Appendix A: Description of Equipment

Introduction

In the Sand Survey Activities Environmental Assessment (EA), Table 2-1 summarizes survey equipment, and previous documents (BOEM 2017, Crocker and Fratantonio 2016, BOEM 2014a, BOEM 2014b) provide a more detailed characterization of these proposed sources and their sound propagation characteristics, particularly as they relate to activities similar to those proposed here. Source level, frequency, and operational restrictions are outlined in the proposed action, with mitigations in Appendix B. No airguns or sparkers are proposed for use.

Frequency (i.e., number of cycles per second, with hertz (Hz) as the unit of measurement) and amplitude (loudness, measured in decibels, or dB) are typically used to describe sound. The frequency is often proportional to the resolution of acquired data. The source level is the equivalent of the sound power and is measured as an acoustic pressure at a reference distance of 1 m from the source. Sound source levels are typically based on manufacturer's specifications or, where available, field measurements. Use of manufacturer's specifications often represents a conservative estimation, as equipment power settings and sound output is often adjusted given data needs and/or site-specific conditions.

The level of sound in water can be expressed in several different ways, but always in terms of dB relative to 1 microPascal (1 µPa) at 1 meter (m). Each 10 dB increase represents a ten-fold increase in sound pressure. Peak pressure level is the maximum sound pressure level (highest level of sound) in a signal measured in dB re 1 µPa. Root mean square (rms) sound pressure level (SPL) is often used to characterize source levels at a reference distance (of 1 m) or received levels at some distance from the source. The rms SPL (dB re 1 µPa) is the rms pressure level in an operational frequency band over the time window of the pulse, or pulse length. The rms SPL can be thought of as a measure of the average pressure for at least 1 second, or as the "effective" pressure over the duration of an acoustic event.

For the received signals, the time window can change for a fixed signal because of multi-path arrival structure of that signal in the field, and it is necessary to define a "95% energy pulse duration" as the interval over which the pulse energy rises to 95% of the total energy. The SPL over this interval is commonly called the 95% rms SPL. Sound Exposure Level (SEL) is the integration over time of the square of the acoustic pressure in the signal and is thus an indication of the total acoustic energy received. SEL can be used to characterize the source level or the received level. Cumulative SEL represents the total SEL that may be received over the duration of an acoustic event that includes several signals.

Geophysical Equipment and Techniques

Geophysical surveys would be undertaken to identify OCS sand resources. Geophysical surveys use a high-resolution, low-energy electromechanical sound source and receiver system towed behind a vessel. Electromechanical sound sources, like the ones used in the proposed action, create an oscillatory overpressure through vibration of a surface, using either electromagnets or the piezoelectric effect of transducer materials. Transducers produce an acoustic wave of a specific peak frequency, often in a highly directive beam.

Sound characteristics for equipment used in sand survey activities in Table A-1 were tested by Crocker and Fratantonio (2016). Cumulative SEL was calculated based on an assumption that an animal may directly experience a sound source for 10 transmissions, which is conservative given that either one or both of the survey vessel and animal will be in motion. These SEL cumulative values were then used to calculate distances to thresholds for Level A or B Harassment of marine mammal hearing groups based on how sound transmits in the somewhat shallow shelf depths of the Study Area (Table A-2). The threshold for Level A Harassment varies from 173 to 219 dB is determined based on different marine mammal hearing group sensitivities (NOAA 2016 and Table 3-1 of the EA), while Level B Harassment is consistent across groups at 160 dB. All values of dB in Tables A-1 and A-2 are re 1 µPa @ 1 m.

Sub-bottom profiling would use a chirp and/or boomer systems. The primary goal of sub-bottom profiler data collection is to provide an accurate depiction of the geologic framework and near-surface sand thickness (isopach) that can be further evaluated for possible recovery and placement as beach restoration material. The chirp system is generally towed at depth off the seafloor, whereas the boomer is towed at or near the surface.

Chirp sub-bottom. Chirp sonar uses a transducer to emit a frequency-modulated sound pulse towards the seafloor and to receive the return of the pulse once it is reflected from the seafloor or from the contacts between sedimentary layers near the seafloor (acoustic impedance). Chirp systems are generally single-channel systems that operate around a central frequency that is swept electronically across a range of frequencies to provide improved resolution. The most probable system consists of towfish with internal transducer that imparts an acoustic signal with frequencies potentially ranging from 500 Hz up to 24 kilohertz (kHz) approximately every 0.5 to 1 seconds. Chirp signal are generally very short and therefore sound something like a bird chirp and thus their name. For optimal data quality, the chirp system is typically towed at water depths where the towfish remains within approximately 10 feet (30 m) above the seafloor (Figure A-1).

Boomer. A boomer is a low-energy towed device typically consisting of a multi-channel acoustic source that uses a magneto-restrictive plate diaphragm to impart an acoustic pressure signal into the water column. The signal output is generally set to less than 100 to 350 joules and frequency ranges between 300 to 10,000 Hz. Boomers are fixed-frequency sources, but they do operate across a range of frequencies with a broadband signal. The boomer imparts an acoustic signal approximately every 0.5 to 1 seconds. A secondary cable of passive hydrophones is used as a signal receiver. Typical tow length for the boomer is approximately 75 to 100 feet (23 to 30 m) behind or alongside the vessel, and the hydrophones are towed at about 100 to 125 feet (30 to 38 m) from the vessel. Both are towed at the water's surface; the boomer plate is installed on a small catamaran or sled structure (Figure A-1).

Figure A-1. Chirp Towfish Deployment from Port (left); Boomer Sled Deployment from Stern (right)

Other geophysical data could be collected using a combination of equipment and techniques. Multibeam or interferometric swath bathymetry is used to gather information about water depths/seafloor topography/seafloor condition. Not only do such systems provide information on the seabed, but the reflected acoustical signal (backscatter) can also be used to characterize the seabed with regard to archaeological resources, benthic habitat, and sediment composition (Dartnell and Gardner, 2004). Due to the relatively high frequency nature of their signal, they do not penetrate very far into the bottom.

<u>Multibeam Bathymetry</u>: Multibeam bathymetry systems also transmit and receive relatively high frequency acoustic pulses through the water which reflects off the seafloor and returns to the receiver. The time elapsed between the pulse being emitted and received is converted to a distance by multiplying this number by the speed of sound in water. The source level (rms SPL) for multibeam bathymetry ranges from about 210 to 230 dB re 1 µPa @1 m. Frequency range would typically be limited to above 180 kHz to avoid/reduce noise impacts on marine mammals. The system records with a sweep appropriate to the range of water depths in the survey area. A bathymetry system is useful in areas characterized by complex topography or fragile habitats.

In addition to identifying sediment features, acoustic backscatter data can be collected using multibeam bathymetry and analyzed to provide valuable information on archaeological resources and sediments. Surface shape and roughness influence backscatter strength from coarser sediments and from other hard surfaces like reefs and shipwrecks (Gustav 2008). When this type of technique is validated by geologic samples or underwater photography, accuracy is approximately 70 to 80 percent (Gustav 2008). No additional equipment would be needed to implement this approach; however, different software/analytical techniques would be employed.

<u>Interferometric Swath Bathymetry:</u> In contrast with multibeam bathymetry, interferometric swath bathymetry uses two outward-facing transducers, as opposed to an array, to transmit and receive acoustic pulses. The elevation angle of a target on the seafloor is measured from the phase difference between the signals received on the two separate receivers. Frequency range would be limited to above 180 kHz to avoid/reduce noise impacts on marine mammals. Source level (rms SPL) ranges from approximately 200

to 220 dB re 1 µPa. Acoustic backscatter can be used as a substitute for side-scan sonar data, provided that data quality standards are met. Depending on water depth, fewer track lines could be surveyed using an interferometric swath system, in comparison to multibeam, to achieve the same coverage.

Side-Scan Sonar: Side-scan sonar generates an image of seabed morphology, submerged objects, and other features by emitting a high-frequency acoustic pulse, which typically has frequency ranges from 100 to 900 kHz, which attenuates rapidly in the water column. However, to limit sound exposure, any use of side-scan sonar would be limited to operating at frequencies greater than 180 kHz. Source level ranges from approximately 200 to 240 dB re 1 µPa (rms SPL).

When possible, backscatter data for multibeam and/or interferometric swath surveys would be used as a substitute to side-scan sonar, provided along-track resolution is less than 1 m at 100 m slant range. Side-scan sonar and/or swath bathymetry backscatter data would be used to construct a mosaic image to provide a true plan view with 100 percent coverage of the area of interest. The resulting image would be automatically corrected for slant range, lay-back, and vessel speed. As an added data feature, the rate of signal attenuation backscatter can indicate surficial sediment type or seafloor habitat information.

Magnetometer: The marine magnetometer is a passive remote sensing device (i.e., no energy is transmitted) that identifies materials with ferrous or ferric components or other objects having a distinct magnetic signature. For surveys such as these, variations would be caused by local deposits of ferromagnetic material that could be attributable to unexploded ordnances (UXO), objects of archaeological significance, or seafloor hazards such as buried cables. The magnetometer sensor should be towed as closely as possible to the seafloor not to exceed an altitude of greater than 20 feet (6 m) above the seafloor, and using line spacing not to exceed 98 ft (30 m). The sensor should be towed in a manner that minimizes interference from the vessel hull and other survey instruments.

Acoustic Characteristics of Geophysical Sources

There are numerous and complex factors to consider when describing the propagation of sound emitted from a geophysical source in the marine environment. The perception of sound is equally complex and depends on several factors, such as the hearing range of the animal, the intensity of the sound, etc. As sound propagates away from a source, its amplitude, or loudness, decreases exponentially and is influenced by environmental factors including: source characteristics, directionality, beamwidth, the sound speed profile, and the signal's interaction with the oceans boundaries (the sea surface and the seafloor). These factors ultimately determine the distance and characteristics of the transmitted signal and how it will compare to the local ambient noise.

Table A-1. Characteristics of Electromechanical Sources Proposed for Geophysical Surveys*

Source	Operational Frequency Range	Peak Source Level	Representative Beam Pattern (Horizontal and Vertical)	Frequency for Testing[1]	Representative Pulse Length (ms)	RMS (dB)	SEL (dB)	Cumulative SEL (dB)
Boomer (surface tow)	300 Hz — < 10 kHz	< 220 dB	Horizontal: omnidirectional Vertical: downward focused	6.2 kHz	0.6	205	172	182
Chirp sub-bottom profiler (tow above seafloor)	500 Hz — 24 kHz	< 220 dB	Horizontal: omnidirectional Vertical: Downward focused	4-20 kHz (wideband)	4.6	180	156	166
Side-scan sonar (near-surface tow)	*> 180– 900 kHz*	*< 240 dB*	*Along-track: very narrow Across-track: wide*	*445 kHz*	*0.1*	*223*	*182*	*192*
Multibeam (hull or davit mounted)	*> 180 - 500 kHz*	*< 230 dB*	*Determined by number of beams, beam spacing, frequency, etc. Along-track: very narrow Across-track: wide*	*300 kHz*	*0.3*	*221*	*185*	*195*
Interferometric Swath (davit mounted)	*> 180 – 600 kHz*	*< 220 dB*	*Depends on frequency Along-track: very narrow Across-track: wide*	*234 kHz*	*0.2*	*218*	*180*	*190*
Single Beam (hull mounted)	*> 180 – 540 kHz*	*< 230 dB*	*Horizontal: omnidirectional Vertical: Downward*	*200 kHz*	*0.7*	*194*	*163*	*173*

*Italics indicate the operational frequency is beyond hearing range of cetaceans, manatees, seals, sea turtles, and most fish. [1]Testing by Crocker and Fratantonio 2016; see report for details.

Table A-2. Distance to Level A and Level B Harassment of Marine Mammal Hearing Groups*

	Range to Level B (m)	Range to Level A (m)				
Source	**All marine mammals (160 dB)**	**Low-frequency cetaceans (199 dB)**	**Mid-frequency cetaceans (198 dB)**	**High-frequency cetaceans (173 dB)**	**Phocid pinnipeds (201 dB)**	**Otariid pinnipeds (219 dB)**
Boomer (surface tow)	29.3	< 1	< 1	4.0	< 1	< 1
Chirp sub-bottom profiler (tow above seafloor)	2.5	< 1	< 1	< 1	< 1	< 1
Side-scan sonar (near-surface tow)	*135.9*	*< 1*	*< 1*	*18.5*	*< 1*	*< 1*
Multibeam (hull or davit mounted)	*215.4*	*< 1*	*< 1*	*29.3*	*< 1*	*< 1*
Interferometric Swath (davit mounted)	*100.0*	*< 1*	*< 1*	*13.6*	*< 1*	*< 1*
Single Beam (hull mounted)	*7.4*	*< 1*	*< 1*	*1.0*	*< 1*	*< 1*

*Italics indicate the operational frequency is beyond hearing range of cetaceans, manatees, seals, sea turtles, and most fish.

Geological and Geotechnical Equipment and Techniques

Information from geological surveys (i.e., sediment sampling) would be used in tandem with geophysical data to ground-truth geophysical data and to determine the geometry, volume, and quality of offshore sand resources/deposits. Sediment sampling would occur at selected locations where existing geophysical data indicates promising targets for quality sand. Some samples would be taken at sites on the flanks of the geomorphic features or sand resource areas to determine the footprint and other geologic characteristics, and other samples would be taken in the center of the resource areas to verify data regarding the thickness and textural properties of the sand resource. Sediment sampling could be completed using a vibracore or a grab sampler. In general, grab sampling is conducted when surficial sediment composition needs to be studied as opposed to sediment thickness and stratigraphy. The two techniques of sediment sampling are discussed below.

<u>Vibracoring</u>. A 3- or 4-inch (7.6- 10.1-centimeter (cm)) diameter aluminum core barrel mounted on a platform or support assembly would be used to penetrate sediments in the upper 20 feet (6 m) of the seafloor. A sediment sample of 5 to 20 feet (1.5 to 6 m) would be acquired to determine sediment characteristics and sand resource thickness. To penetrate seafloor sediments, the core barrel is vibrated by a pneumatic or electric vibrahead, which results in local liquefaction of sediment along the core barrel surface, facilitating penetration into the sediment (Fugro 2003; ISSMGE 2005). Some operations use a single, non-reusable aluminum core barrel to collect and preserve the core sample, whereas others have a reusable core barrel that is lined with a plastic or Kevlar sleeve that collects and preserves the sample. A typical vibracore survey would obtain 15 to 25 cores approximately 20 feet (6 m) deep in an area measuring 1 square mile (640 acres or 259 hectare) per day. The vibratory mechanism on the vibracorer would introduce underwater sound in addition to broadband noise from the vessel. The vibratory mechanism produces a relatively short, broadband noise with peak frequency less than 1 kHz. Source levels are generally expected to be less than 180–190 dB re 1 µPa @ 1 m depending on the intensity of the vibrations, barrel material, and nature of sediment penetration (Reiser et al., 2011). Vessels may be dynamically positioned, live boated, or anchored, under permissible circumstances, during vibracoring (Figure A-2), which may also contribute to the radiated noise during the operation.

Figure A-2. Deployment of a 20-foot Vibracore from Stern A-frame

Grab Samplers. Grab samplers are one of the most common methods of retrieving sediment samples or biological samples from the seabed. A grab sampler is a device that collects a sample from the surface of the seabed by bringing two steel clamshells together. The grab is lowered to the seabed and activated either automatically or by remote control. The shells swivel together in a cutting action and by so doing remove a section of seabed. The sample is recovered to the ship for examination. One grab sample takes approximately 5–15 minutes to obtain. Grab sampling penetrates from a few inches to a few feet below the seafloor. The greatest noise associated with grab sampling is expected to be vessel noise, which would also be 150-180 dB re 1 μPa @ 1 m (CEDA 2011).

Geological sampling disturbs the seafloor; however, due to the small size of the vibracores and associated platforms, the area of seabed to be disturbed during individual sampling events is estimated to range from 1 to 9 square feet (0.3 to 2.7 square m). The total area of seafloor disturbed by bottom sampling and shallow coring activities would be a very small portion of the total Study Area.

Survey Vessels, Timing, and Design

Surveys can occur either through one mobilization for simultaneous collection of data, or through separate mobilizations (one to collect geophysical data and one to collect geological or geotechnical information) from regional ports and shorebases. Either mobilization could potentially use more than one vessel. Depending on the nature of operations, surveys would be conducted by vessels that could potentially remain offshore for 1 to 30 days of their survey duration, but could travel periodically to an onshore support base for fuel, supplies, equipment repairs, and crew changes. Before any geological sampling occurs, the area would be investigated by appropriate means to ensure impacts to sensitive resources are avoided; this could entail advance or real-time interpretation of geophysical data by qualified personnel or by divers assisting with vibracoring. Data collection would be continuous during the survey, but could stop while the vessel repositions or temporarily cease due to environmental considerations. Survey plans that include details of mobilization and data collection expectations would be developed and approved prior to a specific project.

The survey time of year is largely constrained by seasonal sea state conditions, with a desired conditions consisting of wave heights of less than 3 feet (1 m) for geophysical surveys and less than 5 feet (1.5 m) for geological sampling. Surveys in the North and Mid-Atlantic are typically more efficient after the spring winds of May have subsided until mid-September/October, when the probability for nor'easters and other strong storms increases. For the South Atlantic and the Gulf of Mexico, opportune times for surveying are the same as the North and Mid-Atlantic; however, peak hurricane season from summer to fall could affect the ability to conduct surveys. Geophysical activities usually occur during daylight hours, unless nighttime surveying occurs with consideration of a passive acoustic monitoring system (Appendix B). Sand survey activities would take into consideration areas designated as North Atlantic Right Whale critical habitat or seasonal management areas (SMAs) in the Atlantic (Appendix B).

Depending on the type of equipment being deployed, a vessel with an A-frame, boom, or davit could be required to assist with instrument retrieval. Typically, survey equipment would be deployed from a single vessel ranging from approximately 28 to 120 feet (9 to 37 m) in length, depending on the survey activity to be conducted/equipment needs, and would travel at speeds between 3 and 5 knots (5.6 to 9.3 kilometers per hour (km/hr)), but may travel 10-12 knots (19-22 km/h) in transit. Vessels would be equipped with and transmit Automatic Identification System (AIS) (or equivalent) data to the extent practicable. Vessels would be equipped with an integrated navigational system with layback ranging instrumentation to track the position and depth of towed survey equipment. Bathymetric data would be tidally corrected using satellite altimetry, or in limited cases, coastal or temporarily-installed water level gauges. Vessels with a vibracoring rig could be larger to support the rig and associated equipment. In addition to a boat captain, a vibracoring operation team requires about three to six crew members, including a geotechnical engineer, one to three researchers, and PSOs, depending on length of survey day. Liftboats, or other spudded boats, would not be used as a vibracoring platform.

Depending on the size of the vessel and length of the geophysical survey, operations would generally be managed by a boat captain, crew (optional), one to three researchers, and protected species observers (PSOs) (see Appendix A for a discussion on observer requirements). Vessels would be generating continuous noise levels from bow-wave slap, wake bubble collapse, propeller cavitation, and engine noise; these sounds are less intense and occur in the broadband spectrum between 10 Hz and 100 kHz. This is especially true during surveying, when vessel speeds are lower and consequentially so is vessel-related noise (Martin et al., 2012a; Zykov and Carr 2012). Vessels would use dynamic positioning or live-boat during coring; anchoring would be avoided to the maximum extent possible.

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