U.S. Army Corps of Engineers
Charleston District

APPENDIX G

CHARLESTON HARBOR POST 45
CHARLESTON, SOUTH CAROLINA

Noise Assessment

May 2015

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1.0 Overview:

Noise is often defined as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, diminishes the quality of the environment, or is otherwise annoying. Response to noise varies by the type and characteristics of the noise source; distance from the source; receptor sensitivity, and time of day. Noise can be intermittent or continuous, steady or impulsive, and it may be generated by stationary or mobile sources. Noise is described by a weighted sound intensity (or level), which represents sound heard by the human ear and is measured in units called decibels (dBA). The potential impacts of underwater sounds associated with dredging operations have come under increasing scrutiny by regulatory agencies. The objectives of this assessment are to determine current noise levels and to assess the noise impacts of the proposed dredging and deepening of Charleston Harbor. Noise impacts will be assessed for the following:

1. Impact of dredging noise on marine life,
2. Impact of dredging noise on the human environment,
3. Impact of noise from ship traffic as a result of deepening the harbor, and
4. Indirect impact of noise from port operations as a result of deepening the harbor.

An additional goal of this assessment is to aid in the Corps' compliance with the Marine Mammal Protection Act of 1972 (16 U.S.C 1361 et seq, 1401-1407, 1538, 4107). The MMPA requires that the Action Agency coordinates with the USFWS and the NMFS to discuss the potential impacts to any species covered under the Act. All practicable efforts will be made to avoid taking of a marine mammal. Currently the NMFS does not provide Incidental Harassment Authorization (IHA) with regard to dredging operations, but it is an issue being considered for application to future dredging operations (Reine et al., 2012).

Within this document, noise is described by the sound intensity (or level) in units called decibels (dB). The dB scale is logarithmic; therefore, sound intensity increases or decreases exponentially with each dB of change. The strength/extent (or magnitude) and frequency of sound levels vary over the course of the day and can be affected by weather conditions. The most common unit of frequency is the hertz (Hz), corresponding to one crest of a sound wave per second.

2.0 Ambient Noise within Charleston Harbor

Charleston Harbor has functioned as an international harbor since colonial times. Over the last 300 years, Charleston has evolved to accommodate the growing trade industry and as such larger ships have continued to arrive. At the same time, recreational and other commercial boat traffic as well as industrial noise has continued to increase. Several sources of ambient noise are present in the waters of Charleston Harbor. The ambient noise level of an area includes sounds from both natural (wind waves, fish, tidal currents, mammals) and artificial (commercial and recreational ships, dredging, pile driving, etc) sources. Tidal currents produce hydrodynamic sounds, which are most significant at very low frequencies (< 100 Hz). Ship traffic, including ships passing the immediate study area generate sounds can travel considerable distances, in frequencies ranging from 10 to 1000Hz. Sea state as influenced by wind speed also produces ambient sounds above 500 Hz. Being a large commercial and industrial area, the Charleston Harbor area experiences wide ranging noise from a variety of industrial activities. Biological sounds associated with a host of mammals, fishes, and invertebrates can generate broadband noise in the frequency of 1 to 10 kHz with intensities as high as 60 to 90 dB.

Charleston Harbor has the typical noise characteristics of a busy harbor. Sources include recreational and commercial vessel traffic, dredging vessels and dock side facilities. Noise sources for vessels include cranes, whistles and various motors for propulsion. Dockside noise sources include cranes, trucks, cars, and loading and unloading equipment. In addition to water born noise, noise can impact the human environment as well. Background noise exposures change during the course of the day in a gradual manner, which reflects the addition and subtraction of distant noise sources. Ambient noise is the all-encompassing sound associated with a given environment at a specified time. Humans hear sound from 0 – 140 dB. Sound above this level is associated with pain.

3.0 Noise Impacts on Marine Life

Noise has been documented to influence fish behavior. Fish detect and respond to sound utilizing its cues to hunt for prey, avoid predators, and for social interaction. High intensity sounds can permanently damage fish hearing (Nightingale and Simenstad 2001). Dredging operations generally produce lower levels of sound energy but last for more extended periods of time than more intense construction activities (e.g., pile driving) (Nightengale and Simenstad 2001). These sounds have been documented to be continuous and low frequencies (< 1000 Hz) and are within the audible range of listed species of both whales (7Hz–22kHz) and sea turtles (100-1000Hz) (Clarke et al., 2002). Fish produce sound when swimming, mating, or fighting and also noise associated with swimming. Fish use a wide range of mechanisms for sound production, including scraping structures against one another, vibrating muscles, and a variety of other methods. Sounds produced by spawning fishes, such as sciaenids, are sufficiently loud and characteristic for them to be used by humans to locate spawning locations. SCDNR provided information on known spawning sites for sciaenids (Figure 1). Only two of these hotspots are in close proximity to dredging operations: Ravenel Bridge and the Grillage.

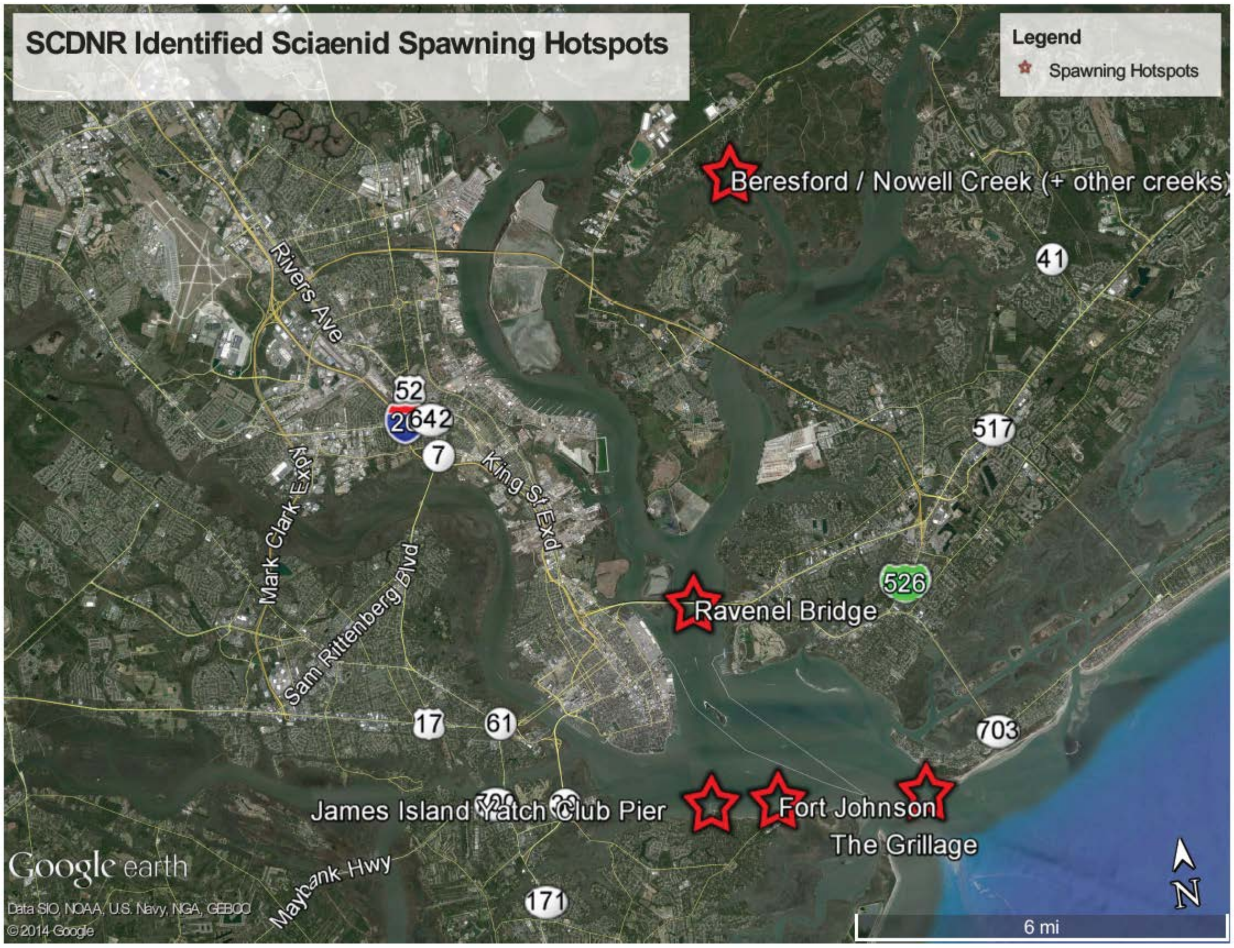

Figure 1. SCDNR sciaenid spawning hotspots in Charleston Harbor

Relative to exposure to anthropogenic noise, NOAA guidelines define two levels of harassment for marine mammals: Level A based on a temporary threshold shift (190 dB for pinnipeds and 180 dB for cetaceans), and Level B harassment with the potential to disturb a marine mammal in the wild by causing disruption to behavorial patterns such as migration, breeding, feeding, and sheltering (160 dB for impulse noise such as pile driving and 120 dB for continuous noise such as vessel thrusters) (http://www.nwr.noaa.gov/Marine-Mammals/MM-sound-thrshld.cfm). According to Richardson et al. (1995) the following noise levels could be detrimental to marine mammals:

- Prolonged exposure of 140 dB re 1 µPa/m (continuous man-made noise), at 1 km can cause permanent hearing loss.
- Prolonged exposure of 195 to 225 dB re 1 µPa/m (intermittent noise), at a few meters or tens of meters, can cause immediate hearing damage.

At the time of this document NOAA has released a draft report that provides guidance for assessing the effects of anthropogenic sound on marine mammal species under the jurisdiction of NMFS (NOAA

2013). The guidance will replace the current thresholds used by NOAA and described above. NOAA compiled, interpreted, and synthesized best available science to update the threshold levels for temporary (TTS) and permanent hearing threshold shifts (PTS). Different target species for protection have widely divergent tolerance levels for sounds (owing to different hearing sensitivities, hearing integration times, etc.). This guidance has not yet been finalized but NOAA indicates that it will be finalized in late 2015 (http://www.nmfs.noaa.gov/pr/acoustics/faq.htm, accessed 07 April 2015). NOAA states that the guidance may necessitate new methodologies for determining impacts and the application of thresholds in the regulatory context under applicable statutes (NOAA, 2013). It should be noted that the application of thresholds is not addressed within the guidance. The following table (Table 1) illustrates the proposed permanent threshold shift (PTS) levels for various species of cetaceans and pinnipeds (NOAA, 2014).

Table 1. NOAA proposed PTS onset threshold levels.

	PTS Onset* (Received Level)	
Hearing Group	**Impulsive**	**Non-impulsive**
Low-Frequency (LF) Cetaceans	230 dB_{peak} **&** 187 dB SEL_{cum}	230 dB_{peak} **&** 198 dB SEL_{cum}
Mid-frequency (MF) Cetaceans	230 dB_{peak} **&** 187 dB SEL_{cum}	230 dB_{peak} **&** 198 dB SEL_{cum}
High-Frequency (HF) Cetaceans	201 dB_{peak} **&** 161 dB SEL_{cum}	201 dB_{peak} **&** 180 dB SEL_{cum}
Phocid Pinnipeds (Underwater)	235 dB_{peak} **&** 192 dB SEL_{cum}	235 dB_{peak} **&** 197 dB SEL_{cum}
Otariid Pinnipeds (Underwater)	235 dB_{peak} **&** 215 dB SEL_{cum}	235 dB_{peak} **&** 220 dB SEL_{cum}
* Dual criteria: Use one [dB_{peak} or dB SEL_{cum}] exceeded first. All SEL_{cum} thresholds (re: 1 μPa^2-s) are weighted.		

In the interim, NMFS recognizes the aforementioned thresholds for Level A and Level B harassment

3.1 Dredge Type and Sound:

The most likely dredges to be employed as a result of this study would be hydraulic pipeline cutterhead dredges, bucket dredges, and hopper dredges. Sound production is largely influence by sediment properties – to excavate hard, cohesive and consolidated soils, the dredger must apply greater force to dislodge the material (Robinson et al., 2011). Sounds from dredges can be variable, depending on the phase of operation, and the type of dredge used, but typically occur at low frequencies (<500 Hz) (Reine et al., 2014). While very little research has been carried out on the effects of sound from dredging on marine life, the USACE Engineering Research and Development Center (ERDC) has carried out a few studies (Clarke et al., 2002, Reine et al., 2010, Reine et al., 2012, Reine et al., 2014) and developed a program to characterize sounds produced by different dredging practices. USACE is collecting data across dredge type, substrate type, and environmental settings. The following sections describe sound from the types of dredges anticipated to be used in this project. The most significant source of sound from dredging operations would come from underwater blasting which is not anticipated since hard rock is not expected in the dredging area.

Hydraulic pipeline cutterhead dredges are commonly used throughout the US for both new work and maintenance dredging operations. They are capable of removing most types of material and pumping the slurry through pipelines for several miles or longer with the use of booster pumps. The major processes contributing to hydraulic dredging sounds include: 1) dredge material collection sounds originating from the rotating cutterhead in contact with the bed and intake of the sediment-water slurry, 2) sounds generated by pumps and impellers driving the suction of material through the pipes, 3) transport sounds involving the movement of sediment through the pipes, and 4) ship and machinery sounds, including those associated with the lowering and lifting of spuds and moving of anchors by dredge tenders (Reine et al., 2012). CEDA (2011) indicate that pipeline cutterhead dredges have a source level at 1 m of 172 dB – 185 dB re 1uPa rms, ranging from 100 – 500 Hz. In a study by Clarke (2002), cutterhead sounds peaked at 100-110 dB in the frequency range of 70-1000 Hz and were inaudible at ~500 m from the source.

Bucket dredges produce a repetitive sequence of sounds generated by winches, bucket impact with the substrate, bucket closing, and bucket emptying. The noise generated from a mechanical dredge entails lowering the open bucket through the water column, closing the bucket after impact on the bottom, lifting the closed bucket up through the water column, and emptying the bucket into an adjacent barge. Once the barge is full, it would be towed by a tug offshore and emptied into the Charleston ODMDS or other approved placement sites. The maximum noise spike with mechanical dredges is when the bucket hits the bottom. All other noises from this operation (i.e., winch motor, spuds, etc.) are insignificant. Clarke et al. (2002) found that the sound of a bucket impact with the substrate was at the limit of detection by a low-noise hydrophone and hydrophone audio amplifier at 7 km from the impact point. These dredges are anticipated to be used in the lower harbor and in the entrance channel to dredge soft rock from the channel for beneficial reef creation.

Hopper dredges hydraulically remove sediment from the seafloor through dragheads. Sediment is sucked upward through a pipe by means of centrifugal pumps, and the slurry is transferred to the hopper bin. Much of the sound is associated with propeller and engine noise with additional sounds emanating from pumps and generators. Similar to the cutterhead suction dredge, produce noise ranging from 70 to 1,000 Hz with peaks at 120 to 140 dB (Clarke et al 2002, unpublished). Robinson et al., (2011) carried out an extensive study of the noise generated by a number of trailing suction hopper dredges during marine aggregate extraction. Source levels of the vessels were estimated and an investigation undertaken into the origin of the noise. Source levels at frequencies below 500 Hz were generally in line with those expected for a cargo ship travelling at modest speed. Levels at frequencies above 1 kHz were elevated by additional noise generated by the extraction in harder substrate (e.g., gravel), and attenuate rapidly with distance. CEDA (2011) indicate that hopper dredges have a source level of 186 dB – 188 dB re 1uPa rms ranging from 100 – 500 Hz. In a study of hopper dredge noise on a sand shoal, Reine et al., (2014) found that source levels peaked at 178.7 db re 1uPa at 1m. Using the current threshold by NMFS, peak source levels did not exceed Level A Criterion, but did exceed Level B Criterion for harassment.

3.2 Commercial Vessels

Background sounds have steadily increased as shipping and other anthropogenic uses of the oceans and inland waters have increased. For instance, in much of the northern hemisphere, shipping noise is the dominant source of underwater noise below 300 Hz (Ross 1987, 1993); vessel operations have increased over time and as a result have increased low-frequency ambient noise levels in some areas (Curtis et al. 1999; Andrew et al. 2002; McDonald et al. 2006). One of the most serious implications of this increase in shipping noise is the impact it may have in terms of masking sounds of the soundscape, including sounds of biological origin, affecting communication between fish. The primary auditory effect of vessel noise on marine animals is the masking of biologically significant sounds. Because most of the acoustic energy radiated from large commercial vessels is below 1 kHz, the greatest potential for masking exists for groups of marine animals that produce and receive sounds in this band, and includes mysticetes, pinnipeds, and fish (NOAA 2004).

As stated above, NOAA guidelines define two levels of harassment for marine mammals: Level A based on a temporary threshold shift (190 dB for pinnipeds and 180 dB for cetaceans), and Level B harassment with the potential to disturb a marine mammal in the wild by causing disruption to behavorial patterns such as migration, breeding, feeding, and sheltering (160 dB for impulse noise such as pile driving and 120 dB for continuous noise such as vessel thrusters). Ships create noise from their propellers, motors and gears. The noise created by the motor is continuous and caused by the mini-explosions that occur as fuel burns rapidly inside the engine cylinders and by the rotating gears and shafts. Sound is also created by bubbles formed by the rotating propellers and, to a lesser extent, by the wake of waves produced by the movement of the ship. As the ship moves and the propellers rotate, many bubbles form in the water. The formation of these bubbles is known as cavitation. The breaking of these bubbles creates a loud acoustic sound. Cavitation noise is directly related to the speed of the boat. The faster the propeller rotates, the more cavitation. The breaking bubbles produce sound over a range of frequencies, and at high speeds, these frequencies can be as high as 20,000 Hz. On the other extreme, a large ship with slowly turning propellers can generate very low frequencies (below 10 Hz). The rotation of the propellers creates bands of noise at more or less constant frequencies that are proportional to the rate of rotation of the propeller (DOSITS, 2013). Most vessels, but particularly large ships, produce predominantly low frequency sound (below 1 kHz) from onboard machinery, hydrodynamic flow, and from propeller cavitation (Ross 1987, 1993). Source levels can range from < 150 db re: 1uPa to over 190 dB for the largest commercial vessels (Richardson et al. 1995; Arvenson and Vendittis 2000; Hildebrand 2009).

4.0 Impact Determination

4.1 Impact of dredging noise on marine life

Reine et al (2012) found that the majority of underwater sounds produced by hydraulic cutterhead dredging operations were of relatively low frequency (< 1000 Hz). Their study was conducted during rock fragmentation and therefore represented a worst case scenario. The source level was estimated to be between 170 and 175 dB re 1uPa@1-m. These sound levels decreased with increasing distance from the source. The authors determined that the area of influence was limited to less than 100 m from the source. At 100 m received levels were less than 150 dB re 1uPa rms. While NMFS is currently developing guidelines for determining sound pressure level thresholds for fish and marine mammals, based on existing studies, the NMFS current thresholds for determining impacts to marine mammals is between 180 and 190 dB re 1 uPa for potential injury to cetaceans and pinnipeds respectively, and 160 dB re 1 uPa for behavioral disturbance/harassment from an impulsive noise source, and 120 dB re 1 uPa from a continuous source. Reine et al (2012) found that the 120 dB re 1uPa proposed threshold was exceeded by ambient noises in their study area. Based on reviews by Popper et al (2006) and Southall et al (2007) it is unlikely that underwater sound from conventional dredging operations can cause physical injury to fish species. Some temporary loss of hearing could occur if fish remain in the immediate vicinity of the dredge for lengthy durations, although the risk of this outcome is low (CEDA 2011). Fish will likely respond to dredging by using avoidance techniques. Avoidance is defined as an effect that causes fish to not occupy an area that is periodically or infrequently occupied. Dredging is likely to cause avoidance due to noise (and increased suspended sediments and other temporary water quality changes).

NMFS interim criterion for physical injury to fish is 206 dB peak, regardless of fish size. However, dredging operations would likely cause the temporary displacement of fish species as a behavioral response to the noise. This will not likely have an effect on populations of fish as they will be able to use areas outside of the navigation channel to traverse to and from spawning and feeding grounds.

The sediment within Charleston Harbor is predominantly sand/silt/mud mixture. No hard rock, gravel, or cobbles are located within the portion of the navigation channel to be deepened. The entrance channel does contain significant quantities of soft limestone rock. According to the Clarke et al (2002), the peak amplitude for the bucket hitting the rocky, gravel, cobble bottom at Cook Inlet, Alaska was about 120 dB. Both Doug Clarke and Charles Dickerson, from USACE ERDC, stated that the peak amplitude of the bucket hitting sand/silt/mud substrate would be significantly less than 120dB. Since the substrate composition of Charleston Harbor is predominantly sand/silt/clay material, it is reasonable to assume that the Charleston Harbor dredging would have a similar sound level.

According to Richardson et al (1995), received noise levels diminish by about 60 dB between the noise source and a radius of 1 km. For marine mammals to be exposed to a received level of 140 dB at 1-km radius, the source level would have to be about 200 dB re 1 µPa/m. Furthermore, few human activities emit continuous sounds at source levels greater than or equal to 200 dB re 1 µPa/m.

4.1.1 Marine Mammal Protection Act (MMPA)

All marine mammals are protected by the MMPA of 1972, as amended, but the West Indian manatee and six large whale species are also listed as endangered and, therefore, are afforded additional protection under the Endangered Species Act (ESA). The MMPA prohibits, with certain exceptions, the *take* of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. All marine mammals that may be present within the study area and are federally listed as threatened or endangered under the ESA are addressed in the biological assessment (Appendix F of the Environmental Impact Statement (EIS)).

Several marine mammal species occur in the study area, which are not federally listed but are protected under the MMPA. The Navy uses a Marine Resource Assessment program to develop a comprehensive data and literature compilation of protected and managed marine resources within its various operating areas, which includes the vicinity of the study area. The document is used for planning purposes and for various types of environmental documentation, such as biological and environmental assessments, that must be prepared in accordance with NEPA, MMPA, ESA, and Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) and was used for developing a marine mammal inventory for this study. Based on this document, thirty-eight marine mammal species have been recorded in or adjacent to the study area. Those species include 33 cetaceans (whales, dolphins, and porpoises), 4 pinnipeds (seals, sea lions, and fur seals), and 1 sirenian. Only 24 of those species are expected to regularly occur in the region (Table 2). Some cetacean species occur in the study area year-round (e.g., bottlenose dolphin, beaked whales), while others (e.g., right whale, humpback whale) occur seasonally as they migrate through the area. Only seasonal occurrences of the West Indian manatee are anticipated.

A study conducted on the effects of dredging noise on bottlenose dolphins determined that frequencies generated from dredging activities were not unlike those generated from shipping, tourist, and recreational boat traffic (NAVFAC 2008). Bottlenose dolphins are most sensitive to frequencies from 4 to 20 kHz and although source frequencies generated from a dredging vessel can fall in this range, noise effects are unlikely to acoustically mask bottlenose dolphin sound, particularly when generated within 100 meters of a dredging vessel (Applied Ecology Solutions 2006). In addition, dolphins are highly mobile and are likely to only be in the vicinity of dredging operations for a short period of time. Although bottlenose dolphins are common in the study area, the Corps has never documented a direct effect on bottlenose dolphins from dredging activities during its numerous dredging projects throughout the United States, therefore, an Incidental Harassment Authorization in accordance with the MMPA is not anticipated for this project. In the April 25, 2005, notice in the *Federal Register* for the issuance of an Incidental Harassment Authorization for blasting at the Port of Miami, NMFS concluded, “According to the Corps, bottlenose dolphins and other marine mammals have not been documented as being directly affected by dredging activities and, therefore, the Corps does not anticipate any incidental harassment of bottlenose dolphins. NMFS concurs” (Geo-Marine, 2005).

On the basis of (1) the predicted noise effect thresholds noted by Richardson et al. (1995), (2) the background noise that already exists in the marine environment (approximately 120 dB), and (3) the ability of marine mammals to move away from the immediate noise source, noise generated by bucket, cutterhead, and hopper dredge activities would not be expected to affect the migration, nursing/breeding, feeding/sheltering or communication of marine mammals. Although behavioral effects are possible (i.e., a whale changing course to move away from a vessel), the number and frequency of vessels present in a given project area is would be small, and any behavioral impacts would be expected to be minor. The dredging operations for the proposed project will not take place in every area of the channel at one time. While multiple dredges may be used at any given time, they will operate at distances that allow enough space for the movement of marine mammals and other species around the vessels. Furthermore, for hopper dredging activities, endangered species observers would be on board and would record all large whale sightings and note any potential behavioral impacts. Per the standard Corps specifications for all dredging projects, the Corps and the contractor would keep the date, time, and approximate location of all marine mammal sightings. Care would be taken not to closely approach any whales, manatees, or other marine mammals during dredging operations or transportation of dredged material. An observer would serve as a lookout to alert the dredge operator or vessel pilot or both of the occurrences of the animals. If any marine mammals are observed during other dredging operations, including vessel movements and transit to the dredged material disposal site, collisions must be avoided either through reduced vessel speed, course alteration, or both. In light of the factors listed, the proposed harbor deepening is not expected to result in more than minimal and temporary adverse impacts to marine life as a result of dredging and dredge equipment noise. Therefore, no further coordination under the MMPA is anticipated for this project.

Table 2. Marine mammal species that could be found in the study area.

Order Cetacea
Suborder Mysticeti (baleen whales)
Family Balaenidae
North Atlantic right whale *Eubalaena glacialis* ENDANGERED
Family Balaenopteridae (rorquals)
Humpback whale *Megaptera novaeangliae* ENDANGERED
Minke whale *Balaenoptera acutorostrata* RARE
Bryde's whale *Balaenoptera edeni* REGULAR
Sei whale *Balaenoptera borealis* ENDANGERED
Fin whale *Balaenoptera physalus* ENDANGERED
Blue whale *Balaenoptera musculus* ENDANGERED
Suborder Odontoceti (toothed whales)
Family Physeteridae
Sperm whale *Physeter macrocephalus* ENDANGERED
Family Kogiidae
Pygmy sperm whale *Kogia breviceps* REGULAR
Dwarf sperm whale *Kogia sima* REGULAR
Family Ziphiidae (beaked whales)
Cuvier's beaked whale *Ziphius cavirostris* REGULAR
True's beaked whale *Mesoplodon mirus* RARE
Gervais' beaked whale *Mesoplodon europaeus* REGULAR
Blainville's beaked whale *Mesoplodon densirostris* REGULAR
Sowerby's beaked whale *Mesoplodon bidens* EXTRALIMITAL
Family Delphinidae (dolphins)
Rough-toothed dolphin *Steno bredanensi*s RARE
Bottlenose dolphin *Tursiops truncatus* REGULAR
Pantropical spotted dolphin *Stenella attenuata* REGULAR
Atlantic spotted dolphin *Stenella frontalis* REGULAR
Spinner dolphin *Stenella longirostris* RARE
Striped dolphin *Stenella coeruleoalba* REGULAR
Clymene dolphin *Stenella clymene* REGULAR
Short-beaked common dolphin *Delphinus delphis* RARE
Fraser's dolphin *Lagenodelphis hosei* RARE
Risso's dolphin *Grampus griseus* REGULAR
Melon-headed whale *Peponocephala electra* RARE
Pygmy killer whale *Feresa attenuate* RARE
False killer whale *Pseudorca crassidens* RARE
Killer whale *Orcinus orca* RARE
Long-finned pilot whale *Globicephala melas* EXTRALIMITAL
Short-finned pilot whale *Globicephala macrorhynchus* REGULAR
Family Phocoenidae
Harbor porpoise *Phocoena phocoena* EXTRALIMITAL
Order Carnivora
Suborder Pinnipedia (seals, sea lions, walruses)
Family Phocidae (true seals)
Harbor seal *Phoca vitulina* EXTRALIMITAL
Hooded seal *Cystophora cristata* EXTRALIMITAL
Order Sirenia
Family Trichechidae (manatees)
West Indian manatee *Trichechus manatus* ENDANGERED RARE

Source: DON, 2008

Note: Those species identified as endangered under the ESA are addressed in the biological assessment (Appendix F of the EIS).

4.2 Impact of dredging noise on the human environment

Maintenance dredging and periodic new work dredging has occurred in Charleston Harbor for over 100 years. For continued maintenance dredging, the dredging equipment is usually present in the harbor on a 12 to 18 month frequency and that frequency is not expected to change with the proposed action. While there would be an increase in the ambient noise level during the dredging phase of the project, the source of noise is at a distance far enough away from any sensitive receptors that no impact is anticipated. The closest the dredging would be to any sensitive receptors would be along the Cooper River portion of the channel. Most of these communities are buffered from the river by the old Naval Base. Since dredging does not occur in one position for any extended period of time, there will be no disproportionate impact on any communities. Noise generated by this project should not be substantially different from other ambient noise levels of a typical harbor.

4.3 Impact of underwater noise from ship traffic

Most vessels produce low frequency sound (below 1kHz) from onboard machinery, hydrodynamic flow around the hull, and from propeller cavitation. This frequency relates to ship size, speed, load, condition, age, and engine type. Low frequency sound can travel hundreds of miles and can increase ambient noise in large areas of the ocean. Additionally, Okeanos (2008) showed that shipping noise doesn't exceed 100 dB. The economic assessment (Appendix C of the final IFR/EIS) from this project has determined that the number of vessels transiting in and out of Charleston Harbor will decrease as a result of the proposed project (compared to the no action alternative) and that the same number of larger ships will call on the Harbor regardless of channel depth. The difference being that with a deeper channel, the larger ships can fully load their cargo and be unrestricted by tide. Without the project, a greater number of ships would be required to deliver the same amount of commercial containers which would have a greater impact on marine noise. While it is true that the number of ships will increase in the future and therefore, potential for sound production will increase, the rate of increase will be less in the future if larger ships can fully load their cargo when calling on Charleston Harbor. As a result of this, no adverse impact is anticipated from underwater noise resulting from ship activity as a result of deepening the harbor.

4.4 Indirect impact of noise from port operations as a result of deepening the harbor

Noise from ports can come from port services and facilities, cranes, cargo handling equipment, warehousing, vessel repair or maintenance, engine noise from vessels at berth. The proposed project will not cause an increase in the number of containers anticipated to arrive in the Port of Charleston. Therefore, there will be no increase in the amount of truck traffic from the various port terminals. The only change would be in the timing of vessel unloading and container movements. In light of these factors, the proposed harbor deepening is not expected to result in adverse noise impacts to surrounding communities as a result of port operations.

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