantic Right Whale Sighting Survey

[3] New Jersey Department of Environment

[4] Southeast Fisheries Science Centers

[5] University of North Carolina – Wilmington

The track lines for all sighting survey programs and the associated sightings records for the Atlantic spotted dolphin are shown in Figure 4 as an example of the combined survey effort and species data used in the Duke MGEL analysis.

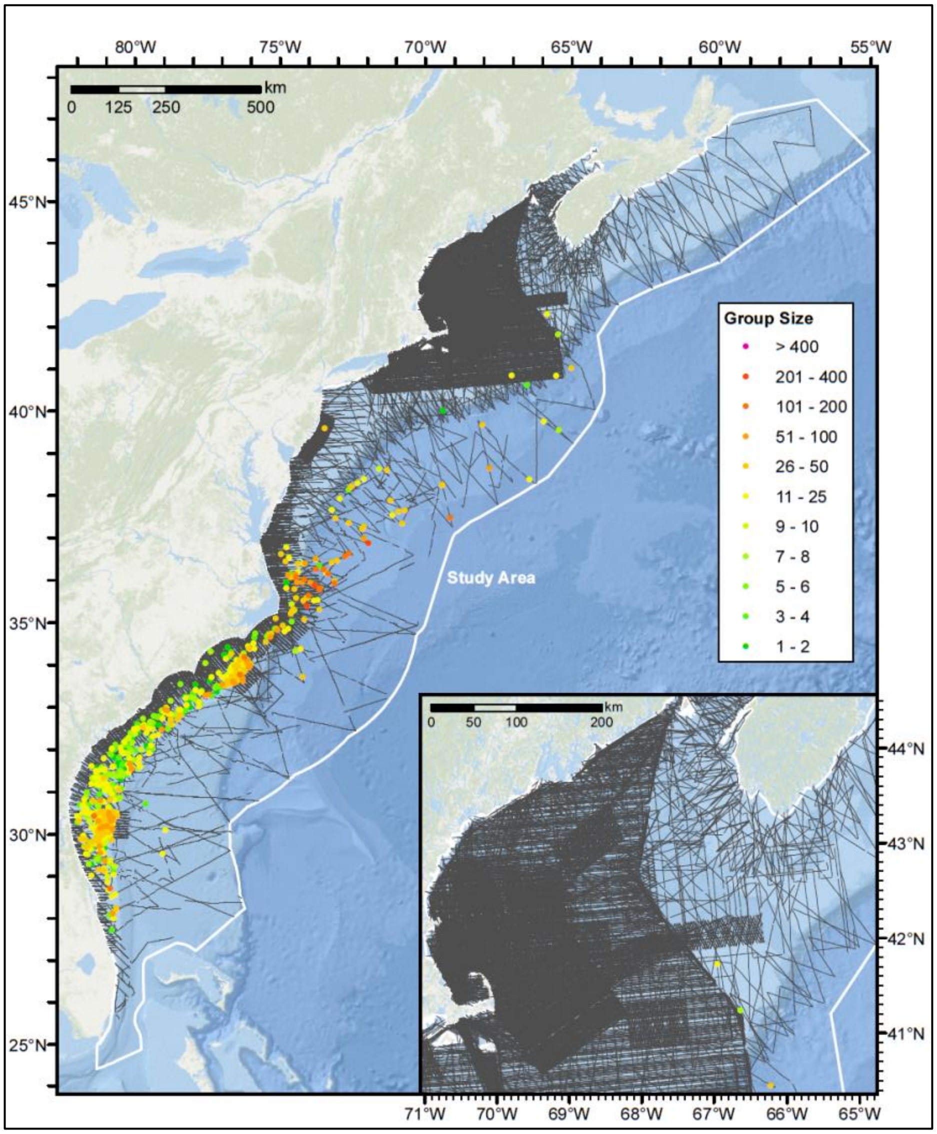


Figure 4 Atlantic spotted dolphin sightings recorded during surveys from 1992 – 2014 (Roberts et al. 2015b). The study area encompasses the US and Canadian 200 nm EEZ territory.

The habitat-based density prediction models provide the best possible estimates of density and highest possible spatial and temporal resolutions for 28 marine mammal taxa in the Northwest Atlantic. The methodology accounts for:

- species detection capability differences between aerial and shipboard surveys including comparison of survey-specific protocols
- species that were not seen and could result in an underestimated abundance (Thomas et al. 2013) (i.e., deep-divers, inconspicuous species)
- spatiotemporal distribution of species (i.e., individual or species migration patterns)
- the number of sightings made for each species

The density surface modeling (DSM) (Miller et al. 2013; Hedley & Buckland 2004; Thomas et al. 2010) approach was used for 15 of the 28 modeled taxa to predict individual density (per km^2) at different points in space and time (Becker et al 2014) (See Table 5). Using generalized additive models (GAM) (e.g., Wood 2006), distance sampling methods were applied to line transect survey data and coupled with environmental covariates (depending on data availability) to produce the habitat-based density models. The models generated for each taxon are either annual or monthly resolution models. All of the following criteria must be met for a taxon to be predicted at a monthly time-step: (1) conclusive literature of varying seasonal distribution; (2) sufficient amount of sighting data over space and time (based on Buckland et al. 2001); and (3) species data used in the analysis is consistent with available literature. Monthly models were produced for 11 species. An annual map based on one season was produced for the four marine mammal taxa that did not meet all three criteria mentioned above. The annual predicted habitat-distribution of the Atlantic spotted dolphin in the Northwest Atlantic EEZ is shown in Figure 5 as an example.

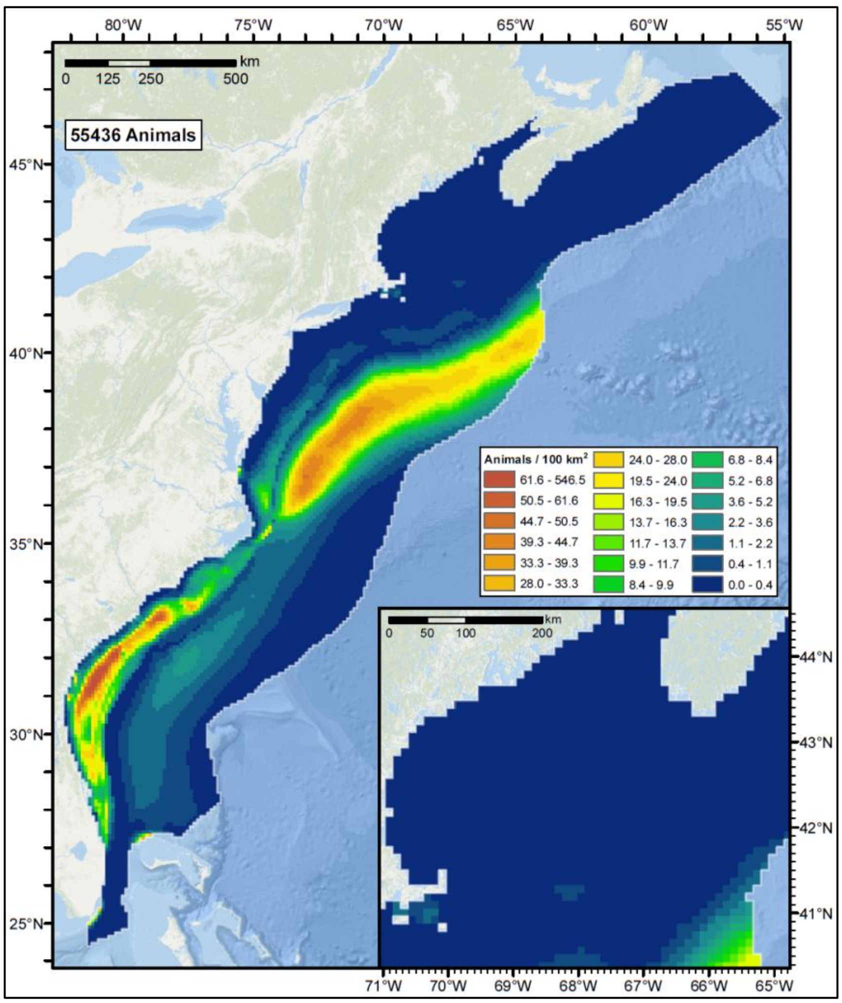


Figure 5 Predicted annual distribution of the Atlantic spotted dolphin using DSM modeling (Roberts et al. 2015b)

The remaining 13 of the 28 modeled taxa were recorded too infrequently (species with less than 20 sightings) to apply environmental covariates and were therefore fitted with a single stratified model (see Table 5). This means density was homogenously distributed across the study area based on the known species ecology. The taxa that were either known or thought to occur in all parts of the study area were fitted to a regional model. The taxa known to occupy only certain regions in the study area were fitted to a sub-regional model. An example is provided in Figure 6 which shows the predicted sub-regional density distribution model for the northern bottlenose whale (Roberts et al. 2015c). See Table 5 for the species that fit either the regional or sub-regional category.

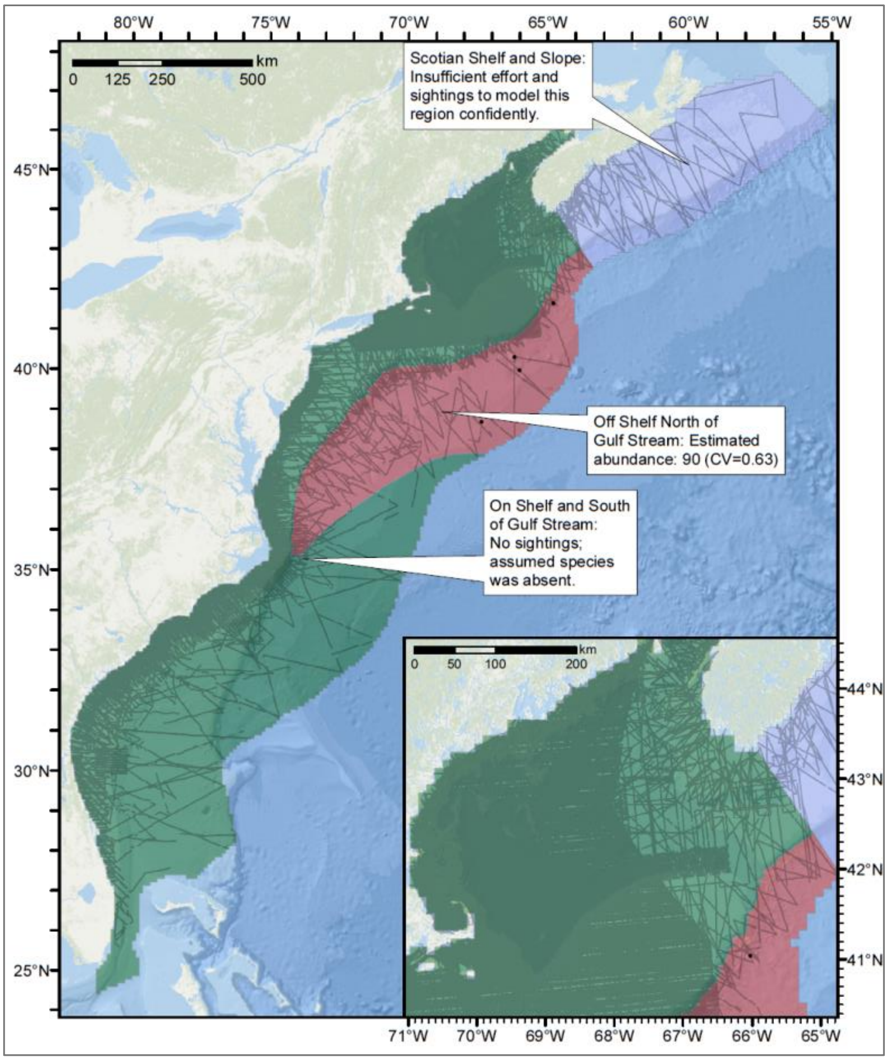


Figure 7 Stratified sub-regional northern bottlenose whale predicted distribution model (Roberts et al. 2015c).

Model type	Model specifics	Species and species groups
Density Surface Modeling (DSM)	Monthly	Atlantic white-sided dolphin; bottlenose dolphin; fin whale; North Atlantic right whale; minke whale; harbor porpoise; humpback whale; Risso's dolphin; sei whale; short-beaked common dolphin; sperm whale
	Annual	beaked whales (*Ziphiidae* and *Mesoplodon*); Atlantic spotted dolphin; pilot whales (*Globicephala sp.*); striped dolphin
Stratified modeling	Regional	blue whale; false killer whale; killer whale
	Sub-regional	Bryde's whale; Clymene dolphin; Fraser's dolphin; melon-headed whale; northern bottlenose whale; *Kogia sp.*; pantropical spotted dolphin; rough-toothed dolphin; spinner dolphin; white-beaked dolphin

Table 6 Summary of model types used to produce Roberts et al. (2015a) marine mammal habitat-density maps. Monthly and sub-regional habitat-density model types were modeled for species that have known seasonal variation. Annual and regional model types were modeled for animals that are not known to exhibit seasonal movements.

It should be noted that there are temporal and spatial limitations to Roberts et al. (2015a) models (Rickard 2015). For example, there was less survey coverage during the fall season and seaward of the continental shelf break than in other seasons and areas. In some instances, this resulted in the application of correction and probability factors that could yield unrealistic abundance and distribution models.

6.2 Marine Mammal Harassment Estimate Methodology

This analysis aims at predicting the number of individuals of each species that could be exposed to potentially disturbing sound levels generated by the 5,400 in3 seismic acoustic source. ArcGIS was used to produce the initial exposure estimate output for analyzing geospatial information. The report output was the predicted density of a species or species group per 100 square kilometers (km^2) (10 km x 10 km) of ensonified area.

- A 6,751 m (22,149 ft) radius, representing the extent of the 160 dB rms ensonification zone, was drawn around each sail line. The methodology for estimating the size of the 160 dB rms ensonification radius is described in Section 1.3.2.2. The total ensonified area for 28,670 line-km of sail line was determined to be 265,406 km^2.

- Preliminary marine mammal habitat-based density models for the Northwest Atlantic (Roberts et al. 2015a) developed by the Duke MGEL were uploaded into ArcGIS for each species or species group (taxon). Section 6.1 describes the cetacean habitat-based density models in detail. Each model comprises 100 km^2 (10 km x 10 km) grid cells and contains a geometric value representing the predicted abundance for a specific taxon.

- The "cetacean density grid cells" were converted into a compatible format and then spatially and geographically referenced over the ensonified sail lines. The ensonified sail lines were populated with the cetacean density grids by calculating the difference between the pre- and post-extracted area.

- The Roberts et al. (2015a) models do not include cetacean density data for waters beyond the Northwest Atlantic 200 nm EEZ territory. An interpolation analysis was carried out to estimate the 28,922 km^2 of survey area (~11%) outside of the 200 nm EEZ where no density values existed.

- The interpolation analysis projected a cetacean density grid for each taxon across the 28,922 km^2 of ensonified area outside of the 200 nm EEZ boundary. The estimated density grid values inside and outside of the 200 nm EEZ boundary were combined and averaged over a six month period to reflect the survey duration.

- A separate literature review was conducted for each species to compare the results with other research[3]. In a few instances, the estimated exposure number was deemed unrealistic and a different number of takes was requested (See Section 6.5). When the literature review was completed, the number of requested authorization of individual takes by Level B harassment was finalized.

- The finalized exposure estimates were multiplied by the best available population data to predict the population impact for each species or species group.

6.3 Marine Mammal Harassment Estimate Results

Table 7 presents a summary of the estimated number of marine mammal exposures to 160 dB rms during CGG's 2D Atlantic Seismic Program and the predicted population impact. These estimates will need to be compared to actual sighting data acquired during CGG's 2D Seismic Program in order to understand realistic numbers.

[3] In addition to data comparison, the purpose of the literature review was to identify what areas, if any, in CGG's program area may be of biological importance for the species vitality (e.g., reproductive, migration, feeding).

Table 7 The estimated number of individual exposures of marine mammals to received seismic impulse sound levels ≥160 dB rms re 1 μPa (Level B harassment) during CGG's proposed 2D Atlantic Seismic Program.

Species	Estimated individual exposures	Requested Level B Take authorization	Estimated abundance[1]	Estimated population impact (%)
Suborder Mysticeti				
Family Balaenidae (right whales)				
North Atlantic right whale[2]	1	2	476[3]	0.4%
Family Balaenopteridae (roquals)				
Blue whale	2	2	DD [4]	0.2%
Bryde's whale	3	3	DD	DD
Fin whale	50	50	4,633	1.1%
Minke whale	134	134	20,741	0.6%
Humpback whale	7	7	921	0.8%
Sei whale	14	14	370	3.8%
Suborder Odontoceti (toothed whales)				
Family Ziphiidae (beaked whales)				
Beaked whale	3,722	3,722	14,491	25.7%
Northern bottlenose whale	8	0	DD	DD
Family Physeteridae (sperm whales)				
Sperm whale	1,406	1,406	5,747	24.5%
Family Delphinidae (dolphins)				
Atlantic spotted dolphin	6,880	6,880	55,436	12.4%
Atlantic white-sided dolphin	441	441	48,819	0.9%
Bottlenose dolphin	9,276	9,276	97,476	9.5%
Clymene dolphin	6,609	6,609	DD	DD
False killer whale	20	20	DD	DD
Fraser's dolphin	268	268	DD	DD
Killer whale	2	6	DD	DD
Kogia whale	249	249	3,785	6.6%
Melon-headed whale	620	100	DD	DD
Pantropical spotted dolphin	1,623	1,623	4,436	36.6%
Pilot whales	2,043	2,043	27,150	7.5%
Risso's dolphin	831	831	7,732	10.7%
Rough-toothed dolphin	183	183	532	34.4%
Short-beaked common dolphin	6,220	6,220	86,098	7.2%
Spinner dolphin	108	108	DD	DD
Striped dolphin	6,722	6,722	75,657	8.9%
White-beaked dolphin	0	0	2,003	0.0%
Family Phocoenidae (porpoise)				
Harbor porpoise	32	32	79,883	0.0%

1 Estimated species population in the US and Canada EEZ territory (Roberts et al. 2015a) unless otherwise cited.
2 Italics identify species listed as 'Endangered' under the ESA.
3 DD = Data Deficient

6.4 Abundance estimates

The species population estimates used to predict population impact in Table 7 was based on the best available science that is most applicable to the proposed survey area. Duke MGEL abundance estimates are preferred in order to maintain consistency with the statistical methodology used to predict species habitat-density models. For some species NOAA SAR reports were more appropriate. This section compares Duke MGEL and NOAA SAR species abundance estimates and provides justification for the data source that was used to predict population impact. It should be noted that Duke MGEL did not incorporate Canadian Trans North Atlantic Sightings Survey data (TNASS) or AMAPPS data into their analysis and some taxon abundance estimates are likely underestimated (Roberts et al. 2015).

- **North Atlantic Right Whale.** Duke MGEL predicted a 12 month mean abundance based on a seasonal analysis: 535 (coefficient of variation (CV) 0.45) winter abundance; 416 (CV 0.12) spring abundance; 369 (CV 0.07) summer abundance; and 334 (CV 0.25) fall abundance (Roberts et al. 2015r). Climatological models were used to predict NARW density and distribution for all seasons with the exception of winter. Winter density models were predicted using contemporaneous models. NOAA SAR 2015 reported a minimum western North Atlantic population estimate of 476 in 2011 (Waring et al. 2015b). The estimate is based on a direct count using photo-identification techniques and has no associated CV. NOAA's minimum population estimate was selected to predict NARW population impact because it is a direct census count. The estimate is comparable with Duke MGEL's mean summer to winter abundance of 428 which reflects the timing of our proposed 2D seismic survey (July to December).
- **Blue whales.** Duke MGEL used a stratified model (a uniform density distribution across the study area) based on 4 sightings north of 40^0 N because there was insufficient data to prepare habitat-based density models (Roberts et al. 2015g). The NOAA SAR 2010 concluded that there was not enough information to predict abundance for the western North Atlantic stock (Waring et al. 2010). Based on extensive research, we do not feel there is enough available data to predict a population impact for blue whales in the US East Coast Atlantic.
- **Bryde's whale**. Duke MGEL predicted an abundance of 7 (CV 0.58) based on four ambiguous "Bryde's or sei whale" sightings that were distributed uniformly across the study area in the month of January (Roberts et al. 2015i). There is no NOAA SAR for Bryde's whales in the western North Atlantic. Based on extensive research, we do not feel there is enough available data to predict a population impact for Bryde's whales in the US East Coast Atlantic.
- **Fin whale.** Duke MGEL predicted a mean abundance of 4,633 (CV 0.08) based on a climatological model (Roberts et al. 2015e). The NOAA SAR 2014 reported a predicted abundance of 1,618 (CV 0.33) for the Western North Atlantic stock (Waring et al. 2015b). Duke MGEL's mean abundance was selected because the dataset encompassed a broader range and more sighting records that were relevant to the proposed 2D program area.
- **Minke whale.** Duke MGEL predicted a mean seasonal population model of 740 (CV 0.23) in the winter and 2,112 (CV 0.05) in the summer. These stratified models showed transitions at October/November and March/April based on the reduced presence of minke whales in the Gulf of

Maine in November-March, and the sighting of minke whales from December to March between Cape Hatteras and Florida (Roberts et al. 2015q). The NOAA SAR 2014 (Waring et al. 2015b) predicted a best population abundance of 20,741 (CV 0.30) for the Canadian East Coast stock. The estimate was derived from Canadian TNASS in 2007 (Lawson and Gosselin 2009) and is considered the best available data because the survey covered more of the minke whale range than other surveys. Duke MGEL models for minke whales encompass more southern data than NOAA SAR but didn't include Canadian TNASS 2007 survey, which Duke MGEL acknowledged would improve the dataset.

- **Humpback whale.** Duke MGEL predicted a mean population of 921 based on a contemporaneous model (Roberts et al. 2015bb). The NOAA SAR 2014 (Waring et al. 2015b) predicted a minimum abundance of 823 (no CV) for the Gulf of Maine stock. Duke MGEL data was selected as most applicable source for predicting population impact because the analysis incorporated a broader area of effort and sighting data relevant to CGG’s proposed survey area.
- **Sei whale.** Duke MGEL predicted mean abundance based on seasonal distribution: 98 (CV 0.25) in the winter; 627 (CV 0.14) in the spring; 717 (CV 0.30) in the summer; and 37 (CV 0.19) in the fall (Roberts et al. 2015w). Climatological models were used to predict density and distribution for all seasons with the exception of spring which were fitted to contemporaneous models. The NOAA SAR 2015 (Waring et al. 2015b) predicted 357 (CV 0.52) as the best available abundance for the Nova Scotia stock. The estimate was generated from a shipboard and aerial survey conducted during June–August 2011 (Palka 2012) and is considered to be conservative due to insufficient survey coverage of the Nova Scotia stocks range. Duke MGEL’s highest seasonal abundance estimate was selected to determine population impact data because the analysis utilized data that is more relevant to our proposed survey area.
- **Beaked whales.** Duke MGEL selected a contemporaneous model as the best predictor of mean annual abundance: 14,491 (CV 0.17) (Roberts et al. 2015f). This estimate is similar to the NOAA SAR 2013 estimated abundance of 13,624 (includes *Ziphius* and *Mesoplodon spp.*) based on June-August 2011 Central Florida to lower Bay of Fundy sighting surveys (Waring et al. 2014). Duke MGEL’s predicted abundance was selected because the analysis accounts for species that are not seen at the water surface (e.g., diving). It should be noted that sighting surveys beyond the continental shelf break (i.e., AMAPPS surveys) are lacking and the actual population size may be underestimated.
- **Northern bottlenose whale.** Duke MGEL models predicted a northern bottlenose whale population estimate of 90 (CV 0.63) based on four sightings occurring north of 38^0 N (Roberts et al. 2015c). The models assumed the species is absent in the US East Coast EEZ along the continental shelf and south of the Gulf Stream. There is no NOAA SAR population estimate due to insufficient information (Waring et al. 2015). Following extensive research, we do not feel there is enough data to predict a population estimate for the US East Coast Mid- and South Atlantic region.
- **Sperm whale.** Duke MGEL selected a contemporaneous model as the best predictor of abundance: 5,747 (CV 0.12) (Roberts et al. 2015y). The report recommends off-shelf regions should be approached with caution as the estimates don't incorporate complex social dynamics that influence population shifts, particularly in summer. NOAA SAR 2014 reported a best abundance estimate of 2,288 (CV 0.28) based on combined sightings from surveys conducted from Florida to Maine in

2011 (Waring et al. 2015a). The reported abundance is likely underestimated because the surveys did not account for whales under the surface. Duke MGEL's abundance prediction was selected because it included more data in our proposed survey area than NOAA (reported sightings were primarily north of 35^0 N). It should be noted that both Duke MGEL and NOAA consider the population estimate unknown in deeper waters.

- **Atlantic spotted dolphin.** Duke MGEL estimated a mean annual abundance of 55,436 (CV 0.32) based on a climatological model (Roberts et al. 2015b). The NOAA SAR 2013 (Waring et al. 2015c) best available abundance estimate for the western North Atlantic stock is 44,715 (CV 0.43). The Duke MGEL abundance prediction was selected to maintain consistency with the data used in the take estimate analysis.
- **Atlantic white-sided dolphin.** Duke MGEL predicted a mean population of 37,180 (CV 0.07) based on a contemporaneous model (Roberts et al. 2015bb). NOAA SAR 2014 best available abundance estimate for the western North Atlantic stock was based on combined efforts of a 2011 shipboard and aerial sighting survey: 48,819 (CV 0.61) (Waring et al. 2015b). Duke MGEL's prediction model does not incorporate Canadian TNASS survey data (Lawson and Gosselin 2009) and is likely underestimated as the white-sided dolphin is predominate at latitudes north of 40^o N. Therefore, the NOAA SAR abundance estimate is considered the best available data.
- **Bottlenose dolphin.** Duke MGEL predicted a mean abundance of 97,476 (0.06) based on a climatological model (Roberts et al. 2015h). This model estimated an aggregate density of multiple stocks. The NOAA SAR 2014 (Waring et al. 2015a) best available abundance estimate is 77,532 (CV .40). The Duke MGEL abundance estimate is considered the best available data because the dataset includes more sightings than the NOAA SAR 2014 report in our proposed survey area.
- **Clymene dolphin**. Duke MGEL selected a stratified model to predict a mean annual abundance of 12,524 (CV 0.56) based on only 11 sightings (Roberts et al. 2015a). NOAA SAR 2013 concluded that present data were insufficient to calculate a minimum population estimate for the western North Atlantic stock. Based on extensive research, we do not feel there is sufficient available data to predict a population impact for Clymene dolphins in the US East Coast Atlantic.
- **False killer whale.** Duke MGEL predicted a mean annual abundance of 94 (CV 0.84) based on two sightings in the US and Canadian 200 nm EEZ territory (Roberts et al. 2015k). A stratified model for the entire study area was generated because there was not enough data to model abundance from environmental predictors. The NOAA SAR 2014 was the first report generated for the western North Atlantic stock of false killer whales. The report predicted an abundance estimate of 442 (CV 1.06) from summer 2011 surveys covering waters from central Florida to the lower Bay of Fundy (Waring et al. 2015a). Duke MGEL's did not utilize other available data such as The Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) database, a 1995 NOAA shipboard abundance survey, or AMAPPS. This data would certainly have improved the degree of uncertainty in the analysis. NOAA's abundance estimate was selected to predict population impact because it incorporated more sightings and is considered precautionary.
- **Fraser's dolphin**. Duke MGEL predicted a mean annual abundance of 492 (CV 0.76) based on two sightings between 35^0 N and 37^0 N (Roberts et al. 2015l). A stratified model was fitted to off-shelf waters (water depth > 125 m (410 ft)) because not enough data was available to produce habitat-based density models using environmental predictors. There is currently no species

abundance estimate for the western North Atlantic stock of Fraser's dolphins due to insufficient data (Waring et al. 2007). After a thorough analysis of available research, we feel there is not enough available abundance data to predict a realistic population impact.

- **Killer whale.** Duke MGEL predicted a mean abundance of 11 (CV 0.82) based on four sightings north of 40^0 N (Roberts et al. 2015d). NOAA SAR 2014 concluded there is not enough available data to estimate abundance for the western North Atlantic stock (Waring et al. 2015a). Lawson and Stevens (2014) used photographic identification to predict a minimum population estimate of 67 killer whales from 40^0 N to 60^0 N and 40^0 W to 75^0 W. This number is considered an underestimate of the true population (Roberts et al. 2015d). Based on extensive research, we feel there is too much uncertainty to predict a realistic population impact for killer whales in the US East Coast Atlantic.
- ***Kogia spp.*** Duke MGEL selected a stratified density model to predict a mean off-shelf annual abundance of 678 (CV 0.23) (Roberts et al. 2015o) for dwarf sperm whale (*Kogia sima*) and the pygmy sperm whale (*Kogia breviceps*). There was not enough data to apply the environmental predictors needed to generate habitat-based density models. NOAA SAR 2013 used summer 2011 sighting surveys covering waters from central Florida to the lower Bay of Fundy to determine the best abundance estimates for *Kogia spp.*: 3,785 (CV 0.47) (Waring et al. 2014). NOAA's abundance estimate was selected because Duke MGEL appears to underestimate present-day Kogia abundance and does not provide any information on the spatial distribution of Kogia beyond NOAA's dataset.
- **Melon-headed whale.** Duke MGEL models predicted a mean annual abundance of 1,175 (CV 0.50) based on only four sightings of melon-headed whales (Roberts et al. 2015p). NOAA SAR concluded there is not enough available data to establish a population abundance estimate in the US East Coast Atlantic (Waring et al. 2014). Based on extensive research, we do not feel there is sufficient available data to predict population impact of melon-headed whales.
- **Pantropical spotted dolphin.** Duke MGEL applied a stratified model to estimate an abundance of 4,436 (CV 0.33) (Roberts et al. 2015s). A habitat-based density model was not possible because the analysis was based on only 17 sightings. NOAA SAR 2007 determined the best estimate of abundance for the western North Atlantic stock is 4,439 (CV 0.49) (Waring et al. 2007). Duke MGEL was selected as the best available data.
- **Pilot whales**. Duke MGEL fit a climatological model to 909 pilot whale sightings to predict a mean annual abundance of 18, 977 (CV 0.11) (Roberts et al. 2015t). NOAA SAR 2015 reported a best abundance estimate 5,635 (CV 0.63) for long-pilot whales and 21,515 (CV 0.37) for short-finned pilot whales (Waring et al. 2015b). Long-finned pilot whales are underestimated because the latest survey data does not incorporate the Scotian Shelf where the highest densities have been observed. NOAA's abundance estimate was selected because Duke MGEL did not incorporate Canadian TNASS data or AMAPPS 2010-2014 data.
- **Risso's dolphin.** Duke MGEL predicted mean Risso's abundance to be 7,732 (CV 0.9) based on a climatological model (Roberts et al. 2015u). NOAA SAR 2014 summed the NEFSC and SEFSC 2011 aerial and sighting surveys to determine a best abundance estimate of 18,250 (CV 0.46) (Waring et al. 2015a). We selected Duke MGEL as the best indicator of abundance because it shows seasonal shifts in population. It should be noted that the winter abundance and distribution in the US Atlantic EEZ may be underestimated due to a lack of winter off-shelf sighting survey effort (Roberts et al. 2015u).

- **Rough-toothed dolphin.** Duke MGEL selected a stratified density model to predict a mean annual abundance of 532 (CV 0.36) (Roberts et al. 2015v). There was insufficient data to apply the environmental covariates needed to generate habitat-based models. NOAA SAR 2013 reported an estimated abundance of 271 (1.00) for the western North Atlantic (Waring et al. 2014). The estimate is based on a 2011 shipboard survey covering waters from central Florida to the lower Bay of Fundy. Duke MGEL's abundance estimate was selected because all 11 sightings used in the analysis are located in the proposed survey area.
- **Short-beaked common dolphin.** Duke MGEL selected a contemporaneous model to predict a mean abundance of 86,098 (CV 0.12) (Roberts et al. 2015x). The prediction models included year-round density and distribution in the US and Canadian Atlantic EEZ due to the large amount of available data utilized in the analysis. NOAA SAR 2015 utilized TNAAS surveys to estimate and abundance of 173,486 (0.55) for the western North Atlantic stock (Waring et al. 2015b). Duke's prediction was selected to predict population impact because the model incorporates a larger area of effort than the SAR and contains more sightings relevant to our survey area.
- **Spinner dolphin.** Duke MGEL predicted an off-shelf abundance of 262 (CV 0.93) based on two sightings between 36^{0} N and 40^{0} N (Roberts et al. 2015z). Due to the rarity of sightings a habitat-based density model was not possible and a stratified model was used to show species abundance and distribution. NOAA SAR 2014 concluded there is not enough available data to establish a population abundance estimate in the US East Coast Atlantic (Waring et al. 2015a). Following a thorough assessment of available research, we do not feel confident that enough data exists to predict spinner dolphin abundance capable of estimating a realistic population impact.
- **Striped dolphin.** Duke MGEL selected the contemporaneous model as the best predictor of mean annual abundance: 75,657 (CV 0.21) (Roberts et al. 2015aa). NOAA SAR 2013 reported the best abundance estimate for the western North Atlantic stock of striped dolphins based on the sum of the 2011 NEFSC and SEFSC survey estimates: 54,807 (CV 0.3) (Waring et al. 2014). Duke MGEL abundance estimate was used to predict population impact because the analysis covers a broader range that is more relevant to our proposed survey area.
- **White-beaked dolphin.** Duke MGEL applied a stratified model to predict a mean abundance of 39 (CV 0.42) based on 12 sightings occurring north of 41^{0} N (Roberts et al. 2015bb). The density and abundance estimate averaged all data available in the northeast U.S. during the 1995-2013 periods, and included effort extending south to Cape Hatteras based on a historical sighting. NOAA SAR 2007 predicted the best population estimate of 2,003 (CV 0.94) based on a single survey that occurred northward of South Gulf of Maine (Waring et al. 2007). The estimate is considered precautionary as it accounts for potential abundance that could occur in particular years. Duke's MGEL was selected as the best available and most relevant to our survey because it covers a broader range of sighting data to predict long-term average density and abundance.
- **Harbor porpoise.** Duke MGEL used seasonal models based on Palka et al. (1996) and on observed sighting patterns to predict a mean abundance of 17,651 (CV 0.17) in winter and 45,089 (CV 0.12) in the summer (Roberts et al. 2015m). All sightings occurred north the proposed survey area. The NOAA SAR 2014 reported a best abundance estimate of 79,883 (CV=0.32) for the Gulf of Maine/Bay of Fundy stock based on a 2011 line-transect survey (Waring et al. 2015a). The NOAA SAR estimate was selected as a precautionary measure because Duke MGEL warns of possible underestimated abundance due to uncertainty in known species distribution (Roberts et al. 2015m).

6.5 Interpretation of Results

This section addresses the individual exposure estimates, as well as uncertainties and assumptions that resulted in overly conservative estimates. Section 4 provides detailed distribution and general information based on a substantial literature review for each species throughout the year.

The marine mammal exposure analysis estimated that 47,474individual marine mammals could be exposed to 160 dB rms sound levels within the seismic acoustic source acoustic field during the six month survey. The total estimate encompasses 32 species including 18 species of dolphin, 13 species of whale, and one porpoise species. The white-beaked dolphin is included in the table but is considered extralimital in the survey area (Waring et al. 2007; CETAP 1982) and will not be discussed further. It should be noted that seals are neither included in Table 4 nor described in Section 4 because (1) the exposure estimate analysis did not generate any exposure estimates for seals during the proposed seismic survey and (2) they are not likely to be seen as far offshore as the proposed seismic survey.

Based on a thorough analysis and extensive literature review, CGG is requesting NMFS authorization for take by Level B harassment of 46,951 incidents of exposure. Only four species have a requested take authorization number that differs from the species estimated exposure number. Based on the known data, the estimated exposures for these four species are believed to be either overestimated or underestimated.

- **Killer whale.** The analysis predicted that two killer whale incidents of exposure to received sounds levels that constitute Level B harassmentcould occur during the proposed six month survey. Roberts et al. (2015a) applied a uniform density across the study area based on four sightings (all north of 40^{0} N) from 23 years of line-transect survey data. Only one sighting was recently recorded off the coast of North Carolina during a spring 2014 AMAPPS survey. Despite the lack of sightings that have occurred in CGG’s proposed survey area, we determined it reasonable to take the over-precautionary approach to use the largest of the average group size (based on 836 sighting events over 250 years) as predicted by Lawson & Stevens (2014) and request six killer whale take authorizations. The request is consistent with pertinent literature (Roberts et al. 2015d; AMAPPS 2014; NOAA OPR 2015g; CETAP 1982).
- **North Atlantic right whale.** The exposure analysis predicted only one individual NARW would be within the ensonified range of our seismic acoustic source during the proposed six month survey. We felt it more appropriate to request two takes based on the average NARW group size in the area (LaBrecque 2015; NOAA SAR 2015).
- **Melon-headed whale.** The analysis results predicted an average of 620 incidents of melon-headed whale exposures to received sound levels that constitute Level B harassment could occur. However, the database Roberts et al. (2015p) used to produce a predicted habitat-based density model for melon-headed whales only contained four sightings. Sightings of Risso’s dolphins, striped dolphins, and bottlenose dolphins were used as proxy species to generate the number of sightings necessary to conduct a statistical analysis of distribution (Buckland et al. 2001). Despite numerous sighting surveys spanning over two decades, there are only five recorded melon-headed whale sightings in the North Atlantic (Waring et al. 2014; DoN 2013; Halpin et al. 2009; CETAP 1984). The lack of sightings is probably due to the small number of groups in the US East Coast Atlantic (Waring et al. 2007). Based on historical records, melon-headed whales are expected to be encountered rarely

in the survey area. We conclude that requesting the average group size of 100, based on the available evidence referenced in this paragraph, is a more realistic prediction of the number of exposed individuals.

- **Northern bottlenose whale.** The exposure analysis estimated that eight northern bottlenose whales could potentially be exposed to disturbing sound levels produced by the seismic acoustic source during the proposed survey. However, no sightings have ever been recorded in or near the proposed seismic survey area. The prediction model used four sightings that occurred north of 39^0 N and extrapolated a uniform density value across the entire study area. Based on historical sightings (AMAPPS 2014; Wimmer & Whitehead 2004; CETAP 1981) the northern bottlenose whale is expected to occur only north of the survey area. Hence, we did not request any Level B harassment takes authorizations. This species is described in detail in Section 4.

6.6 Animals present outside of the US EEZ

Following the interpolation analysis, only nine species are predicted to be absent from the 28,922 km^2 of ensonified survey area which extends beyond the 200 nm EEZ. These species are the NARW, blue whale, Bryde's whale, fin whale, humpback whale, Atlantic white-sided dolphin, killer whale, harbor porpoise, and the short-beaked common dolphin. It is also likely that other species included in this analysis do not inhabit waters at these depths. However, the numbers are included as a precautionary measure. The most prevalent species abundance beyond the US EEZ territory is the Clymene dolphin at 735 individuals (11% of the total Clymene exposures). The *Mesoplodon spp. and Ziphius* beaked whales are predicted to have the highest abundance for whales at 283 predicted individual exposures (7% of the total beaked whale exposures). These examples are consistent with research that suggests these species prefer deep waters.

6.6.1 Analysis limitations and uncertainties

The predicted exposure estimate results in Table 6 are based on the best available information at the time of this analysis. However, the predicted exposure estimates are considered to be conservative based on the following analysis limitations and uncertainties:

- **Species that move away from approaching vessels.** The estimated marine mammal exposure numbers assume that the individual animals do not move away from the area as the seismic research vessel approaches. This assumption is not practical as several species are known to shy away from vessels (Palka & Hammond 2011; Berini 2009; Würsig et al. 1998).
- **Mitigation measures were not factored into the analysis.** The seismic acoustic source soft start was not factored into the analysis. The soft start is designed to alert marine life in the area of the pending operation by gradually increasing the pressure output of the seismic acoustic source over a period of at least 20 minutes. This standard operating procedure enables animals to move away from the approaching vessel, thereby reducing the likelihood of exposure to disturbing sound levels. In addition, the shut down and power down of the seismic acoustic source actioned by diligent PSO and PAM monitoring will also reduce the potential for exposure to sounds that could potentially constitute a take by Level A harassment.
- **Statistical assumptions based on limited data**. Roberts et al. (2015a) applied a uniform density value across the entire Northwest Atlantic to predict abundance for infrequently sighted species. We acknowledge that Duke MGEL performed an extensive literature review and statistical analysis

to generate the best possible results. However, applying uniform density values across an area as large as the US and Canada EEZ is likely going to result in overestimated density predictions for rarely sighted species. The Roberts et al. (2015) models should incorporate the significant amount of species data acquired during the 2010 to 2014 AMAPPS sighting surveys to reduce habitat uncertainty.

The exposure estimates, despite being based on best available knowledge, should be compared with the actual species that are encountered in the 6,175 m (22,149 ft) ensonification radius surrounding the seismic acoustic source during CGG's proposed seismic survey.

6.6.2 Dolphins

The Delphinidae family accounts for 89% of all requested takes by Level B harassment. In total, 42,127individuals that comprise 18 dolphin species are predicted to be within range of the seismic acoustic source for which received sound levels are 160 dB rms. Dolphin population abundance is distributed throughout the proposed survey area but most heavily concentrated along the continental shelf slope and break of South Carolina and Virginia. Seasonal abundance is highest mid-winter through early summer and lowest late autumn to early winter. There are no ESA-listed species in the Delphinidae family that occur along the US East Coast Atlantic.

The common bottlenose dolphin is anticipated to have the highest densities within the 265,406 km^2 ensonified area of the survey and accounts for 20% of all estimated exposures. In our proposed survey area, common dolphins are predominant along the continental shelf edge and slope throughout the year.

6.6.3 Whales

Take authorizations by Level B harassment were requested for 13 species of whales. Six of the 13 whales are ESA-listed species: blue whale, fin whale, humpback whale, North Atlantic right whale, sei whale, and sperm whale. ESA-listed species comprise three percent of all requested Level B harassment takes for whales.

Beaked whales are predicted to have the highest number of exposed individuals at 3,722 and account for eight percent of all whale take requests. Roberts et al. (2015a) group all sub-species (Gervais', Sowerby's, Cuvier's, Blainville's, True's) of beaked whale in one prediction model due to the difficulty in distinguishing between species at sea. This could explain such a high number. Beaked whales are known to occur off the continental shelf and in deep water year-round (Waring et al. 2015b).

Although whale migration patterns are largely unknown, abundance is anticipated to be most prevalent in the survey area along the continental shelf and edge from fall through early summer.

6.6.4 Porpoise

The harbor porpoise is the only member of the Phocoena family that occurs in the US East Coast Atlantic waters. The exposure analysis estimates a total of 32 individuals, or less than one percent of the population, could occur in the 6,751 m (22,149 ft) ensonification radius of the active seismic acoustic source during

CGG's seismic survey. Porpoises are most likely to be present in the proposed survey area along the continental shelf and shelf edge during the winter and spring months.

7.0 ANTICIPATED IMPACT OF THE ACTIVITY

Any sound source that overlaps the same auditory bandwidth of an animal has the potential to elicit behavioral or, less frequently, physiological response. The type of response varies among individuals and the specific activity that an animal is engaged in at the time (Simmonds et al. 2003; NRC 2005; Southall et al. 2007; Ellison et al. 2011). Potential effects of anthropogenic noise on marine mammals could range from subtle responses (i.e., changes in swim speed) to more significant responses (i.e., shifts in migration paths, hearing threshold shifts, stress) which are unique to a marine mammal's biological function (Weilgart 2007; BOEM PEIS 2014, A-95).

The sound generated by the active seismic acoustic source has the potential to result in some behavioral changes of a small number of marine mammals or stocks. There will be continuous monitoring to detect and observe marine mammals near the mitigation zone. The seismic acoustic source will either be shut down, reduced in power, or delayed from activation, as appropriate, if there is indication that a marine mammal could experience detrimental effects resulting from the received sound level. Any behavioral disturbances are expected to be localized and short-term. It is unlikely that the proposed seismic program would result in any events of significant non-auditory effects or hearing impairment. There is no documented scientific evidence to date which indicates that the energy released from a seismic acoustic source has had lethal implications for marine mammals.

7.1 Physiological Responses

7.1.1 Non-auditory effects

Research suggests that under specific conditions a marine mammal exposed to peak pressure levels of pulsed sound could experience stress responses, neurological effects, bubble formation, and organ or tissue damage (Miksis et al. 2001; Goertner 1982; Young 1991). An electrophysiology study carried out on a captive beluga whale and a bottlenose dolphin recorded an increase in cortisol and other stress hormones in the blood when exposed to an impulsive seismic acoustic source (Romano et al. 2004). The study concludes that elevated stress hormone levels returned to baseline levels within 24 hours, concluding that the effects were short-term. Aside from stress reactions, some researchers theorize that a marine mammal reacting to an active seismic acoustic source by rapidly diving or surfacing could experience physiological consequences. Ridgway and Howard (1979) suggest that variations in marine mammal diving behavior or avoidance responses to noise could result in supersaturation of nitrogen in tissues and blood vessels and lead to deleterious bubble formation. There is no conclusive evidence that exposure to the seismic acoustic source has resulted in the accumulation of nitrogen bubbles in tissues. Limitations in carrying out direct empirical studies mean that most data related to physiological impacts from the seismic acoustic source is speculative or based on post-mortem investigation. There is no documented scientific evidence to date which indicates the energy released from a seismic acoustic source has had physiological or injurious implications on marine mammals. It is unlikely that a cetacean will experience any physiological effects during the proposed seismic survey because (1) exposure to the proposed activity will be brief in any given area; (2) the sound intensity decays rapidly as it propagates from the seismic acoustic source; and (3) a comprehensive mitigation and monitoring plan will be in place throughout the proposed seismic survey.

7.1.2 Auditory Effects

Because of the complexity of carrying out in vivo research, fewer than 25% of the known marine mammal species have undergone behavioral and/or physiological assessments to measure hearing capabilities (BOEM PEIS 2014, A-44). Thus, hearing frequency ranges have been determined through a combined research effort of vocalizations, anatomy, behavioral responses, and nominal ambient noise. Southall et al. (2007) categorize marine mammals into five functional hearing groups as is listed below in Table 5. The table includes the 32 species discussed in Section 4.

Functional hearing group	Estimated auditory bandwidth	Species likely to occur in the proposed survey area
Low-frequency cetacean	7 Hz to 22 kHz	blue whale; Bryde’s whale; fin whale; humpback whale; North Atlantic right whale; minke whale; sei whale
Mid-frequency cetacean	150 Hz to 160 kHz	Atlantic spotted dolphin; Atlantic white-sided dolphin; beaked whales; bottlenose dolphin; Clymene dolphin; false killer whale; Fraser’s dolphin; killer whale; long-finned pilot whale; melon-headed whale; pantropical spotted dolphin; pygmy killer whale; Risso’s dolphin; rough-toothed dolphin; short-finned pilot whale; short-beaked common dolphin; spinner dolphin; sperm whale; striped dolphin
High- frequency cetacean	200 Hz to 180 kHz	harbor porpoise; dwarf sperm whale; pygmy sperm whale

Table 8 Functional hearing groups and estimated functional hearing ranges of species known to occur in the proposed survey area. Southall et al. (2007) designated marine mammal “functional hearing groups” and estimated the associated lower and upper frequencies.

7.1.2.1 Hearing threshold shifts

Studies conducted by Southall et al. (2007) and Finneran et al. (2005) suggest that under certain conditions marine mammals exposed to specific sound levels could experience temporary or permanent shifts in hearing thresholds. The type and magnitude of hearing threshold shifts are based on the duration, frequency, and intensity of a sound (Ketten 2012; Popov et al. 2013). Permanent Threshold Shift (PTS) is believed to occur after sustained or frequent exposure to a sound which results in irreversible hearing impairment. PTS can also result from exposure to a rapid onset of extreme peak sound pressure levels. There is no available data to date which quantifies the sound levels required to cause permanent damage. Temporary Threshold Shift (TTS) is a non-permanent elevation of the hearing threshold as a result of noise exposure and can last from minutes to days (Richardson et al. 1995). Although TTS is not considered an injury, it could impair a marine mammal’s ability to hear cues about the environment while recovering.

There are currently no criteria (i.e., recovery time, severity of TTS) that define the point at which temporary hearing shifts would be considered as detrimental to a marine mammal's biological functions.

The NMFS recognizes the High Energy Seismic Survey team (HESS 1999) research as the regulatory criteria at which a cetacean could experience physical injury (PTS) if exposed to an impulsive seismic acoustic source (NMFS 2000). HESS concludes that a cetacean exposed to sound levels which meet or exceed 180 dB re 1 μPa rms could potentially incur "serious behavioral, physiological, and hearing effects." NMFS considers exposure to impulsive noise which meets or exceeds 160 dB re 1 μPa rms as the threshold criteria for behavioral harassment.

There is no definitive evidence that the sound produced by a seismic acoustic source under realistic field operating conditions has resulted in auditory damage of non-captive cetaceans. Based on the mitigation and monitoring plan for the proposed survey, it is unlikely that a cetacean will remain close enough to the seismic acoustic source to be exposed to sound levels resulting in temporary or permanent hearing shifts. The plan includes a seismic acoustic source soft start, mitigation zone, seismic survey buffer zone, and continuous visual and acoustic monitoring by trained independent third party contractors.

7.2 Behavioral Responses

Behavioral reactions to sound exposure are less predictable and depend on many factors including species, sex, age, reproductive state, and activity at the time of exposure (Ellison et al. 2011; Southall et. al 2007; Weilgart 2007). A cetacean's reaction to sound could have subtle effects, such as changes in diving frequency and breathing, but does not necessarily constitute a deleterious impact. According to NMFS (2001, p.9293), short-term subtle behavioral responses that are within the animal's normal hearing range do not have any biological significance and are not considered to require a small take authorization. A biologically significant response means, "in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations," as defined by the National Resource Council (NRC 2005). Exposure to noise can also have more conspicuous effects which interfere with a cetacean's normal biological functions. A conspicuous effect would be a cetacean's displacement from or avoidance of an area as a result of noise disturbance during feeding or migration activities. Avoidance reactions are considered to be the most obvious indication of disturbance (Richardson 1995a).

7.3 Masking

Marine mammals rely on acoustic signals for vital biological functions including communication, feeding, reproduction, navigation, and receiving environmental information (Weilgart 2007; Dolman et al. 2009). The manner in which marine mammals utilize acoustics for specific behaviors varies according to species. Masking occurs when sounds in the environment are of a similar frequency and amplitude which equal or exceed the auditory signal an animal is trying to receive. Ambient noise from natural and anthropogenic sources can interfere with signal detections. The extent of interference is based on the spectral, temporal, and spatial overlap between the masking noise and the sender and receiver (Reichmuth 2012, p. 26). Masking could affect auditory threshold shifts, communication call frequency and length, navigation, and predator/prey detection ability (Parks et al. 2011; Southall et al. 2000).

The sound produced by an active seismic acoustic source has the potential to overlap with some baleen whale hearing thresholds. It should be noted that the number of individuals of baleen whale species that could be exposed to received levels of seismic impulse sounds levels ≥160 dB rms comprised less than one percent of the total predicted marine mammal exposures (see Section 6). Richardson et al. (2005b) and Madsen et al. (2006) conclude that masking can occur at great distances due to the multi-directional spreading and reverberation of a seismic pulse but at significantly reduced signal intensity. Therefore, the seismic acoustic source impulse will likely reduce a species' ability to detect calls and other ambient noises for a brief time while the acoustic energy travels through different mediums. Some cetaceans are known to modify their vocalization rate or pitch, and/or shift their peak thresholds in response to acoustic sounds (Blackwell et al. 2013; Cerchio et al. 2014; Castellote et al. 2012). Any masking effects caused by the active seismic acoustic source on marine mammal biological functions are expected to be minor because of the transient nature of the proposed survey. Masking will also be intermittent as the seismic acoustic source impulse occurs every 25 m (65.61 ft) and lasts for a period of one second.

8.0 ANTICIPATED IMPACTS ON SUBSISTENCE

Not applicable. The proposed activity will take place off of the U.S coastline in the Mid- and South-Atlantic between 30° and 40° N. No activity will take place in or near a traditional Arctic subsistence hunting area. Therefore, there are no relevant subsistence uses for marine mammals implicated by this action.

9.0 ANTICIPATED IMPACT ON HABITAT

CGG's proposed seismic survey is not expected to have a permanent impact on habitats used by marine mammals in the survey area. The active seismic acoustic source will likely cause temporary displacement of a small number of fish and invertebrates. Some non-lethal or mortal impacts on individual fish which are located in direct proximity to the active seismic acoustic source could also occur. There is no evidence to date that indicates a significant impact on fish or invertebrate populations as a result of seismic survey activity. The seismic research vessel will travel continuously along survey lines which are spaced 20 km (12 mi) apart and take up to 90 hours to complete. Thus, the vessel will have a minimal presence in any one location, briefly elevating noise levels. The western boundary of the survey area will be 84 km (50 mi) to 129 km (80 mi) from the coastline and outside of any ESA-defined critical habitat areas.

10.0 ANTICIPATED EFFECTS OF HABITAT IMPACTS ON MARINE MAMMALS

The proposed seismic survey is not expected to have any permanent habitat-related effects which would be deleterious for marine mammal individuals and populations. Major migration corridors, feeding, and breeding areas on the U.S East Coast Atlantic have been identified along coastal to continental shelf areas (LaBrecque et al. 2015). A small percentage of the survey area along the western boundary overlaps with migration corridors. The primary effect of the proposed activity on the habitat will be temporarily elevated noise levels. As stated in Section 10, the seismic research vessel will be continuously moving and have a minimal presence in any one location. Seismic surveys conducted simultaneously will maintain a separation distance of at least 17.5 km (10.8 mi) and are not expected to result in excessive background noise above ambient levels. There is no evidence to date indicating a long-term displacement, mortality, or significant population impact to marine mammals as a result of seismic acoustic source activities.

11.0 MITIGATION MEASURES

The mitigation measures for CGG's proposed Atlantic 2D Seismic Program are designed to have an impact as low as reasonably possible on affected marine mammal species and stocks. Only the acoustic impacts associated with the specified activities, as described in Section 1, are considered in the mitigation plan. With effective mitigations in place, acoustic impacts on marine mammal species and their habitat is expected to be negligible and short-term.

11.1 Vessel Strike Avoidance

Deep diving species (e.g., sperm whales, beaked whales) require extended periods of time at the water surface to replenish oxygen levels and are therefore the most vulnerable to vessel strikes. A study concludes that North Atlantic right whales (NARW) are, at times, unresponsive to vessel sound which increases the likelihood of vessel collisions (Nowacek et al. 2004). The support vessel and escort vessel will adhere to the Joint BOEM-BSEE Notice to Lessees (NTL) 2012-G01 ("Vessel Strike Avoidance and Inured/Dead Protected Species Reporting") and NMFS Compliance Guide for the Right Whale Ship Strike Reduction Rule (50 CFR § 224.105) (see Figure 4) at all times during the survey. The seismic research vessel will adhere to the same measures while transiting to and from the survey area. These guidelines include collision avoidance measures, reporting for mariners, and speed restrictions in Seasonal Management Areas (SMA) and voluntary Dynamic Management Areas (DMA). While transiting through an SMA or DMA, all vessels will limit their speed to ten knots during restriction periods or avoid the areas altogether.

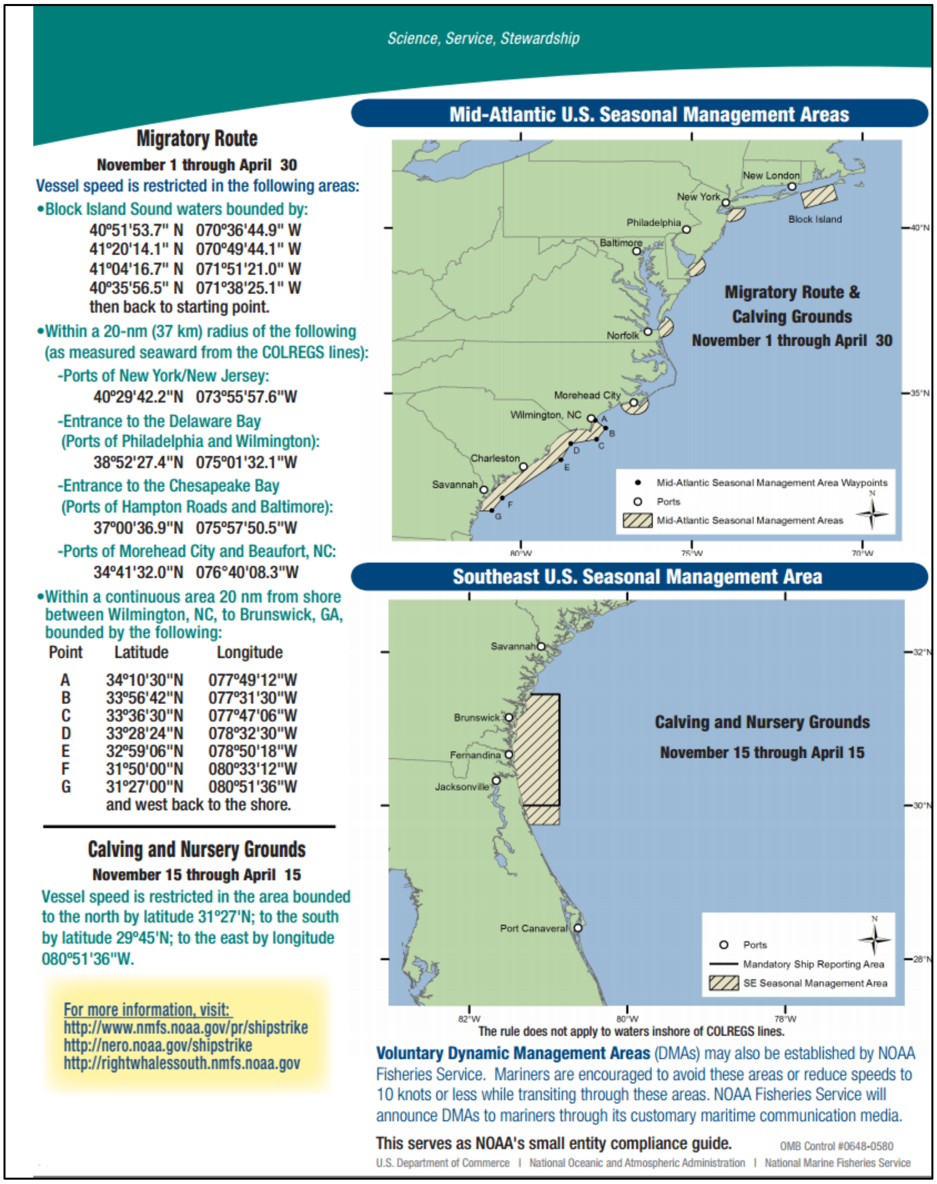


Figure 8 Speed restrictions and seasonal management areas for North Atlantic right whales. Guidance for vessel operator compliance with the Right Whale Strike Reduction Rule (USDOC NOAA 2014).

During the seismic operation, the seismic research vessel will adhere to a practical yet effective modification of the Vessel Strike Avoidance measures mentioned above which allow for safe seismic operations. The seismic research vessel will be towing a substantial amount of highly specialized equipment and must maintain a minimum speed of three knots to sustain the tension of the equipment necessary to avoid a collapse that would pose safety risks to personnel and result in possible equipment loss, significant financial loss, and prolonged duration of the survey. Therefore, during the operation, the seismic research vessel will slow to no less than three knots and divert to avoid a strike incident of any ESA species sighted within 100 m (328 ft) from the vessels path, as safely and reasonably as possible.

11.2 Buffer zone

A 17.5 km (10.8 mile) buffer zone between simultaneously operating seismic surveys will be in place to provide a movement corridor for marine mammals where seismic acoustic source noise is well below the Level B harassment threshold. A buffer zone establishes the minimum separation distance between other operating seismic research vessels. A 17.5 km (10.8 mi) buffer zone is the standard distance recognized by seismic operators to avoid incidental overlapping of very low frequency transmissions from separate surveys. The permit conditions set by the BOEM will list the contact information for operators who will be conducting a seismic operation in the general area at the same time. CGG will coordinate with other operators to avoid seismic acoustic source activity within the 17.5 km (10.8 mi) buffer zone as is reasonably practicable and safe.

There is currently no scientific evidence which indicates any potential aggregate effects from simultaneous seismic survey operations. The seismic acoustic source is engineered to direct its energy downward rather than laterally, which the NMFS has acknowledged as a mitigation measure (New Jersey v. NSF 2014). Research conducted by Richardson et al. (1995b) suggests that marine mammal disturbance is unlikely due to the rapid decay of the horizontal sound energy generated by the seismic acoustic source.

11.3 Seismic acoustic source operations

A 907 m (2,975 ft) mitigation zone was established by estimating the distance from the proposed 5,400 in^3 seismic acoustic source at which sound pressure levels exceed 180 dB re 1 μPa-m rms. Section 1.4.1.2 explains the methodology in detail. Specifically, the defined mitigation zone is the radius surrounding the center of the seismic acoustic source array at which Level A harassment could occur. As mentioned previously, the current NMFS injury criteria policy states that marine mammals should not be exposed to a broadband-received sound pressure level of 180 dB rms (Level A harassment).

Independent Protected Species Observers (PSO) and Passive Acoustic Monitoring (PAM) operators will be contracted to monitor the mitigation zone and surrounding areas during the 24/7 seismic operation. PSO will carry out continuous visual monitoring for daytime operations. Operations conducted during night or poor visibility (when the full mitigation zone cannot be visually observed) will be monitored continuously by a PAM operator. Section 14.1 details the roles and responsibilities of PSO and PAM operators.

11.3.1 Pre-watch search

Prior to activating the seismic acoustic source, the mitigation zone and adjacent area will be visually or acoustically monitored by PSO and PAM Operators for 30 minutes. The soft start may be initiated if no marine mammal is detected or observed within the mitigation zone during the pre-watch search. If a marine mammal is detected within the mitigation zone during the pre-watch search, the soft start procedure will be delayed for 30 minutes from the time of the last sighting or detection in the mitigation zone.

11.3.2 Soft start procedure

The purpose of the soft start is to alert marine life of the pending seismic operation in the area and allow sufficient time for those animals to move away and avoid the highest source levels. The soft start consists of activating the 70 in^3 seismic acoustic source element (the smallest element in terms of energy output and volume) and doubling the number of active elements over equal increments of time as is possible until all acoustic elements are operational (i.e., full power). The seismic acoustic source control software is programmed to carry out a soft start over a period of 20 to 40 minutes based on the source-specific parameters. Richardson et al. (1997) predicts that soft starts could reduce the likelihood of acoustic impact as marine mammals find the sound aversive and will move away before hearing damage or physiological effects occur. A soft start procedure will be carried out prior to starting a new line or testing the seismic acoustic source.

11.3.3 Shut down and power down

When active, the seismic acoustic source has the potential to result in physiological or behavioral responses of a marine mammal in close proximity. Shut down and power down procedures for marine mammals entering the 907 m (2,975 ft) mitigation zone will be in place during the proposed seismic survey.A shut down is the action of stopping seismic survey acquisition by immediately turning off power to the active seismic acoustic source. A power down is the action of reducing the energy output of the seismic acoustic source to the smallest acoustic element (see section 1.3.2). For our proposed survey, a power down will be achieved by immediately silencing all seismic acoustic elements with the exception of the 70 in^3 element. Nucleus+ modeling (see section 1.3.2.1) determined the peak-to-peak pressure signature, or total energy output, of the 70 in^3 element to be 216 dB rms re 1 μPa-m (0.89 bar-m) at 1 m (3.2 ft) below the seismic acoustic source. Based on this energy output, the estimated distance from the seismic acoustic source at which received sound levels are ≥180 dB re 1μ Pa rms is 50 m (164 ft).

PSO and PAM operators will conduct continuous monitoring and make judgement calls on mitigation action when necessary. Based on the measures above, it is unlikely that takes by Level A harassment will occur.

11.3.3.1 Whales

If at any time a whale is visually or acoustically detected entering the mitigation zone the observer or operator on duty will call for the immediate shut down of the seismic acoustic source. When the operator on duty confirms that no marine mammal has been detected within the mitigation zone for at least a 30-minute period, a soft start can commence and the seismic operation can continue.

11.3.3.2 Dolphins

No mitigation action will be required if a dolphin is visually observed to be "voluntarily approaching" the seismic research vessel or towed seismic equipment. A voluntary approach is defined as a clear and purposeful approach toward the vessel by a dolphin at a speed and vector that indicates the dolphin intends to approach the vessel (BOEM PEIS, C-21). NMFS (2001, p.9293) states that an exposure to a specific activity that does not disrupt an animal's normal behavioral pattern should not require a take authorization. Therefore, a dolphin voluntarily approaching the seismic research vessel during acquisition would not be considered to display an adverse behavioral reaction that is significant enough to constitute a disturbance. A power down will be observed when a dolphin is:

- visually detected entering the mitigation zone and the PSO determines the dolphin does not intend to approach the vessel

- acoustically detected entering the mitigation zone and a visual observation to determine the dolphin's intent is not possible

The seismic acoustic source impulse interval, or energy release, will remain at 25 m (65.61 ft) to maintain consistency with the normal operating mode. If a dolphin comes within 50 m (164 ft) of the seismic acoustic source where received sound levels are estimated to be ≥180 dB then a shut down will commence immediately. The 70 in^3 acoustic element will be activated again when the animal is confirmed to have moved at least 50 m (164 ft) away from the source. Full power will resume when the PSO and/or PAM operator can confirm the dolphins have left the 907 m (2,975 ft) mitigation zone or are engaged in bow riding or wake riding.

11.3.4 Testing of the seismic acoustic source

Testing of the seismic acoustic source array may be required as a quality control measure to ensure that all seismic acoustic source elements are functioning properly. All seismic acoustic source testing should be preceded by a 30 minute visual or acoustic pre-watch period. The protocol for different testing is as follows:

- **Single acoustic element test.** A soft start will not be observed when only one acoustic element on the seismic acoustic source is being tested. If the test is carried out just prior to start of line, a soft start will commence when the test is completed.
- **Multiple or full source array testing.** A soft start procedure will be carried out until the desired element volumes to be tested are reached, beginning with the lowest volume element. If the test is carried out just prior to the start of line, the gradual activation of seismic acoustic source elements should continue until the full source array is active. The latter should suffice as a soft start and hence should be carried over a period of 20 to 40 minutes.

If a marine mammal is acoustically or visually detected in the mitigation zone during the pre-watch monitoring period, the test will be delayed until the mitigation zone is confirmed clear of marine mammals for 30 minutes.

11.3.5 Line changes

The seismic acoustic source will be silenced following the end of a line. PSO or PAM operators will maintain watch during this time.

11.3.6 Silent periods

Any silent period of the seismic acoustic source for reasons including but not limited to mechanical or electronic failure resulting in the cessation of the source for a period greater than 20 minutes will require a 30 minute all clear period and full soft start. If a silent period is less than 20 minutes, a soft start will not be required when (1) visual or acoustic monitoring is carried out continuously throughout the silent period and (2) no marine mammals are observed in the 907 m (2,975 ft) mitigation zone. A soft start will be required if marine mammals are present in the area during the short silent period.

12.0 ARCTIC PLAN OF COOPERATION

Not applicable. The proposed activity will take place off of the U.S coastline in the Mid- and South-Atlantic between 30° and 40° N latitude. No activities will take place in or near a traditional Arctic subsistence hunting area. Therefore, there are no relevant subsistence uses for marine mammals implicated by this action.

13.0 MONITORING AND REPORTING PLAN

The monitoring and reporting plan for CGG's proposed 2D seismic program is based on the National Standards for a Protected Species Observer and Data Management Program: A Model Using Geological and Geophysical Surveys (Baker et al. 2013) (Joint NTL No. 2012-G02). The plan establishes a monitoring protocol and dictates the minimum qualification requirements in addition to job responsibilities of PSO and PAM operators. The reporting plan is built to increase knowledge of the marine mammal species in the area. It also addresses the protocol for injured or dead marine mammal encounters. CGG will contract independent third-party PSO and PAM operators to conduct monitoring onboard the seismic research vessel.

13.1 Monitoring

The duties of PSO and PAM operators are to (1) ensure that disturbance to marine mammals is minimized according to the operational permit stipulations; (2) document the effects of the proposed seismic activities on marine mammals; and (3) collect data on the occurrence and distribution of marine mammals in the proposed survey area.

13.1.1 Visual monitoring

There will be three PSO onboard the seismic research vessel to conduct visual monitoring for marine life. There will be two PSO, working no more than four hour shift rotations, monitoring continuously from dawn to dusk. Visual monitoring will be carried out using 7 x 50 reticle binoculars, the naked eye, or the Big Eye installed on the wheelhouse exterior deck. The observers will stand watch in safe locations that allow for optimal viewpoints and 360° coverage. Visual monitoring will be diligent and free of distractions for the duration of the watch. The PSO will have no other job responsibilities while onboard the seismic research vessel.

During a sighting, the observer who first sighted the marine mammal will closely monitor the animal's movement and, if possible, identify the species. The second observer will serve as the data recorder and alert the crew if mitigation is required. They will also assist with monitoring. The PSO will remain on continuous watch even if the seismic acoustic source is not operating to compare animal abundance and behaviors during times of production and silence.

The PSO must have the following qualifications: (1) 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; (2) experience with computer data entry; and (3) a certificate of completion of a BOEM recognized PSO training course.

13.1.2 Passive Acoustic Monitoring (PAM)

PAM data has become increasingly useful as a tool for defining marine mammal populations and stocks (Delarue et al. 2009) and appears to be very effective for detecting vocalizing marine mammal species when they are not visible. The use of PAM assists in the monitoring of acoustic takes authorized under the MMPA. Mitigation action will be taken when animals are acoustically detected within the mitigation zone.

A PAM system will be used for detecting, localizing (range and bearing), and classifying vocalizing marine mammals in real time. A typical PAM system is comprised of a tow cable, deck cable, and a data processing and monitoring system which processes, displays, and stores selected data. The systems have a listening frequency range between 10 Hz – 180 kHz. A minimum of three hydrophones covering the whole frequency range are used to determine the bearing and range for a detection signal. A Global Positioning System (GPS) receiver will assist in tracking acoustic detections relative to the seismic acoustic source and the seismic research vessel. As new technology improvements may become available, the specific PAM system will be confirmed close to the survey start date.

Continuous acoustic monitoring will be conducted by two PAM operators working coordinated shifts during periods of darkness and low visibility. The PAM system will be installed in the instrument room or in the wheelhouse to allow for fast, efficient communication between the crew and PSO. Acoustic monitoring must be diligent and free of distractions for the duration of the watch. The PAM operators can act as PSO if necessary but will otherwise have no other job assignments onboard. In the event of an acoustic detection which requires mitigation action (i.e., shut down, power down, delay to soft start) the operator on duty will communicate accordingly to the relevant crew and, if on duty, the PSO.

The PAM operator must be proficient in identifying species, calibrating the PAM system, and troubleshooting issues to take advantage of the benefits of PAM. In addition to the PSO qualification requirements as stated in Section 14.1.1, PAM operators must have completed a PAM training course which includes a minimum of two days of classroom training and one day of technical and practical training offshore.

13.1.3 Fixed 'Big Eye' binoculars

Big Eye binoculars will be used to complement visual monitoring. These large, high magnification binoculars will aid the PSO in confirming sightings and determining if mitigation measures are required. A reticle enables the PSO to assess more accurately the distance of the marine mammal from the seismic acoustic source and observe behaviors that would otherwise be out of range. The binoculars will be mounted at a location on the wheelhouse deck which allows for an optimal viewing range.

13.2 Reporting

The PSO & PAM Operator Effort, Survey, and Sighting Data Report will be submitted to Bureau of Safety and Environmental Enforcement (BSEE) on the last day of each month unless a sighting takes place which results in a shutdown. The report will detail the monitoring time of the PSO and PAM operator and the details of protected species sightings or acoustic detections. Any sightings or acoustic detections that require a shut down of the seismic acoustic source will be submitted to BSEE within 24 hours. These sightings will also be included in the regular monthly report following the incident.

The PSO & PAM Operator Effort, Survey, and Sighting Data Report will include the following information:

- Vessel name
- Date
- Time
- PSO/ PAM Operator names and affiliations
- Survey type (e.g; 2D)
- BOEM permit number
- Time when survey (observing and activities) began and ended.
- Vessel location (latitude/longitude) when survey (observing and activities) began / ended
- Vessel heading and speed (knots)
- Environmental conditions while on visual survey (including weather and sea state)
- Factors that may be contributing to impaired observations during each PSO shift change or as needed as environmental conditions change (e.g., vessel traffic, equipment malfunction)
- G&G activity information, such as the number and volume of seismic acoustic sources operating in the array, tow depth of the array, and any other notes of significance (i.e., pre-watch, ramp up, power down, shut down, testing, ramp up completion, end of operations, streamers)
- If a marine mammal is sighted, the following information will be recorded:
    - Watch status (sighting or detections made by PSO, PAM operator, crew, or other vessel)
    - PSO or PAM Operator who sighted or detected the animal
    - Time of sighting
    - Vessel location at time of sighting
    - Water depth (m)
    - Vessel heading (compass direction)
    - Direction of animal's travel relative to the vessel (drawing is preferred)
    - Pace of the animal
    - Estimated distance to the animal and its heading relative to vessel at initial sighting
    - Identification of the animal (genus/species/sub-species)
    - Estimated number of animals (high/low/best)
    - Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.)
    - Certainty of identification
    - Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics)
    - Detailed behavior observations (e.g., number of blows, number of surfaces, breaching, spy hopping, diving, feeding, traveling, including any observed changes)
    - Animal's closest point of approach (CPA) and/or closest distance from the center point of the seismic acoustic source array
    - Activity at time of sighting (e.g., deploying, recovering, testing, data acquisition, etc.)
    - Description of any actions implemented in response to the sighting (e.g., soft start delay, power down, shut down, speed or course alteration, etc.) including the time and location of the action

- If a marine mammal is detected while using the PAM system, the following information will be recorded
  - An acoustic encounter identification number and information as to whether the detection was linked with a visual sighting
  - Time when animal was first and last heard
  - Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal, etc.)
  - Any additional information recorded such as water depth of the hydrophone array
  - Bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram images, and any other notable information

In the unanticipated event that the specified seismic survey activity clearly causes the take of a marine mammal in a manner prohibited by the IHA, such as an injury (Level A harassment), serious injury or mortality (e.g., ship strike, gear interaction, and/or entanglement), CGG shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at (301) 427-8401 and/or by email, and the NMFS Southeast Region Marine Mammal Stranding Network at (877) 433-8299, Florida Marine Mammal Stranding Hotline at (888) 404-3922. The report must include the following information:

- Vessel name and type
- Date
- Time
- Location (latitude/longitude) of the incident
- Vessel speed during and leading up to the incident
- Description of the incident
- All seismic acoustic source activity in the 24 hours preceding the incident
- Water depth
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover and visibility)
- Description of marine mammal observations in the 24 hours preceding the incident: species identification or description of the animal(s) involved
- Animal's state
- Photographs or video footage of the animal (if equipment is available)

Activities will not resume until NMFS is able to review the circumstances of the prohibited take. CGG will coordinate with NMFS to determine what is necessary to minimize the likelihood of further prohibited takes and ensure MMPA compliance. CGG will not resume seismic acquisition activities until notified by NMFS via letter, e-mail, or telephone.

In the event of an injured or dead marine mammal for which the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (i.e., in less than a moderate state of decomposition as described in the next paragraph), CGG will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at (301) 427-8401, and the NMFS Southeast Region Marine Mammal Stranding Network (877) 433-8299, and to the NMFS

Southeast Regional Stranding Coordinator and Southeast Regional Stranding Program Administrator. The report must include the same information as identified in the previous paragraph. Activities may continue while the NMFS reviews the circumstances of the incident. CGG will coordinate with the NMFS to determine whether modifications in their activities are required.

In the event that CGG discovers an injured or dead marine mammal and the lead PSO determines that the injury or death is not associated with or related to the activities included in this IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), CGG shall report the incident to the NMFS Chief of the Permits and Conservation Division, Office of Protected Resources at (301) 427-8401, the NMFS Southeast Region Marine Mammal Stranding Network (877) 433-8299, and to the Southeast Regional Stranding Coordinator and Southeast Regional Stranding Program Administrator, within 24 hours of the discovery. CGG shall provide photographs or video footage (if available) or other documentation of the stranded animal sighting to the NMFS and the Marine Mammal Stranding Network. Seismic acquisition activities may continue while the NMFS reviews the circumstances of the incident.

At the completion of the survey, CGG will provide a draft report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days of the completion of the Atlantic 2D Offshore Seismic Program. The report will contain the following:

- a summary of the monthly reports submitted to BSEE
- a comparison of the estimated number of individual marine mammals species that have been exposed to the 160 dB re 1 μPa (rms) and, if applicable, 180 dB re 1 μPa (rms) sound levels during the survey (based on visual observation or acoustic detection) vs. the estimated number of individual species exposed to160 dB re 1 μPa (rms) and 180 dB re 1 μPa (rms) as identified in the marine mammal exposure estimates of the 5,400 in^3 seismic acoustic source modeling. A discussion section will include information about any specific behaviors for the observed or detected individuals exhibited and analysis of the results
- a description of the implementation and effectiveness of the terms and conditions of the IHA and operational permit for minimizing the adverse effects of the survey activity

A full report will be submitted to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS within 30 days after receiving comments from NMFS on the draft report. If the NMFS approves the draft report contents, the said draft report shall be considered to be the final report.

14.0 SUGGESTED MEANS OF COOPERATION

CGG will discuss with NMFS to ensure the mitigation and monitoring plan proposed in this IHA is effective and results in a negligible impact to marine mammal species and their habitat. We remain committed to an improved understanding of the cumulative effects of seismic exploration. We are open to discuss the specific needs required by NMFS which will contribute to research-based knowledge of mitigation effectiveness and species data.

CGG has contacted the East Coast states associated with our proposed 2D seismic program to explain the scope of work and address all state concerns. We will continue to coordinate with the state legislative personnel and specific group representatives throughout all stages of the proposed seismic program.

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